Credit Standards and Segregation[*]

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Abstract

How do credit standards on the mortgage market affect neighborhood choice and the resulting level of urban segregation? To answer this question, we first develop a model of neighborhood choice with credit constraints. The model shows that a relaxation of credit standards can either increase or decrease segregation, depending on racial income gaps and on races' preferences for neighborhoods. We then estimate the effect of the relaxation of credit standards that accompanied the 1995–2007 mortgage credit boom on the level of urban and school segregation. Matching a national data set of mortgage originations with annual racial demographics of each of the public schools in the United States from 1995 to 2007, we find that the relaxation of credit standards has caused an increase in segregation.

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1 Introduction

Although the availability of mortgage credit is an important determinant of housing options for households, the links between mortgage credit market conditions, neighborhood choice, and the resulting level of urban segregation have so far been neglected.[1] This paper analyzes theoretically and empirically how changes in credit standards affect segregation levels. Introducing mortgage credit and liquidity constraints in a neighborhood choice general equilibrium model, we show how a relaxation of mortgage lending standards can either increase or decrease segregation depending on the income gap and neighborhood valuation differences across different ethnic groups. The paper then empirically estimates the effect of a relaxation of lending standards on segregation during the pre-crisis mortgage credit boom in the United States (1995–2007). Combining extensive information on school segregation (available at annual frequency) with the public record of mortgage originations, we show that the relaxation of lending standards during the boom period has resulted in a significant increase in the level of school segregation experienced by Black and Hispanic students.

We use the mortgage credit boom of the late 1990s until 2007 as a large-scale experiment to analyze how mortgage credit markets affect racial segregation across schools and neighborhoods. Figure 1 shows that the number of mortgage originations to Hispanic households increased five fold during the 1995–2007 period; the number of mortgage originations to black households doubled during the same period, and the number of mortgage originations to white households increased by 50%. Borrowers were also allowed much higher loan-to-income ratios. In 1995, the average new homeowner borrowed 1.9 times his income, whereas by 2004 this ratio has risen 2.4 times annual income. Because this expansion of the supply of mortgage credit did not benefit all races equally, we expect that it changed the patterns of racial segregation.

Does easier access to credit and higher leverage lead to reduced racial segregation? To understand the effects of a relaxation of credit standards on racial segregation, we develop a model of neighborhood choice (cf. Benabou (1996) and Epple, Filimon & Romer (1984)) in which households value neighborhoods differently based on the quality of housing and the quality of associated public goods (e.g., schools). We contribute to the literature by emphasizing the role of credit constraints in the choice of neighborhood and ownership status. Households in our model must borrow in order to buy a house, and their loan-to-income (LTI) ratio plays a critical role in the decision of banks to originate loans.

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[1] There is, of course, extensive literature on discrimination in mortgage applications at the micro level (see, e.g., Munell et al. 1996) and on redlining — that is, discrimination by geography at the micro level (Tootell 1996).

Homeowners choose optimally between rental and homeownership. A relaxation of lending standards leads to a greater number of originated loans and higher loan-to-income ratios. This effect differentially influences whites' and minorities' ability to purchase houses in desirable neighborhoods because these groups have different incomes and value neighborhoods differently. Segregation could increase or decrease depending on who benefits from an increased availability of mortgage credit and who values living in desirable neighborhoods. If whites value local amenities or white neighbors much more than do minoritie and if the white–minority income gap is not too large, then there will be more segregation. If whites' valuation of local amenities and/or white neighbors is lower or only slightly higher than minorities' valuation of local amenities or if the income gap is high, then looser lending standards will lead to reduced segregation.

The paper tests empirically whether a relaxation of credit standards in a typical Metropolitan Statistical Area (MSA) causes an increase or a decrease in school segregation within that MSA over the period 1995–2007. An innovation of this paper is to use school demographics for every public and private school from the US Department of Education's Common Core of Data to combine measures of segregation at *annual frequency* that can be geographically matched with a comprehensive annual data set on individual mortgage origination compiled by the Federal Financial Institutions Examination Council applying the Home Mortgage Disclosure Act of 1975.

The focus of this paper is on estimating of the causal effect of credit standards on segregation while controlling for borrowers' income shocks, racial demographics, and other drivers of demand shocks. Using controls for MSA fixed effects, MSA demographics, and risk measures as well as an instrumental variables strategy that relies on the initial mortgage market structure in each MSA, we show that higher loan-to-income ratios have led to the increased isolation of both Black and of Hispanic students. An increase in the median LTI ratio from two times to three times the income of borrowers increases the isolation of Black students by 3 percentage points. An increase of 1 in the extreme (90th percentile) LTI ratio — holding constant the median LTI ratio — increases the isolation of Hispanic students by 2.1 percentage points. We show that the effect of credit conditions on school segregation is amplified in Metropolitan Statistical Areas with high elasticity of housing supply.

This paper is positioned at the juncture of two strands of the literature: that on mortgage credit standards and that on urban and school segregation. On the one hand, the literature on mortgage credit has insisted on the role of supply factors in explaining the relaxation of lending standards. This finance literature has explored the effect of greater mortgage credit availability on housing prices and mortgage default risk but not on the social or racial composition of neighborhoods. On the other hand, the literature

on segregation has extensively analyzed the effects of public policies but has ignored how market transformation, and specifically credit markets, can affect the level and dynamics of urban and school segregation. This paper is, to our knowledge, the first that combines these two literatures in order to explore the consequences of credit market development on the racial transformation of neighborhoods. We begin theoretically by introducing credit market frictions in neighborhood choice models and assessed their roles in shaping urban segregation. We then show empirically that supply-driven mortgage expansion — along with lending standard relaxations — has led to an increase in urban and school segregation.

On the credit market side, this paper builds on a recent literature that shows how the growth in mortgage originations during the pre-crisis boom was, in large part, due to a relaxation of credit standards in the mortgage market. Mian & Sufi (2009), using disaggregated data at the ZIP code level, demonstrate that a supply-based channel is the most likely explanation for the mortgage expansion during the pre-crisis era. The negative correlation (observed during the peak of the boom 2003–2004) between income growth and credit growth in ZIP codes with a historically high share of subprime mortgages support the credit supply hypothesis.[2] According to Mian & Sufi (2009), these "subprime" ZIP codes experienced a fall in denial rates and in spread between the prime and the subprime interest rates.[3] Favara & Imbs (2010) confirm the role of a credit supply channel by relating the increased loan volume, rising LTI ratios, and faling denial rates in the mortgage credit market to a policy index of interstate branching deregulation. Dell'Arriccia, Igan & Laeven (2009) document the link between mortgage expansion and the relaxation of lending standards by showing that the increase in the number of mortgage applicants has been systemically associated with a decrease in lending standards. Keys, Mukherjee, Seru & Vig (2010) demonstrate how securitization led both to an increase in the supply of mortgages and a decline in lending standards.[4].

On the segregation side, this paper builds on an extensive literature that shows how market prices reflect differences in neighborhoods' racial composition and local public goods quality. Cutler, Glaeser & Vigdor (1999) show that after the 1970s, house prices became a barrier to racial integration and that whites now pay more for housing in predominantly white areas. Structural micro-econometric estimation of households' preferences suggests significant preferences for predominantly white neighborhoods, and for neighborhoods with high school quality (Bayer, Ferreira & McMillan 2007, Bayer, McMillan & Rueben 2004). However, mortgage credit distorts the relationship between prices and neighborhood qual-

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[2]In Section 3, our strategy for instrumenting mortgage credit supply builds on such findings.

[3]Furthermore, that these patterns hold in zip codes with very elastic housing supply rules out the possibility that mortgage expansion was driven by expectations of an increase in future housing prices.

[4]See also Mian & Sufi (2009) and Levitin & Wachter (2010).

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ity, and this paper explains how credit constraints affect prices and racial segregation in a model of residential location choice.

Finally, a major focus of the literature so far has been on such active desegregation policies as busing (Angrist & Lang 2004), school reassignment programs (Hoxby & Weingarth 2006), and court-ordered desegregation plans (Reber 2005, Boustan 2010). In contrast, this paper focuses on the effect of market-driven forces — the relaxation of leverage constraints in mortgage credit markets — on segregation. Since the *Milliken v. Bradley* (1974) Supreme Court decision, court-ordered desegregation plans are constrained by the boundaries of school districts; this holds even though racial segregation across school districts accounts for a large share of school segregation (Clotfelter 1999). Also, busing and school reassignment programs are constrained by the commuting distance. Mortgage market shocks that affect both households' residential location and school choice may have significant MSA-level effects on segregation beyond the effect of busing or school reassignment programs.

The rest of the paper is structured as follows. In Section 2, we present the theoretical framework. In Section 3, we present stylized facts, the identification strategy, and the empirical results. Section 4 concludes.

2 A model of residential choice with credit constraints.

We present here a model in which agents make locational choices based on neighborhood characteristics but also on the ability to secure mortgage credit. This model's contribution is to extend the standard neighborhood choice model to an environment where agents are credit constrained. Segregation is expressed structurally as a function of credit conditions, household preferences, and neighborhood quality. The model features two neighborhoods and two ethnic groups. Although stylized, this model is sufficient to establish the core of our argument that relaxing lending standards can either increase or reduce the level of urban segregation.

2.1 The environment

We consider a metropolitan area formed by two neighborhoods indexed by $j = 1, 2$ and with a continuum of households of density N. The population is divided between two racial or ethnic groups indexed by $r \in \{\text{whites}, \text{minorities}\}$. Minority racial groups represent a share s and white homeowners represent a share $1 - s$ of the total population density N.

Households

Households have an infinite horizon and exhibit separable preferences over how much they want to consume, the neighborhood they want to live in, and their housing status (homeowner or renter). For simplicity we assume that residential choices are irreversibly made at the beginning of a household's life. The lifetime utility of household i of race $r(i)$ living in neighborhood j can be expressed as

$$V_{i,j} = \sum_{t=0}^{\infty} \beta^t U(c_{j,r(i),t}) + v_{j,r(i)} + I^h(i,j).\zeta + e_{i,j}.$$

Here $v_{j,r}$ represents the valuation of neighborhood j by agents belonging to the ethnic group r, $I^h(i,j)$ equals one (zero) if household i is a homeowner (renter) in neighborhood j, ζ denotes the utility derived from homeownership, and e_{ij} is an idiosyncratic preference shock that we assume be to extreme-value distributed. For the sake of simplicity, we also assume that U is isoelastic, $U(c) = \frac{1}{1-\gamma}c^{1-\gamma}$; however, none of the mechanisms of the model rely on this specific functional form.

Households receive a constant wage income ω_r that is specific to their ethnic group. At time zero, they make the residential choice to live in the first or second neighborhood as homeowners or renters. Homeowners entirely finance their housing purchase by borrowing through a perpetuity mortgage loan issued by competitive lenders whose cost of funds is equal to the risk-free rate. We assume that mortgage loans are not defaultable and so do not carry a default risk premium. However, borrowers are screened out during an origination process that will be described shortly.

The intertemporal budget constraint of a household of race r living in neighborhood j is:

$$\sum_{t=1}^{\infty} \left(\frac{1}{1+\rho}\right)^t c_{r,j,t} = \sum_{t=1}^{\infty} \left(\frac{1}{1+\rho}\right)^t \omega_r - \sum_{t=1}^{\infty} \left(\frac{1}{1+\rho}\right)^t \pi_j,$$

where π_j is the payment for housing services; this payment is either equal to the rent χ_j or to the mortgage payment ρD_j on a loan of size D_j. The size of the loan is equal to the price of the purchased house p_j, and comparative loan pricing implies that $\rho D_j = \frac{p_j}{1+\rho^{-1}}$. If we assume that $\beta = \frac{1}{1+\rho}$, then agents perfectly smooth consumption and the intertemporal budget constraint collapses to

$$c_{r,j} = \omega_r - \pi_j,$$

which makes clear that the consumption level is determined by the choice of neighborhood and housing status.

The origination process
Households need to apply for a loan when financing their home purchase, and they

are subject to a screening process by competitive lenders. Based on the characteristics of the household and the price of the house, lenders decide whether or not to originate a mortgage loan. Households can apply for a loan in both neighborhoods. A household that is rejected in both has no choice but to become renter.

The origination decision variable $O_{i,j}$ is equal to one if the application is accepted and to zero if the application is rejected. The origination decision in each neighborhood follows a logit latent variable model:

$$O_{i,j} = \begin{cases} 1 & \text{if } y_{i,j} = \alpha_{r(i)} + \beta LTI_{j,i} + \eta_{i,j} \geq 0, \\ 0 & \text{otherwise,} \end{cases}$$

where α_r is an (ethnic) group-specific constant term, $LTI_{j,i} = p_j/\omega_{r(i)}$ is the loan-to-income ratio, and $\eta_{i,j}$ captures the non observable random characteristics that determine creditworthiness. Because $\eta_{i,j}$ is logistically distributed across households, the origination probabilities can be summarized as

$$\Pr(O_{i,j} = 1) = \frac{\exp(\alpha_{r(i)} + \beta p_j/\omega_{r(i)})}{1 + \exp(\alpha_{r(i)} + \beta p_j/\omega_{r(i)})} \tag{1}$$

The model assumes that the idiosyncratic terms $e_{i,j}$ and $\eta_{i,j}$ are independent. The parameters $\alpha_{r(i)}$ and β capture the severity of the lending standards that lenders choose to impose when seeking to ensure repayment.[5] For simplicity we also assume that, conditional on observable characteristics, origination decisions are independent across neighborhoods, $corr(\eta_{i,1}, \eta_{i,2}) = 0$.[6]

Housing supply

The supply of housing, both for purchase and for rentals, is provided by competitive developers whose marginal cost of developing any additional housing units in neighborhood j is given by

$$MC(H_j) = H_j^{1/\varepsilon_j}.$$

The cost of developing extra housing units is assumed to be the same for rental and owner-occupied units. Therefore, in order for rental and purchasable units to be supplied, developers must be indifferent between developing the two types of units. As long as there is nonzero demand for rentals and housing purchases, the pricing of owner-occupied houses and rental units must satisfy the following *no-arbitrage* condition:

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[5]We implicitly assume that lenders compete on loan pricing — so that the interest rate is equal to the risk-free rate — but apply the same lending standards.

[6]Assuming a non zero correlation $corr(\eta_{i,1}, \eta_{i,2}) > 0$ does not affect the mechanisms illustrated by the model.

$$p_j = \sum_{t=1}^{\infty} \left(\frac{1}{1+\rho}\right)^t \chi_j \iff \chi_j = \frac{p_j}{1+\rho^{-1}}$$

Under marginal cost pricing we have $p_j = H_j^{1/\varepsilon_j}$, where ε_j is the price elasticity of neighborhood j for $j = 1, 2$ and where the supply of housing in neighborhood j is $s_j(p_j) = H_j = p_j^{\varepsilon_j}$.

Neighborhood choice

Individual households maximize their utilities by choosing a combination of neighborhood and housing status that is compatible with lenders' decisions on loan applications $O_{i,j}$. Given that $I^h(i,j) = O_{i,j}$, the problem can expressed as

$$J(i) \equiv \operatorname{argmax}_j \ V_{i,j} = \underbrace{\frac{1}{1-\gamma}\left(\omega_{r(i)} - \frac{1}{1+1/\rho}p_j\right)^{1-\gamma} + v_{j,r(i)} + O_{i,j}.\zeta}_{U_{j,r(i)}} + e_{i,j}$$

The decision rule derives from comparing utilities across the two neighborhoods:

$$\{J(i) = 1\} \iff U_{1,r} + e_{1,i} \geq U_{2,r} + e_{2,i} \iff U_{1,r} - U_{2,r} \geq e_{i,2} - e_{i,1} \qquad (2)$$

Because $e_{i,2}$ and $e_{i,1}$ are drawn from an extreme-value distribution, we can follow McFadden (1974) and infer, from the decision rule, the probability of choosing each neighborhood:

$$\Pr(J(i) = 1) = \frac{\exp(U_{j,r(i)})}{\sum_j \exp(U_{j,r(i)})} \qquad (3)$$

Aggregate housing demand and market clearing

In order to derive aggregate demand for each neighborhood, we aggregate the individual probabilities or neighborhood choices (equation (3)), conditional on origination decisions, multiplied by the probabilities of origination (equation (1)). Minority and white demand for housing in neighborhood 1 is thus equal to the sum of the demand for homeownership and the demand for rentals in that neighborhood.

$$d_{1,minority}^{rental}(p_1, p_2) = \int_i [\Pr(J(i) = 1 | O_{i,1} = 0 \text{ and } O_{2,1} = 0, r = \text{minority}) \Pr(O_{i,1} = 0) \Pr(O_{i,2} = 0)$$

$$+ \Pr(J(i) = 1 | O_{i,1} = 0 \text{ and } O_{2,1} = 1, r = \text{minority}) \Pr(O_{i,1} = 0) \Pr(O_{i,2} = 1)] di$$

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$$d_{1,minority}^{ownership}(p_1, p_2) = \int_i [\Pr(J(i) = 1 | O_{i,1} = 1 \text{ and } O_{2,1} = 1, r = \text{minority}) \Pr(O_{i,1} = 1) \Pr(O_{i,2} = 1)$$

$$+ \Pr(J(i) = 1 | O_{i,1} = 1 \text{ and } O_{2,1} = 0, r = \text{minority}) \Pr(O_{i,1} = 1) \Pr(O_{i,2} = 0)]di$$

Exploiting that the idiosyncratic terms $e_{i,j}$ and $\eta_{i,j}$ are assumed to be independent, we can compute the aggregate demand for each neighborhood by using (3) and (1) and the share of minorities in the population. The market-clearing condition is given by

$$d_j(p_1, p_2) = d_{j,minority}^{rental}(p_1, p_2) + d_{j,minority}^{ownership}(p_1, p_2) + d_{j,whites}^{rental}(p_1, p_2) + d_{j,whites}^{ownership}(p_1, p_2)$$

$$= s_j(p_j) = p_j^{\varepsilon_j}$$

for $j = 1, 2$. The parameters α and β of the origination equation are implicit, so $d_j(p_1, p_2) = d_j(p_1, p_2, \alpha, \beta)$.

2.2 The equilibrium

The equilibrium concept in the economy is the one of a *sorting equilibrium (Bayer et al. 2004)* in which:

- households choose consumption, neighborhood and housing status optimally;

- competitive developers supply housing in order to maximize profits;

- competitive lenders break even on loans originated; and

- the housing market clears at prices $(p_1, p_2) = (p_1^*, p_2^*)$.

Given the assumptions, neighborhood choice probabilities and origination probabilities are implicitly defined by the following fixed-point mappings:

$$d_1(p_1^*, p_2^*) = s_1(p_1^*),$$
$$d_2(p_1^*, p_2^*) = s_2(p_2^*) \tag{4}$$

The appendix gives our proof of the existence and uniqueness of the equilibrium in specific cases. Simulations of our model show the existence and uniqueness of the equilibrium for a large set of parameter values.

2.3 Equilibrium segregation

Among the many available segregation measures (Massey & Denton 1988), we choose the isolation and exposure indices. Isolation and exposure have been extensively used in recent literature (Cutler et al. 1999). The isolation index is the average fraction of neighbors of the same race across neighborhoods. For instance, the isolation of whites is the average fraction of white neighbors for white households. The isolation index is a particularly relevant measure when the effect of neighbors on outcomes is considered— as in, for example, standard models with linear-in-means peer effects specification (Manski 1993, Hoxby 2001).[7]

The isolation of whites in the metropolitan area is:

$$\text{Isolation}(whites) = \sum_j \frac{whites_j}{whites} \cdot \frac{whites_j}{population_j} \tag{5}$$

where $whites_j$ is the number of white students in neighborhood j, $whites$ is the overall number of whites, and $population_j$ is overall population in the metropolitan area.

The isolation of whites decreases as white households are more exposed to minority neighbors. The exposure of whites to minorities is

$$\text{Exposure}(minorities|whites) = \sum_j \frac{whites_j}{whites} \cdot \frac{minorities_j}{population_j} \tag{6}$$

where $minorities_j$ is the density of minorities in neighborhood j. In the case of two racial groups, isolation increases when the exposure to other racial groups decreases:[8]

$$\text{Isolation}(whites) = 1 - \text{Exposure}(whites|minorities)$$

Finally, the equilibrium demand for housing in each neighborhood, by race, together with the equilibrium size of neighborhoods, gives the equilibrium level of segregation.

$$\text{Isolation}(whites, p_1, p_2, \alpha, \beta) = \sum_{j=1,2} \frac{d_{j,whites}(p_1, p_2, \alpha, \beta)}{N \cdot (1-s)} \cdot \frac{d_{j,whites}(p_1, p_2, \alpha, \beta)}{s_j(p_j)}$$

$$\text{Isolation}(minorities, p_1, p_2, \alpha, \beta) = \sum_{j=1,2} \frac{d_{j,minorities}(p_1, p_2, \alpha, \beta)}{N \cdot s} \cdot \frac{d_{j,minorities}(p_1, p_2, \alpha, \beta)}{s_j(p_j)}$$

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[7]Take, for instance, a peer-effects specification in which an outcome of interest depends on peers' race and other characteristics: Then $outcome = x_i'\beta + \gamma \text{Neighbors' Race} + \varepsilon_i$. The isolation and exposure indices, which are multiplied by β, measure the effect of segregation on the outcome.

[8]In Section 3, we extend the measures to more than two racial groups.

Here j indexes neighborhoods, $N \cdot s$ is total minority population, $N \cdot (1-s)$ is total white population, and other notation is as before. In the next section, we look at the effect of a change of α or β on the equilibrium isolation for whites and minorities.

2.4 Analytical results

This section presents analytical results that explain the effect of the relaxation of credit constraints on urban segregation. Because the model combined two stochastic distributions — one for the unobserved valuation of each neighborhood $e_{i,j}$ and one for the unobserved determinants $\eta_{i,j}$ of the origination decision — the model's comparative statics are tractable in special cases only. Simulation results presented in the next section give a full account of the comparative statics of the model for cases not covered here.

For tractability, we assume here that the elasticity of housing supply is zero and that developers supply the same fixed quantity of housing in each neighborhood. There is no rental market and the origination screening process applies only to the most valuable neighborhood (i.e., neighborhood 1). The other neighborhood is a reservation option where loans are always originated.

Two parameters, α and β, measure the tightness of lending standards in neighborhood 1. An increase in α corresponds to a relaxation of *overall lending standards* whereas an increase in β captures more specifically a relaxation of *leverage constraints,* since β measures the sensitivity of the likelihood of origination to a change in the loan-to-income or price-to-income ratio. Hereafter we put $\alpha = \alpha_{\text{minority}} = \alpha_{\text{white}}$, which means that our analysis abstracts from the role of racial discrimination in lending practices.

The two racial groups we consider (whites and minorities) differ along two dimensions: their income and their relative valuation of neighborhoods. The propositions consider each of these dimensions in turn.

The consequences of a relaxation of lending standards on segregation are the outcome of two effects: a *leverage effect* resultsfrom higher probabilities of origination for a given level of income and for a given price, and a *general equilibrium effect* results from an upward shift in demand, which drives prices up in the most valued neighborhood. A change in β affects isolation at given prices (leverage effect), and also affects prices (general equilibrium effect*),* which in turn affect isolation:

$$\frac{d\text{Isolation}}{d\beta}(p_1^*, p_2^*, \alpha, \beta) = \frac{\partial \text{Isolation}}{\partial \beta}(p_1^*, p_2^*, \alpha, \beta) + \sum_{j=1,2} \frac{\partial \text{Isolation}}{\partial p_j^*} \cdot \frac{dp_j^*}{d\beta} \qquad (7)$$

The first term on the right-hand side is the leverage effect of a change in β on isolation. This effect is typically negative, that is, a higher $\beta < 0$ lowers racial segregation. The

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second term is the *general equilibrium effect* of a change in β on prices multiplied by the effect of prices on isolation. The sign and magnitude of this second effect depend on races' incomes and valuations of the two neighborhoods.

Our first two propositions show that, depending on incomes and valuations, either the leverage effect or the general equilibrium effect dominates.

Proposition 1. *If whites have higher income than minorities, $\omega_w > \omega_m$, and if whites and minorities value neighborhood 1 equally, then the following statements hold.*

1. *A relaxation of leverage constraints (i.e., a higher β) reduces isolation.*

2. *If the probability of origination is insensitive to the LTI ratio ($\beta = 0$), there is no segregation; in other words, the isolation of whites is equal to the fraction of whites in the metropolitan area.*

   In addition, if the difference between the valuations of the two neighborhoods is not too large:

3. *A relaxation of overall lending standard constraints (i.e., a higher α) reduces isolation.*

Proof. See Appendix. □

Because minorities' income is lower, they face higher denial rates when applying for mortgage credit. Buying in the same neighborhood as whites requires greater leverage, which mechanically increases denial rates. However, at a given price, minorities, benefit more than whites do from the *leverage effect*.

A relaxation of overall lending standards (a higher α), although it does not affect directly the sensitivity to the loan-to-income ratio, plays a similar role because it reduces the relative importance of leverage constraints in the origination process.

Because it allows for a higher LTI ratio and supply is fixed, relaxing credit standards results in an increase in the price of the most desirable neighborhood. This general equilibrium effect hurts the group with the lowest income the most. The change in the level of segregation depends on the *relative* strength of the leverage effect and the general equilibrium effect. Proposition 1 states that, if neighborhoods are equally valued by both group, then the leverage effect dominates and segregation is reduced when leverage constraints are relaxed. A similar result holds for relaxation of the overall lending standards when the difference between neighborhood valuations is not too large. When the relative valuation of neighborhoods is equal across groups, a relaxation of lending standards shifts upwards both groups' demand for the best neighborhood, but it does so by more for the minorities.

Proposition 2. *If whites and minorities have equal incomes, $\omega_w = \omega_m$, and if whites value neighborhood 1 more than minorities, then any relaxation of lending standards (a higher α or a higher β) increases isolation.*

In contrast to Proposition 1, where both groups have identical preferences but different incomes, Proposition 2 considers the case of identical incomes but different valuations of housing. Identical incomes lead to the the same leverage effect for both groups; therefore segregation changes only because of the general equilibrium effect. The relaxation of lending standards allows both racial groups to enjoy a greater leverage. However, since white households value neighborhood 1 relatively more, they increase their demand for neighborhood 1 using additional leverage. Hence whites' demand for neighborhood 1 shifts by more than minorities' demand, so a relaxation of leverage constraints leads to higher segregation.

2.5 Simulation results

We now turn to the general model in order to simulate the effect of relaxing the credit constraint on urban segregation for a plausible calibration of the economy. The general model is richer in two important dimensions. First, it includes an option to rent: households apply for credit in both neighborhoods and also choose between rental and homeownership. Second, the general model features elastic housing supply to account for changes in neighborhoods' relative size. The numerical simulations complement our analytical results by including scenarios in which racial groups differ in terms of both income and the relative valuations of neighborhoods.

The simulations presented here are based on a relaxation of the leverage constraint (an increase in β). Very similar results are obtained with a relaxation of the overall lending standards (an increase in α) .

Model calibration.

Baseline simulations

The simulations are based on a two-neighborhood economy populated by two racial groups: whites (which form the larger group) and racial or ethnic minorities. In our baseline simulation, minorities account for 20% of the population. White households' income is set at 60,000 USD per year and minority households' income at 40,000 USD.[9] We consider a MSA in which one (typically inner-city) neighborhood faces severe geographical constraints to expansion and thus exhibits low housing supply elasticity ($\epsilon = 0.3$) while the

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other (typically suburban) neighborhood exhibits a much higher supply elasticity ($\epsilon = 3$).[10] The parameters of the model that remain constant across the two scenarios are summarized in the following table.

Parameter	Value	Definition
r	0.05	Interest rate
N	150,000	Population
s	0.2	Minority share of population.
ω_w	60,000	Whites' annual income
ω_b	40,000	Minorities' annual income
γ	0.0001	Risk neutrality
$\alpha_w = \alpha_b$	2.5	No discrimination
σ	1000	Standard deviation of the idiosyncratic valuation $\varepsilon_{i,j}$
ε_1	0.3	Housing supply elasticity in neighborhood 1
ε_2	3	Housing supply elasticity in neighborhood 2
ζ	10,000	Utility value of homeownership

The group-specific valuation of each neighborhood ($v_{j,r(i)}$) plays a key role here because it determines, for each racial group, the average willingness to pay for housing in each neighborhood. We consider two scenarios. In both, the first neighborhood is more desirable than the second — for instance because it has better school quality. In the first scenario both groups associate a utility value of 10,000 USD with living in neighborhood 1 and a value of of 2,000 USD with living neighborhood 2. In the second scenario whites value living in neighborhood 1 more than minorities do (10,000 USD vs. 5,000 USD).

The two scenarios may be summarized as follows.

Scenario	$\nu_{1,\text{white}}$	$\nu_{2,\text{white}}$	$\nu_{1,\text{minority}}$	$\nu_{2,\text{minority}}$
1	10,000	2,000	10,000	2,000
2	10,000	2,000	5,000	2,000

In each scenario, we look at the effect of an increase in the "looseness" of leverage constraints on the equilibrium variables, with special attention given to its consequences on urban segregation. Toward that end, we increase from -0.75 to 0 the parameter β, which links the ratio of loan (or price) to income to the origination probability in neighborhood 1.

Scenario 1: Relaxation of leverage constraints reduces urban segregation.

[10]The average of the two elasticities (1.85) is close to the median/mean MSA elasticity calculated by Saiz (2010) using topographic information. The sensitivity to different elasticities is analyzed at the end of this section.

This scenario extends the results of proposition 1 to the general model. Figure (2)(a) plots neighborhood 1's relative price of housing, p_1/p_2. Independently of credit conditions, neighborhood 1 is more expensive for reasons of both demand and supply fundamentals: neighborhood 1 is more valued by both ethnic groups and its supply elasticity is lower. However, the relative price of housing is constrained by higher denial rates for credit as occurs when housing becomes more expensive. Thus, higher prices lead to higher denial rates, which reduces the total demand for housing. As leverage constraints are relaxed, the relative price of neighborhood 1 increases and, at $\beta = 0$, fully reflects the difference in quality between the two neighborhoods. Figure (2)(b) plots denial rates (i.e., one minus the probability of origination) in both neighborhoods as a function of the severity of leverage constraints. Minorities have a lower income. Thus, minorities seeking loans ask for higher LTI ratio than do whites and therefore face higher denial rates. When the borrowing constraint is relaxed, both groups can simultaneously enjoy higher LTI ratios and lower denial probabilities. When $\beta = 0$, the denial rates is the same for both group because income no longer plays any role in the origination decision. Because neighborhood 1 is more expensive than neighborhood 2 for fundamental reasons, relaxaxing leverage constraint has a more pronounced effect in this neighborhood. In fact, denial rates in neighborhood 2 are in fact close to (or below 10%) for most of the range of variation in β.[11]

Households put a premium on homeownership over rental, so a consequence of the fall in denial rates is an increase in homeownership. Figure (2)(c) plots the rate of homeownership in both groups and shows that a relaxation of borrowing constraints leads to both an increase and a convergence of ownership rates across both groups.

Figure (2)(d) contrasts the probability of a minority household of living in neighborhood 1 with the share of this neighborhood in the total population. Absent any segregation (i.e., if households were randomly assigned to neighborhoods) the two figures would coincide. When leverage constraints are severe ($\beta = -0.75$) , minorities have only a 48 percent change of living in neighborhood 1 even though that neighborhood hosts 62% of the population. As leverage constraints are relaxed, this gap is gradually reduced, and when $\beta = 0$, segregation no longer exists. These simulated results confirm the analytical results of the previous section: if relative valuations are *identical* across ethnic groups, then a relaxation of credit standards is enough to desegregate cities.

Figure (3) plots the change in standard measures of segregation: the isolation indexes and the exposure of each group to the other group. Consistently with the increase in the probability of minority of living in neighborhood 1, whites' and minorities' isolation indexes are reduced and interracial exposure increases.

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[11]This feature gives some support to the simplification made in Section 2 that origination constraints affect only the most valued neighborhood.

Scenario 2: Relaxation of leverage constraints increases urban segregation.

This scenario extends numerically the results of Proposition 1 to the general model and to the case where groups differ in terms of income. Whites have a higher valuation of neighborhood 2 than do minorities. For example, the former are able to benefit more from given school quality — maybe because they are better educated themselves or form a stronger network. As we will see, this simple difference in valuation is enough to completely reverse the previous result on the effect of leverage constraints on urban segregation. Whites households now use their additional leverage disproportionately more than minorities do to demand housing in neighborhood 1 and, as a result, isolate themselves further.

Figure (4) is the analog of Figure (2) for the second scenario. The plots exhibit a similar pattern in terms of neighborhood relative prices, denial rates, and homeownership. However, figure (4)(d), which plots the probability of a minority household living in neighborhood 1, points to a striking difference with scenario 1. As lending standards are relaxed, minority households are gradually priced out of neighborhood 1 even though this neighborhood is growing in population. When $\beta = -0.75$, there is a 22% probability that a given minority household lives in the good neighborhood; when $\beta = 0$, this probability falls to about 10%. As before, relaxing borrowing constraints shifts the demand of both groups upward but now it shifts whites' demand curve by much more. In this case, the general equilibrium effect, resulting from higher prices, dominates the leverage effect. Figure (5) reveals the consequences of this increase in urban segregation via isolation and exposure indexes. As β is reduced from -0.75 to 0, the isolation of minorities increases from 0.31 to 0.49 and the isolation of whites from 0.83 to 0.87.[12]

The role of social interactions.

In the baseline model, a household's valuation of neighborhoods 1 and 2 does not depend on their racial composition. In line with the literature on neighborhood choice (Benabou 1996), we introduce an additional role for social interactions among households of similar racial background. We do so by rewriting the valuation of neighborhood j for individual i of race r as the sum of an exogenous component and an endogenous component depending on the interaction between the racial composition of neighborhood j and the value of social interactions:

$$v_{j,r(i)} = v^1_{j,r(i)} + \frac{d_{j,white}}{H_j} v^2_{r(i)};$$

here $\frac{d_{j,white}}{H_j}$ is the fraction of households of the same race as i in neighborhood j and $v^2_{r(i)}$

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[12]Although the change in minorities probability of living in neighborhood 1 moves in opposite directions, but with similar magnitude in scenario 1 versus scenario 2, the effect on isolation measures is stronger in scenario 2. The reason is that the the *initial level* of segregation is much higher in scenario 2.

measures the importance of social interactions in households' valuation of neighborhoods 1 and 2. Only white households benefit from social interactions ($v_b^2 = 0$), yet the strength of white households' preferences for whites neighbors v_w^2 is not too large (this ruling out multiple equilibria). Figure (6) contrasts baseline scenario 2 with an alternative scenario in which white households derive additional utility $v_w^2 = 2,500$ USD when in an all-white neighborhood. Social interactions amplify the effect of borrowing constraints on racial segregation. Also, the stronger the relaxation of leverage constraints, the stronger the effect of social interactions on urban segregation.

The role of housing supply elasticity.

In our model, housing supply elasticity affects urban segregation through both a price effect and a neighborhood size effect. The last numerical scenario (Figure (7)) shows these two effects by simulating the baseline economy of scenario 2 for both a small ($\varepsilon_1 = 0.1$) and a high ($\varepsilon_1 = 0.5$) value of supply elasticity in neighborhood 1. Figure (7)(a) shows the relative price of neighborhood 1. Neighborhood 1 is more expensive when elasticity is low and the relative price increases by more when leverage constraints are relaxed; this is the *price effect.* Low elasticity also constrains neighborhood 1's size. When combined with a higher relative price, this lowers minorities' probability of living in neighborhood 1 (Figure (7) (b)); this is *neighborhood size effect.*

The level of and change in segregation are not similarly affected by housing supply elasticity. With low elasticity, the level of segregation is higher when leverage constraints are severe but increases by less than in the case of high elasticity when leverage constraints are relaxed (Figures (7)(c) and (7)(d)). Therefore, the relaxation of borrowing constraints has a stronger positive effect on segregation with high than with low elasticity. [13]

3   Empirics

Scenario 1 and scenario 2, as described in Section 2.5, predict that a relaxation of credit standards can either increase or decrease urban segregation depending on (i) the relative preferences of racial groups for neighborhoods and (ii) income differences. In this section, we empirically assess whether the mortgage credit boom of 1995–2007 and the associated relaxation of lending standards have increased or decreased urban and school segregation.

An empirical analysis of the effect of credit standards on segregation faces several challenges. The first is the *lack of data availability on neighborhood composition at annual*

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[13] Observe that when leverage constraint are sufficiently relaxed, isolation measures indicate a higher segregation with high than with low elasticity. In this case, even if the probability of minorities of living in neighborhood 1 is higher with high than with low elasticity, the probability gap is now small relative to the difference in neighborhood size; this results in higher isolation measures.

frequency; this is addressed in Section 3.1. Whereas (nearly) exhaustive information on mortgage origination is available annually for the entire sample period (1995–2007), urban segregation based on decennial census data can be computed only in 2000 during this period. We therefore devise an alternative measure of racial segregation using a comprehensive annual dataset of school demographics that provides the racial composition of each of the 90,000 public schools matched with their corresponding census tracts.

The second challenge is to *control for several confounding effects* of the empirical analysis. The most important of such effects is that the relaxation of credit standards occurred at the same time as the large increase in the U.S. Hispanic population. This issue is addressed in Section 3.2. The third challenge is to *disentangle the relaxation of credit standards from demand shocks.* We use an instrumental variables strategy in Section 3.3 to address this last challenge. Finally, Section 3.4 shows that the relaxation of lending standards affects segregation across school districts; thus, mortgage credit has effects on segregation that are independent of school districts' racial integration plans.

3.1 Data

Mortgage data is that compiled in accordance with the Home Mortgage Disclosure Act (HMDA) for the years 1995–2007.[14] The data were collected by the Federal Financial Institutions Examination Council (FFIEC). Banks, savings associations, credit unions, and other mortgage lending institutions submit information on mortgage applications and mortgage originations to various federal agencies, which in turn report this information to the FFIEC. Reporting is mandatory for all depository institution as well as for non-depository institutions (i.e. for-profit lenders regulated by the Department of Housing and Urban Development that either have combined assets exceeding 10 million USD or originated 100 or more home purchase loans, including home refinancing loans, in the preceding calendar year). The HMDA covers nearly 90% of all mortgage applications and originations (Dell'Arriccia et al. 2009). Each mortgage is fully documented with the loan amount, the income of the applicant, the race and gender of the applicant, and the census tract of the house.[15]

The annual school data provides us with the racial demographics and the geographic location of each school but census data is only decennial at this level of disaggregation. Yet since schools can be geographically matched to neighborhoods, schools can therefore serve as a proxy for the composition of census tracts and urban segregation.

School demographics come from the US Department of Education's Common Core of

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[14]The Home Mortgage Disclosure Act was enacted by Congress in 1975 to collect information on mortgage lenders' practices, among them discrimination and redlining against minority applicants.

[15]A census tract is a group of contiguous blocks that typically contains a few thousand inhabitants.

Data (Public and Private School Universe) from 1995 to 2007. The Public School Universe is a comprehensive annual data set of public schools in the United States; the Private School Universe is available every other year. In the paper we use secondary schools. In order to study the dynamics of segregation at an annual frequency, we restrict our attention to public schools. This should not affect the analysis because, as we show in section 4 credit standards have no significant impact on sorting between public and private schools. Each school is identified by a unique number, its secondary or unified school district, and its geographic position (latitude, longitude, and 5-digit zip code) and is then matched to Metropolitan Statistical Areas with stable borders from 1995 to 2007.[16]

To see how much of racial composition by census tract can be explained in terms of the racial composition of nearby schools, we regressed census tract composition on school composition interacted with the distance in miles between the school and the census tract (using 2000 census data matched to the 2000 Public School Universe data).[17] Table 1 shows that the racial demographics of the nine nearby schools explain approximately 60% of the variance in census tract racial demographics.

Measures of racial demographics and racial segregation across schools are constructed for each MSA as in Section 2.3.[18] Unlike our approach in the theory part of this paper, within each metropolitan area we measure the segregation of students across schools (instead of the segregation of households across neighborhoods). Urban segregation at the MSA level in the 2000 census and school segregation at the MSA level in 2000 are strongly correlated. The MSA-level measures of credit conditions are: median LTI ratio, 90th percentile LTI ratio, acceptance rate,[19] and number of applications in the MSA.

Finally, our data set is matched to the elasticity measures calculated by Saiz (2010), which take into account both the geographic and regulatory constraints on housing. Elasticity is available for the 258 largest MSAs. The average elasticity is 2.8, the median

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[16]For ZIP codes, we used the geographical correspondence files provided by Geocorr 2K at the Missouri Census Data Center. Latitudes and longitudes are matched to CBSAs using ArcGIS and CBSA shapefiles provided by the US Census Bureau. Latitude and longitude are not available prior to 2000, so we either use the post-2000 latitude and longitude (if the school is still present in the dataset), or match the school using the Geocorr file and the 5-digit ZIP code.

[17]The specification is $\frac{\text{Race}_{r,j}}{\text{Population}_j} = \sum_{k=1}^{9} \frac{\text{Students}_{r,s(j,k)}}{\text{Enrollment}_{s(j,k)}} \cdot (a + b \cdot \text{Distance}_{s(j,k)}) + X_{r,j} \cdot \beta + \varepsilon_j$, where $\text{Race}_{r,j}$ is the number of individuals of race r in census tract j, Population_j is the population of census tract j, $\text{Students}_{r,s}$ is the number of students of race r in school s, and $s(j,k)$ is the k-th closest school from census tract j. For each mortgage, HMDA data contains the census tract of the purchased house. Each census tract is matched to the nine closest schools. The average distance to the closest school is 1.16 miles, and the distance to the ninth closest school is 3.423 miles. Using more than nine schools did not significantly increase the explanatory power of school composition. Enrollment_s is the number of students in school s, $\text{Distance}_{j,s}$ is the distance in miles between school s and census tract j; and $X_{r,j}$ is a set of controls for outliers — dummies for schools that are more than 15 miles and 30 miles from the census tract.

[18]We use the 2003 Core Based Statistical Areas (CBSAs) as our definition of MSAs for the entire period.

[19]The acceptance rate is the ratio of originations to applications.

elasticity is 2.5, and the 90th percentile is 4.6.

3.2   School segregation and credit conditions 1995-2007

The major driving force of changing racial demographics is growth of the Hispanic population, which increased 36% between the 2000 and the 2010 census. In our data set of 363 MSAs, Hispanics make up 13% of the population in 1995, and 18.1% in 2005. Mechanically then, the exposure of other students to Hispanic students increases and isolation decreases: by 6.1 percentage points for whites, by 2.9 percentage points for blacks, and by 1 percentage point for Asians. The isolation of Hispanics tends to rise as they move to Hispanic areas; although the exposure of whites to Hispanics goes up, the exposure of Hispanics to whites goes down. These trends are also observed in the between-school district segregation measures. The exposure of blacks to white households decreases by 4 percentage points at the same time, indicating that something besides the pure migration shock is at play.

The inflow of Hispanics had little effects on the distribution of students across public and private schools. The fraction of students in public schools (which includes charter schools) is quite stable over the period, increasing slightly by 1 percentage point.

In the same period of time, lending standards changed tremendously (see Figure 8): the volume of originations grew fourfold for Hispanics, doubled for blacks, and increased by 50% for whites. The median loan-to-income ratio grew by 0.4, with similar trends for the different racial groups. The 90th percentile LTI grew by nearly 1: the tail of the LTI distribution becomes fatter, as is also illustrated by the growth in acceptance rates for extreme LTIs above 3.5.

We also observe that, across MSAs, the growth in isolation was negatively correlated with the growth in the loan-to-income ratio, $corr(\Delta\text{Isolation}, \Delta\text{LTI}) < 0$. Yet this correlation is not necessarily an indication of a causal effect of leverage on segregation, because the single largest mortgage credit boom in US history coincided with the increase in Hispanic population. Overall there are at least five factors that confound the identification of the effect of a change in lenders' leverage policy. These factors, which are detailed below, have an impact on segregation and may be correlated with the loan-to-income ratio.

- **Demographic trends**: The loan-to-income ratio grew more in areas where there was a larger inflow of Hispanics, $Corr(\Delta Hispanics, \Delta LTI) > 0$. If the inflow of Hispanics causes a fall in isolation, a simple positive correlation of the growth in the LTI ratio and the change in isolation might be due to the migration inflows.

- **Borrowers' creditworthiness**: Hispanic population grew more in areas that experienced a larger decline in borrowers' creditworthiness, $corr(\Delta\text{LTI}, \Delta\text{Past Due}) >$

$0.$[20] The increase in LTI occured alongside a deterioration in borrowers' credit quality. In this paper, the effect of interest is the effect of a relaxation of the leverage constraint on segregation, given borrowers' creditworthiness.

- **Elasticity of housing supply**: Hispanic inflows occured in MSAs that are relatively elastic ($corr(\Delta\text{Hispanics}, \Delta\text{Elasticity}) > 0$). If MSAs that are more elastic are MSAs where the inflow of Hispanics causes a less significant change in isolation (because the housing supply can expand without affecting prices) and where the loan-to-income ratio experiences smaller changes, then the simple negative correlation of the change in isolation and the LTI ratio underestimates the true effect of the LTI ratio on segregation.

- **Demand shocks:** These may occur at the same time as changes in lending standards. However, we observe that the growth in the LTI ratio occurred primarily in areas where the median applicant income declined: $Corr(\Delta\text{LTI}, \Delta\text{Income}) < 0$. This indicates that an increase in demand for credit or for housing is unlikely to be a full explanation for the trends. Lending standards declined over the period.

- **General equilibrium effects of lending standards on prices, and of prices on segregation**: There is both a direct effect of credit conditions on households, conditional on prices, and an indirect effect of credit conditions on segregation as transmitted by prices.

3.3 Identification strategy

The primary interest of this paper is to identify variations in segregation that are due to changes in credit conditions — that is, *beyond* the variations in segregation that are due to external migrations, demand shocks, changes in borrowers' creditworthiness, and correlation between external migrations and the elasticity of housing supply.

The following equation captures how MSA-level segregation is determined by prices, racial demographics, national trends, credit standards, and other MSA-specific factors:

$$
\begin{aligned}
\text{Segregation}_{j,t} = \ & \text{Price}_{j,t}\delta + \text{Credit Standards}_{j,t}\gamma + \text{Year}_t^s + \text{MSA}_j^s \\
& + \text{Racial Demographics}_{j,t}\beta + \text{Demand Shocks}_{j,t}\eta + e_{j,t}^s \quad (8)
\end{aligned}
$$

where j indexes MSAs and t indexes years. The effect of credit standards conditional on prices is the *leverage effect* of Section 2.4.[21] The effect of prices on segregation is

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[20]Past Due is the fraction of borrowers who are past the due date on at least one of their mortgage payments. The data is provided by Haver Analytics.

[21]This effect corresponds to the term $\partial\text{Isolation}/\partial\beta$ in equation (7).

documented in Cutler, Glaeser & Vigdor (2008) and is theoretically grounded in Section 2.4 of this paper.[22] In many MSAs there were large increases in Hispanic population over the period, and some MSAs (e.g. Austin–Round Rock, TX) grew substantially (more than 40%) over the period 1995–2007 owing to a large influx of Hispanic population. These changes have an impact β on segregation independently of credit conditions. Changes in racial demographics are also due to migrations in and out of the MSA, differential birth rates, and differential mortality rates across racial groups. The year dummy Year_t, which is common to all MSAs, captures secular declines or increases in segregation. Finally, demand shocks capture changes in segregation that are due to shifts in either the demand curve for credit or the demand curve for housing. Changes in households' expectations of future price increases or income shocks are part of this vector of covariates.

Likewise, the price of housing is determined by segregation, racial demographics, national trends, credit conditions, and other factors:

$$
\begin{aligned}
\text{Price}_{j,t} \;=\;& \text{Segregation}_{j,t}a + \text{Credit Standards}_{j,t}c + \text{Year}_t^p + \text{MSA}_j^p \\
& + \text{Racial Demographics}_{j,t}b + \text{Demand Shocks}_{j,t}h + e_{j,t}^p.
\end{aligned} \tag{9}
$$

This equation is an aggregated version of the hedonic equation of Cutler et al. (2008). The general equilibrium effect c of credit conditions on prices is debated and analyzed in Glaeser, Gottlieb & Gyourko (2010).[23] The effect a of segregation on prices is indirectly determined by households' valuation of segregation.[24] If we combine equations (8) and (9), the reduced-form model is then:

$$
\begin{aligned}
\text{Segregation}_{j,t} \;=\;& \text{Credit Standards}_{j,t}\frac{c\delta + \gamma}{1 - a\delta} + \text{Year}_t + \text{MSA}_j \\
& + \text{Racial Demographics}_{j,t}\frac{b\delta + \beta}{1 - a\delta} \\
& + \text{Demand Shocks}_{j,t}\frac{h\delta + \eta}{1 - a\delta} + \frac{e_{j,t}^s\delta + e_{j,t}^p}{1 - a\delta},
\end{aligned} \tag{10}
$$

where $\text{Year}_t = (\text{Year}_t^s\delta + \text{Year}_t^p)/(1 - a\delta)$ and $\text{MSA}_j = (\text{MSA}_j^s\delta + \text{MSA}_j^p)/(1 - a\delta)$. Hence the reduced-form effect of credit conditions $(c\delta + \gamma)/(1 - a\delta)$ incorporates the two effects highlighted in the model: the *general equilibrium effect* of credit conditions on prices and

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[22]This effect corresponds to the terms $\partial\text{Isolation}/\partial p_j^*$, $j = 1, 2$, in equation (7).

[23]This effect corresponds to the term $dp_j^*/d\beta$ in equation (7).

[24]To see this, consider a simple form of the hedonic equation $p_i = white_i + white_i \cdot minority_{j(i)} + \varepsilon_i$, where i indexes houses, $white_i$ is a dummy for white individuals, and $minority_j$ is the fraction of minority neighbors in neighborhood $j(i)$. Then the average price is $E(p_i) = E(white) \cdot (\alpha - \gamma + \gamma\text{Isolation}(white))$, which makes it clear that prices are a function of isolation and hence of segregation.

on segregation $(c\delta)/(1-a\delta)$[25] and the *leverage effect* $\gamma/(1-a\delta)$ of credit conditions on segregation (cf. Section 2.4).

By including an MSA fixed effect, we avoid the issue of non–time-varying confounders that may bias our estimate of the effect of credit conditions on school segregation. One of these unobserved factors is the elasticity of housing supply.

The main specification of the paper estimates the reduced-form equation (10) by decomposing the credit standards term into measures of the LTI ratio and measures of applicants' creditworthiness:[26]

$$\begin{aligned} \text{Segregation}_{j,t} &= \text{LTI}_{j,t} \cdot C + \text{Racial Demographics}_{j,t} \cdot B \\ &\quad + \text{Creditworthiness}_{j,t} \cdot D + \text{MSA}_j + \text{Year}_t + u_{j,t}, \end{aligned} \quad (11)$$

where the residual $u_{j,t} = \text{Demand Shocks}_{j,t}\frac{h\delta+\eta}{1-a\delta} + \frac{e^s_{j,t}\delta+e^p_{j,t}}{1-a\delta}$. The dependent variable Segregation$_{j,t}$ is a measure of segregation (isolation of whites, Hispanics, blacks and Asians), or of the exposure of a racial group to another racial group. Here LTI$_{j,t}$ is the median loan-to-income ratio (LTI) and the difference between the 90th percentile and the median LTI ratio in the MSA. Creditworthiness$_{j,t}$ is a vector that includes the fraction of subprime loans;[27] the fraction of jumbo loans[28] in year t; the fraction of delinquencies, foreclosures, and mortgages at least 90+ days past due[29] in year $t+4$; and the fraction of high-risk loans. To identify high-risk loans, we estimate the probability of denial for 1995 mortgages as a function of demographic characteristics (race, gender) and characteristics of the loan (LTI ratio, loan amount), as well as between the interaction of the two sets of variables. We then use this prediction to estimate the fraction of high-risk loans in year $t \geq 1995$ using the credit standards of 1995. The term Racial Demographics$_{j,t}$ is a vector of the fraction of each racial and ethnic group in the MSA: fraction of white non-Hispanic, Hispanic nonwhite, black (non-Hispanic), of Asian, and of other racial groups.

The residual $e_{j,t}$ might not be free of endogeneity. The remaining unobservable demand factor, Demand Shocks$_{j,t}$, is still potentially correlated with the LTI ratio and may still affect segregation. In this case, regression (11) overestimates the true effect of the LTI

---

[25]In the model, this effect corresponds to the term $\sum_{j=1,2} \frac{\partial \text{Isolation}}{\partial p^*_j} \cdot \frac{dp^*_j}{d\beta}$ of equation (7).

[26]This specification augments that of Cutler et al. (2008) with measures of credit conditions and with controls for households' creditworthiness.

[27]We identify subprime loans as those that have been originated by a subprime lender. The US Department of Housing and Urban Development provides a list of lenders that specialize in subprime or manufactured home lending.

[28]A jumbo loan is a loan whose amount is above the conformable loan limit; loans above that limit are seldom bought by the government sponsored enterprises. We use the limits provided by the Department of Housing and Urban Development.

[29]Data based on an MSA-level aggregation from Haver Analytics.

ratio on segregation. To address this potential issue, we add controls for the 10th, 25th and 50th percentile of income by racial group, as well as for the fraction of mortgages with missing income (by race).

Finally, we address the endogeneity issue via an instrumental variable strategy. Our instrument is constructed in the following way. Building up on Mian and Sufi (Mian & Sufi 2009), we construct an index of pre-crisis subprime lending activity by considering the share of mortgages provided by banks that specialized in subprime lending[30] prior to 1995. [31]This measure of market structure in 1995 is likely to be independent of future demand shocks, but is a good predictor of future increases in the loan-to-income ratio. The underlying hypothesis is that MSAs with a high fraction of subprime lenders in 1995 may have disproportionately benefited from the national developments affecting mortgage finance that occured during the subsequent mortgage credit boom. These national developments include such macro-level factors as the strong worldwide demand for high yield U.S. assets (Caballero, Farhi & Gourinchas 2008), and the loose monetary policy following the dot-com bubble. They also include nationwide mortgage market transformations, such as the shift from bank-based to market-based mortgage finance (Adrian & Shin 2010) & the emergence of a new mortgage securitization chain through "private label securitizers" which fueled the origination and securitization of nonprime and nonconventional mortgage loans (Levitin & Wachter 2010). These macro-level developments, too, are likely to be independent of MSA-specific demand shocks. We can therefore obtain an MSA-varying time-varying instrument by *interacting* the MSA-specific market share of subprime lenders in 1995, which captures the cross-sectional difference in pre-crisis prevalence of subprime activity with year dummies that capture nationwide developments.

Thus we adopt a difference-in-differences setup to predict the loan-to-income ratio in MSA j in period t. As the first stage of this instrumental variables strategy, the LTI ratio is regressed on the subprime market share in 1995 interacted with each year dummy from 1996 to 2007:

$$\text{LTI}_{j,t} = \phi_t \text{Subprime Market Share } 1995_j + \text{MSA}_j + \eta_{j,t},$$

where Subprime Market Share 1995_j is the subprime market share in 1995 in MSA j, and ϕ_t is the effect of the 1995 market structure on leverage in year t. The first stage (Table 4)

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[30]The list of mortgage lenders is provided by the US Department of Housing and Urban Development.

[31]In addition to being measured prior to the credit boom, the market share of subprime lenders in 1995 has a significant correlation with state-level regulation of mortgage brokerage activity. In granting mortgage broker licenses, states have different requirements regarding minimum levels of net worth (from 0 to $100K), a minimum surety bond (from 0 to $100K), and a minimum level of experience; more stringent regulations for mortgage brokerage licenses are negatively correlated with the subprime market share in 1995 (these regression results corresponding a "zero-stage" are available upon request).

shows that the market share of subprime lenders in 1995 is a good predictor of the growth of the leverage from 1995 to 2005. When the 1995 subprime market share goes from 0% to 100%, the LTI increases by 0.8 (in 2006).

With both the ordinary least-squares and the instrumental variables approach, our main regressions (equation 11) are estimated using weights: when the dependent variable is black isolation, the regression is weighted by the number of black students in the MSA in 1995, and similarly for other races. This gives more weight to large MSAs and less weight to very small MSAs. The rationale for the weighting is that, if the effect of credit conditions is different in small and large MSAs,[32] then our estimator of the effect of credit conditions will be the average effect of credit conditions on segregation, with weights equal to the size of the racial group in the MSA.

In all specifications, residuals are clustered at the MSA level. There are 355 MSAs overall, so the number of clusters is large; there are 13 years of observations and thus 13 points per MSA. Hence, clustering by MSA is likely to yield good estimates of standard errors (Wooldridge 2003). We also performed "multi-way" clustering (Cameron, Gelbach & Miller 2006).[33]

Finally, we check that our results are robust by replicating them while dropping extreme observations, regressing on subsets of years, or dropping MSAs one by one. We find that no particular year or MSA is driving the results.

3.4 Results

Baseline Regression

Tables 5, 6, and 7 present results of the estimation of baseline regression (11) for the segregation of black, white and Hispanic students respectively [34]. Column 1 of each table presents estimates controlling for demographics and MSA fixed effects. Column 2 introduces controls for the characteristics of demand (i.e. distribution of applicants' income) and for borrowers' creditworthiness. Column 3 introduces the acceptance rate as an additional measure of credit conditions. Column 4 instruments the median loan-to-income ratio by the market share of subprime lenders in 1995, which is arguably an exogenous predictor of increases in the LTI ratio, as described previously. In columns 1 to 4, segregation is

---

[32]We should expect the effect of credit conditions to be different across MSAs. The theory part of this paper emphasizes that the effect of credit conditions depends on households' valuations of housing, the elasticity of housing supply, relative incomes, and other parameters. We measure the average effect of credit conditions on segregation.

[33]Consistent estimation of the standard errors requires a large number of clusters with a small number of observations per cluster. Hence we do not report the results from multi-way clustering because 13 years with 355 observations per year puts us far from the asymptotics.

[34]For Asians, results are mostly small and non significant; results are available on request.

measured by the isolation index. Column 5 onward present effects of the LTI statistics on measures of racial exposure: exposure of blacks to whites (Table 5), exposure of whites to blacks and of whites to Hispanics (Table 6), and exposure of Hispanics to blacks (Table 7). Coefficients in the three tables are stable across specifications, suggesting that demographic controls and MSA fixed effects are enough to control for the confounding effects described in Section 3.2.

In the regressions, the median LTI ratio as well as the difference between the 90th percentile LTI ratio and the median LTI ratio are included as measures of credit conditions. The former measure of credit conditions measures the relaxation of the leverage constraint for the median borrower. The latter measure of credit conditions captures the increase in the most extreme LTI ratios, which arguably benefited low-income and minority applicants relatively more than high-income and white applicants.[35]

Overall, the results suggest that a relaxation of the leverage constraint increased segregation significantly for blacks and Hispanics. A increase of 1 in the median LTI increases black students' isolation by 3 percentage points (Table 5, columns 1–4). Income and creditworthiness controls render nonsignificant any effect of the difference between the 90th and the 50th percentile of the loan-to-income ratio distribution (Table 5, columns 2–4), suggesting that relaxation of the leverage constraint for the most highly leveraged borrowers was due not to a relaxation of the leverage constraint per se but rather to income shocks or to changes in applicants' creditworthiness. The overall positive impact of the median loan-to-income ratio on segregation is essentially due to the mobility of white and Hispanic households, which is confirmed by the effect of leverage constraints on racial exposure (column 5). For example, the exposure of black students to white peers declines by 6 percentage points when the LTI ratio increases by 1. Given the increase of 0.4 in the median LTI ratio by 0.4 over the 1995-2005 period, this amounts to an effect of 2.4 percentage points on the exposure of black students to whites, and an effect of 1.3 percentage points on isolation.

The effect of the median loan-to-income ratio on the isolation of whites is not significant (Table 6, columns 1–4). This lack of effect on isolation masks two underlying effects revealed by exposure measures. First, a higher median LTI ratio makes Hispanic students more likely to move to white areas: the exposure of white students to Hispanic peers increases by 1.375 when the median LTI ratio increases by 1 (Table 6, column 5). Second, a higher median LTI ratio makes whites less likely to be exposed to black students: the

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[35]Figures (c) and (d) of figure 8 show that, over the 1995-2005 period, minority applicants' loan-to-income ratios (both median and 90th percentile) was higher, and whites and minorities roughly followed parallel trends. The median loan-to-income ratio increases by around 0.4 over the 1995-2005 period, for whites, Hispanics, and blacks.

exposure of white students to black peers decreases by 0.708 when the median LTI ratio increases by 1 (Table 6, column 6).

Table 7 presents the results for Hispanic isolation. Results for Hispanic students are of special importance because of the role played by the increase in Hispanic population in reducing white and black isolation. The question here is whether this decline in the isolation of other racial groups would have been *larger* had credit supply not been easier over the period of the boom. This is what the results of Table 7 suggest. An increase in the 'fat tail' of the distribution of loan-to-income ratios increases the isolation of Hispanics: when the 90th percentile of the loan-to-income ratio increases by 1, the isolation of Hispanic students increases from 2.5 (column 1) to 2.9 (column 3). This is due in part to the mobility of Hispanic households, since minority households benefit relatively more than white households from the highest leverages: An increase in the 90th percentile LTI by 1 lowers the exposure of Hispanic households by 0.85.

In sum: leverage significantly increases the segregation of blacks (through a lower exposure to whites) increases the exposure of whites to Hispanics, lowers the exposure of Hispanics to blacks, and increases the segregation of Hispanics.

Effects of leverage by elasticity

Metropolitan areas differ significantly in their restrictions on land use and in their geographical constraints on the supply of housing. Those MSAs with an elastic supply of housing (i.e., where the supply of housing expands when the price of housing rises), may see a greater effect of credit conditions on segregation. This is because, as described in scenario 2 of Section 2.5, a greater expansion in the supply of housing may make it easier for households to segregate.

Table 8 presents results of baseline specification (11) augmented with the interaction of the median (and of the P90–P50 difference in LTI ratio) with metropolitan area elasticity. As in column 4 of the previous tables, regressions control for demographics, income, and creditworthiness measures in addition to MSA and year fixed effects. Table 8 reports uninstrumented results because the instrumental variable estimates yielded similar results as the non-instrumented regression.

These results support the theoretical scenario of Section (2.5), where the effect of relaxing the leverage constraint on the isolation of minorities is *stronger in highly elastic metropolitan areas.* The role of housing elasticity is specially relevant for Hispanics, whose population increased sharply during the period. An increase of 1 in the median loan-to-income ratio does not have a significant impact on low-elasticity metropolitan areas, but an identical increase in the LTI ratio increases Hispanic isolation by 1.4 percentage

points in MSAs with median elasticity (2.55). The effect of the median LTI ratio is also stronger in highly elastic metropolitan areas. An increase of 1 in the difference between the 90th percentile and the 50th percentile LTI ratio increases Hispanic isolation by 1.7 ($= 0.282 + 0.559 \cdot 2.55$) in a metropolitan area with the median elasticity of 2.55, and by 2.9 percentage points in a metropolitan area with the 90th percentile elasticity of 4.6.

Finally, one potential concern is that MSAs with lower elasticities experienced higher increases in house prices, which could make it impossible to identify the effect of elasticity separately from the effect of rising prices. However, additional results (available from the authors) suggest that controlling for an estimate of the housing price index does not change the coefficients of interest.[36]

Between school district segregation

In contrast to the literature emphasizing the effect of desegregation policies, this paper focuses on how market driven forces – the relaxation of leverage constraints in mortgage credit markets – affect segregation. In general, desegregation policies can act within the boundaries of school districts but do not operate across school district boundaries.[37] As a consequence, and in order to better isolate the mortgage credit channel, we look at whether relaxing the leverage constraint can affect segregation *across school districts*.

In each metropolitan statistical area, we calculate between-school district segregation using the "between-school district isolation index." The isolation so calculated for white students is the average fraction of white peers in the school district:

$$\text{Between-School District Isolation}_j(whites) = \sum_{k=1}^{K_j} \frac{whites_{k,j}}{whites_j} \cdot \frac{whites_{k,j}}{students_{k,j}},$$

where $k = 1, 2, \ldots, K_j$ indexes school districts in MSA j, $whites_{k,j}$ is the number of white students in school district k in MSA j, $students_{k,j}$ is the total number of students in school district k in MSA j, and $whites_j$ is the total number of white students in MSA j.

Segregation between school districts has broadly declined over the period. The between-school district isolation of whites declined from 77.1% to 70.9%, and that of blacks from 44.7% to 42.6%; the between-school district isolation of Hispanics stayed constant at 47.8%.

To estimate the effect of credit standards on between school district segregation, we estimate specification (11) using the between-school district segregation measures as dependent variables. The results are presented in Table 9.

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[36] We used the Office of Federal Enterprise Oversight annual house price index.

[37] Since *Milliken v. Bradley*, in 1974, court-ordered desegregation plans are constrained by school district boundaries.

An increase of 1 in the median loan-to-income ratio increases the between-school district isolation of blacks by 2.5 percentage points (Table 9, column 1), which is similar to the result of the main table for blacks (Table 5, column 3). Thus, for blacks, an increase in isolation due to increased leverage is mostly the result of a change in between-school district isolation. In Table 9, column 2 shows that a higher median LTI ratio lowers the between-school district exposure of blacks to whites. (The between-school district exposure of black students to white students is the average fraction of white students in the school district for an average black student.) This fully explains why the between-school district isolation of blacks increases when the median LTI ratio increases: the coefficients on black isolation (column 1) and exposure (column 2) are close and of opposite signs.

Column 6 shows that a higher 50th percentile (median) LTI ratio increases the between-school district isolation of Hispanics (+1.5), but not a higher 90th percentile LTI ratio as in the previous results, which mixed between-school and within-school districts. Easier credit access, as measured by median leverage, helps Hispanic households move into predominantly Hispanic school districs.

Overall, these results explain how more relaxed credit constraints favor household mobility accross school districts and result in higher segregation – a channel markedly different from the within-school district effect of desegregation plans.

Counterfactual analysis: segregation trends without the credit boom

The preceding discussion shows that increases in both the median and the 90th percentile LTI ratio increases the segregation of Hispanics and blacks. Other determinants of segregation include the other measures of credit conditions (applicants' creditworthiness measures, described in Section (3.3)) as well as shocks to applicants' incomes, demographics, MSA fixed effects, and unobservables.

As a final empirical exercise, we compute the counterfactual isolation of blacks by subtracting the effect of the change in the median loan-to-income ratio on isolation from the actual change in isolation. We use the point estimate of the effect of the median LTI ratio on isolation while controlling for MSA fixed effects, demographic controls, income and creditworthiness measures, and year dummies. The effect is 3.265 for blacks, with a standard error of 1.202 (Table 5, column 3). Hence, for blacks,

$$\text{Counterfactual Isolation}_t = \text{Counterfactual Isolation}_{t-1} + \Delta\text{Isolation}_t$$
$$-3.265 \cdot \Delta\text{Median LTI}_t,$$

In 1995, the counterfactual isolation is defined as the actual isolation. In this equation, $\Delta\text{Isolation}_t = \text{Isolation}_t - \text{Isolation}_{t-1}$ and $\Delta\text{Median LTI}_t = \text{Median LTI}_t - \text{Median LTI}_{t-1}$.

For Hispanics, the 90th percentile of the LTI ratio has the most impact on isolation (Table 7, columns 1–4). Hence, to compute the counterfactual isolation of Hispanics, we replace the P50 LTI by the P90 LTI and replace the effect 3.265 by the effect using the same specification: 2.074 with a standard error of 1.146 (Table 7, column 4, second line).[38]

The bold lines in Figure 9 show the actual isolation of black and Hispanic students from 1995 to 2007, as in the upper part of Table 2. What is novel in this figure is the dashed lines showing the counterfactual isolation of Hispanic and black students.

The upper graph of figure 9 plots the isolation and the counterfactual isolation of blacks. Factors other than the leverage make black isolation to fall by 2.9 percentage points. During the same period, the median loan-to-income ratio increased by 0.4. Without this increase in the LTI ratio, the isolation of blacks would have been between 0.4 and 2.7 percentage points lower than it was in 2007 — provided our identification strategy and confidence intervals are correct.

The lower part of Figure 9 plots a similar graph for Hispanic students. Factors other than the loan-to-income ratio caused isolation to increase by 2.6 percentage points from 1995 to 2007. Over this period, the 90th percentile of the LTI ratio increased by 1 (from 2.96 to 3.96), and the difference between the 90th and the 50th percentile LTI increased by 1.6. The effect of the P90–P50 difference is 2.866 in the regression of column 3 (Table 7), and Hispanic isolation would have been between 1 and 1.3 percentage points lower without the relaxation of the leverage constraint (using the 90% confidence intervals of the instrumental variables estimate). This is again conditional on a correct identification and inference strategy.

In short, this counterfactual analysis illustrates how changes in leverage constraints significantly alter segregation dynamics: mitigating the downward trend in segregation for blacks and amplifying the upward trend for Hispanics.

4   Conclusion

The increased availability of mortgage credit — fueled by financial sophistication, banking deregulation, and lenders' supply of credit — dramatically affected lending standards during the credit boom. The mortgage credit market appears to be a powerful driving force of segregation, mainly through its effect on leverage, which affects racial groups' ability to outbid each other for housing in desirable neighborhoods. Greater leverage increases

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[38]In the instrumental variables (IV) regression, the point estimate is 2.074 with a standard error of 1.146, which is significant at 10%. Because in most specifications we could not reject the hypothesis that the estimates of column 3 and the IV estimate of column 4 are equal, we report here the estimate of column 3. For Hispanics, with the IV estimate, the 95% bounds are wider with the IV estimate; for blacks, the effect is stronger with the IV estimate. This means that the estimate in column 3 is conservative.

the isolation of blacks and Hispanics across schools and neighborhoods. This means that segregation declined at a slower pace than would have occured solely from the inflow of Hispanic migrants and other factors.

Viewed through the lens of a neigborhood choice model augmented with leverage constraints, these empirical results offer indirect evidence that households' valuations of neighborhoods differed enough across races for the general equilibrium effects to outweigh leverage effects. These results have important implications for any type of policy designed to foster cheaper access to credit as a means of increasing the welfare of the poor and minorities. Rajan (2010) discusses how the political response to increasing income inequality led to such policies, which boosted the supply of mortgage credit, and, in turn, had the unintended consequence of unleashing an unfettered credit boom that played a major role in the financial crisis of 2008-2009. Our findings underscore another set of unintended consequences which materialize *before* the financial crisis: while the relaxation of credit standards increased home ownership for the poor and for minorities, it significantly aggravated racial segregation.

Research has shown that segregation has negative impacts on households with low human capital (Cutler, Glaeser & Vigdor 2007), which are arguably the most credit-constrained households. Segregation increases black–white test score gaps (Card & Rothstein 2007), and leads to higher crime rates (Weiner, Lutz & Ludwig 2009), and analysis of school desegregation after *Brown v. Board of Education* (1954) shows that segregation explains part of the racial achievement gap (Hanushek, Kain & Rivkin 2009, Rivkin & Welch 2006). Hence this paper suggests that, during the credit boom, the welfare of low human capital households was negatively affected by the relaxation of lending standards — even prior to accounting for the welfare costs of the financial crisis.

Future research may allow the inclusion of households' sensitivity to credit constraints in structural models that use transaction-level micro data with detailed measures of creditworthiness and neighborhoods to estimate households' preferences.

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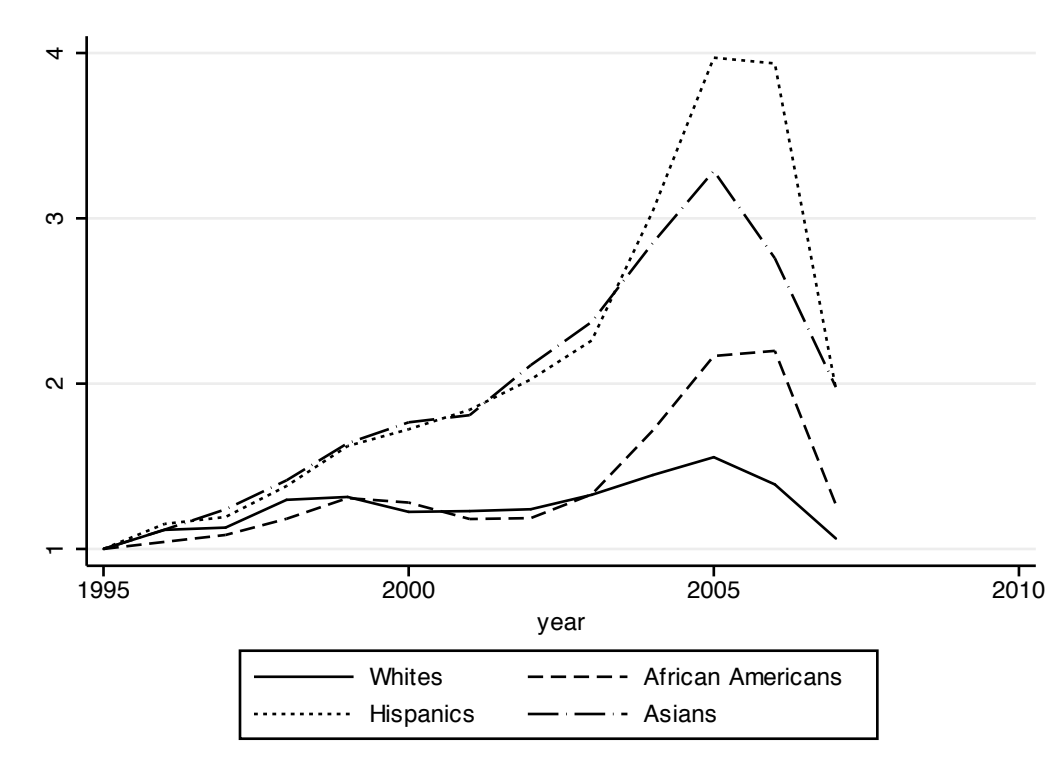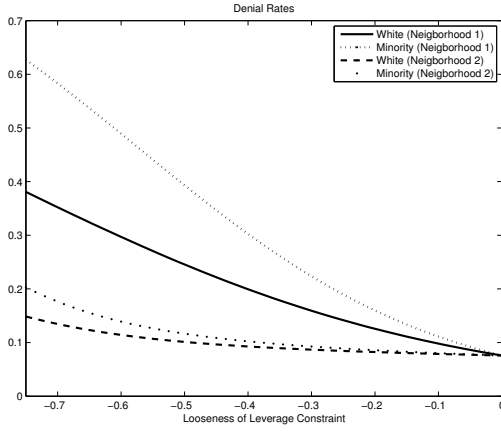
Notes: By race, volume is normalized to 1 in 1995. All racial groups are non-Hispanic members of those races. Hispanics are shown as a separate category.
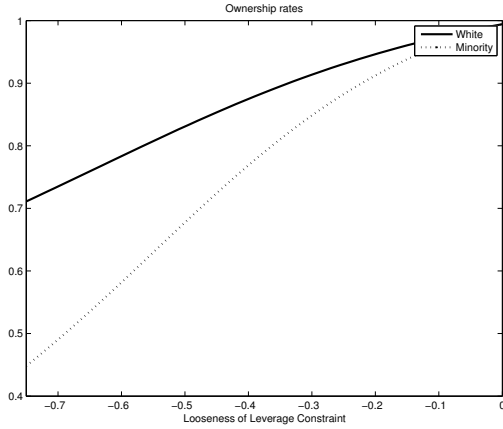Source: Home Mortgage Disclosure Act data, 1995 to 2007.

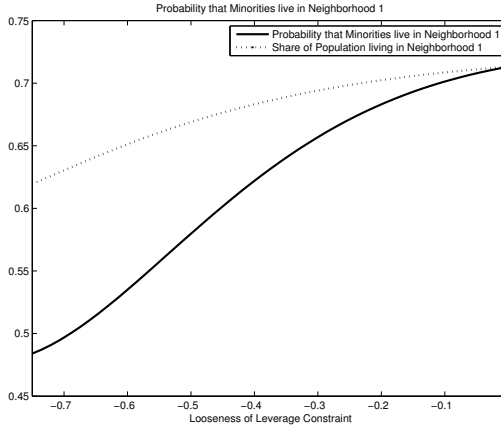Figure 1: Volume of Mortgage Originations
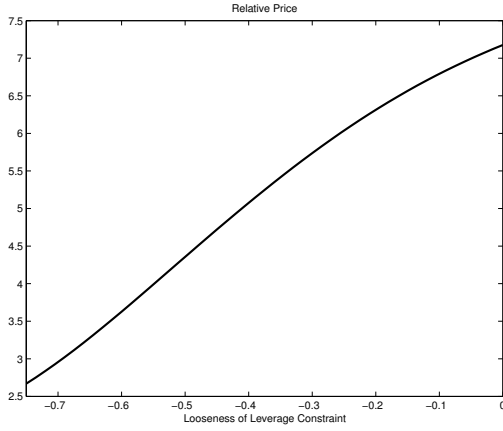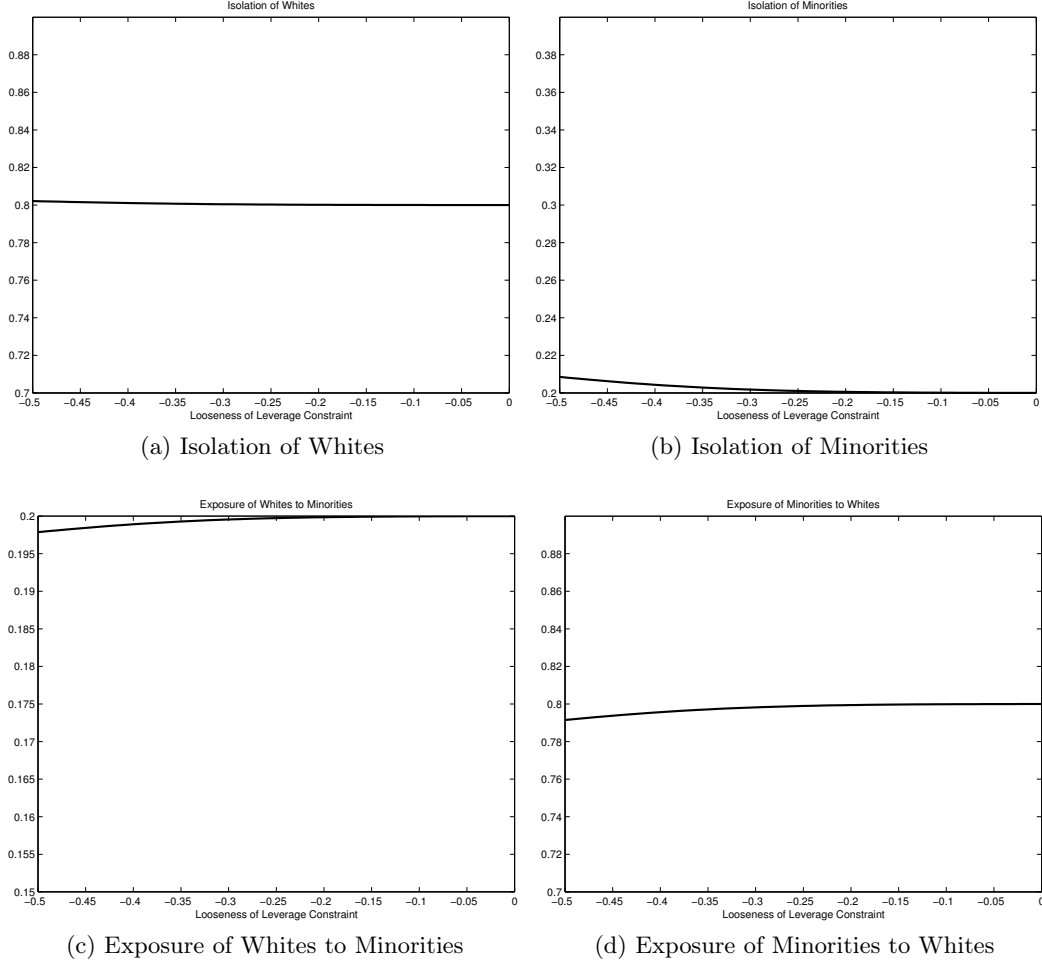
(a) Relative Price

(b) Denial Rate

(c) Home Ownership

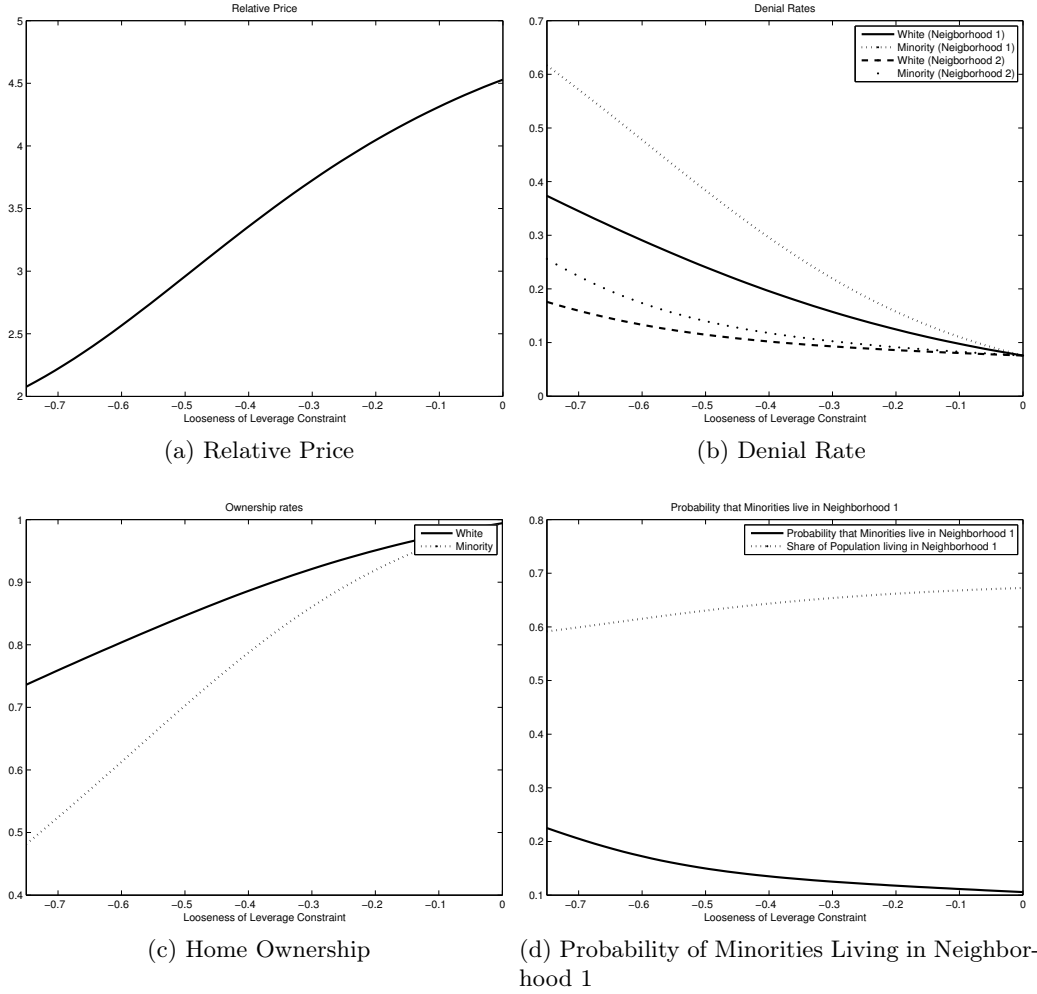(d) Probability of Minorities Living in Neighborhood 1

Note: The looseness of the leverage constraint is the parameter β in the acceptance/rejection decision.

Figure 2: Scenario 1

(a) Isolation of Whites

(b) Isolation of Minorities

(c) Exposure of Whites to Minorities

(d) Exposure of Minorities to Whites

Note: The looseness of the leverage constraint is the parameter β in the acceptance/rejection decision. For definitions of isolation and exposure, see Section 2.3, equations (5) and (6).

Figure 3: Scenario 1 — Segregation and Credit Constraints

(a) Relative Price

(b) Denial Rate

(c) Home Ownership

(d) Probability of Minorities Living in Neighborhood 1

Note: The looseness of the leverage constraint is the parameter β in the acceptance/rejection decision.

Figure 4: Scenario 2

(a) Isolation of Whites

(b) Isolation of Minorities

(c) Exposure of Whites to Minorities
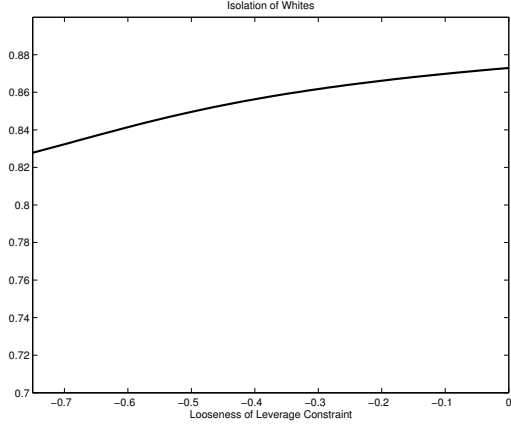
(d) Exposure of Minorities to Whites

Note: The looseness of the leverage constraint is the parameter β in the acceptance/rejection decision. For definitions of isolation and exposure, see section 2.3, equations 5 and 6.

Figure 5: Scenario 2 — Segregation and Credit Constraints
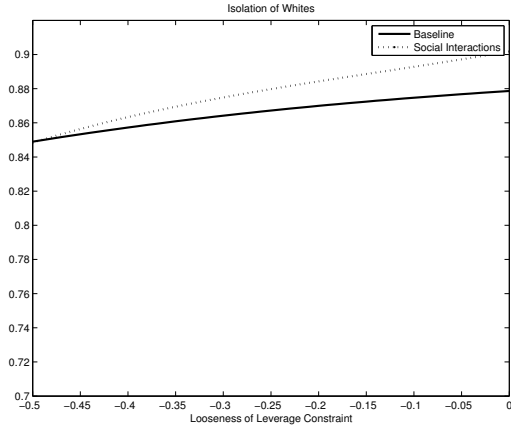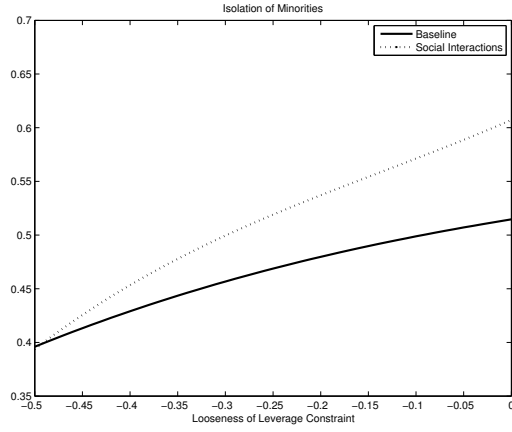
39
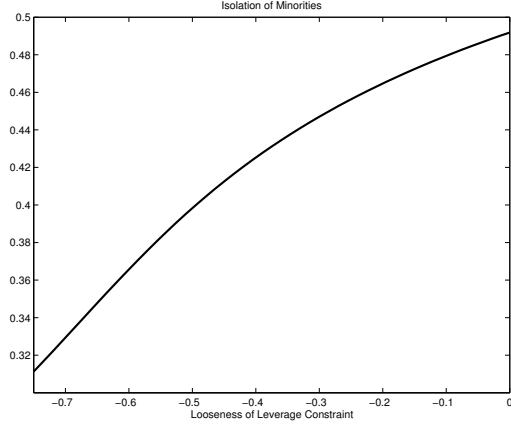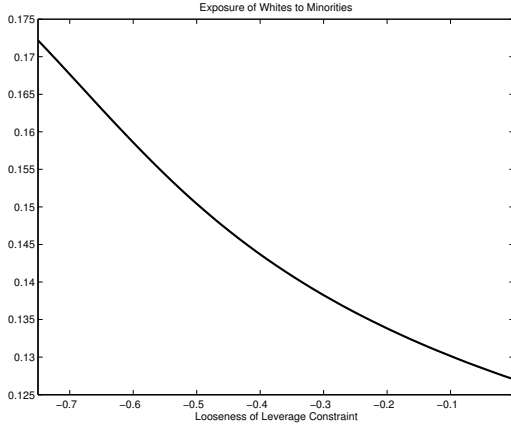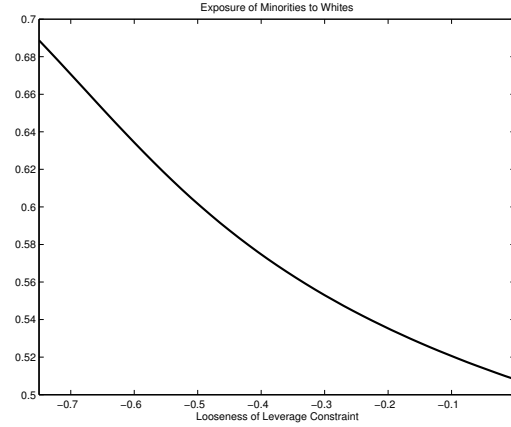
(a) Isolation of Whites

(b) Isolation of Minorities
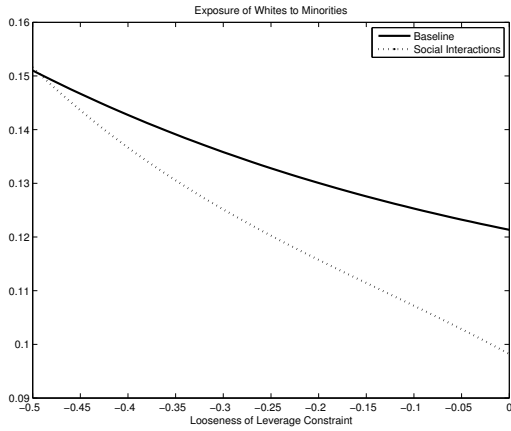
(c) Exposure of Whites to Minorities
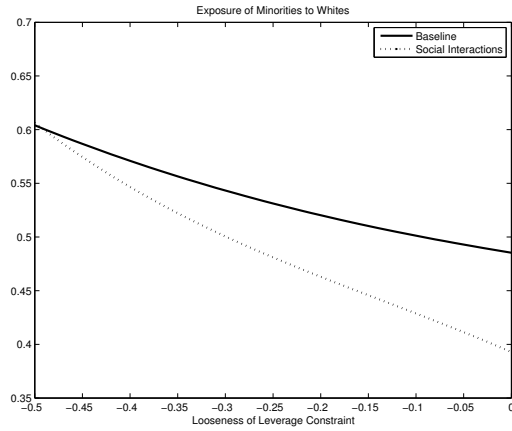
(d) Exposure of Minorities to Whites

Figure 6: The Role of Social Interactions
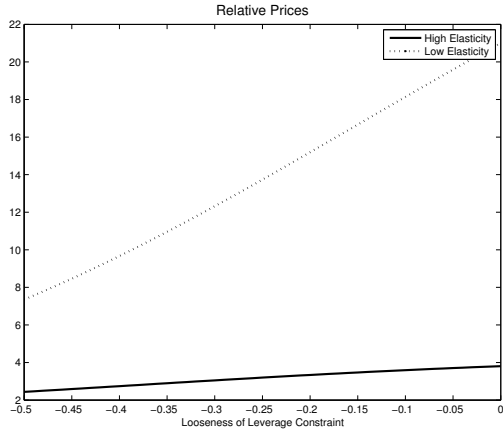
(a) Relative Prices
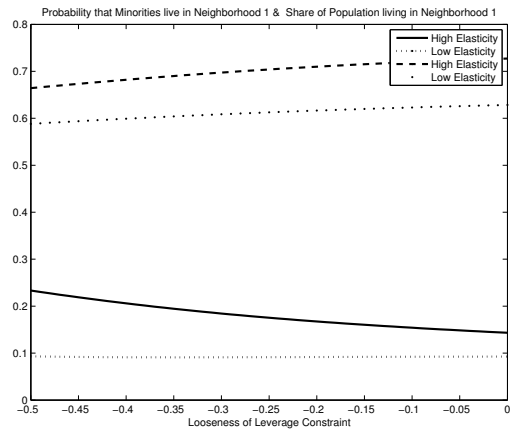
(b) Probability of Living in Neighborhood 1
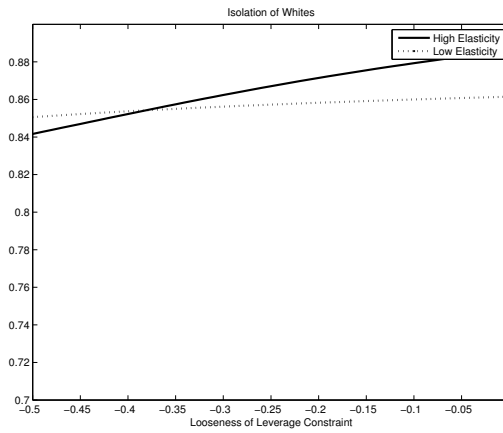
(c) Isolation of Whites
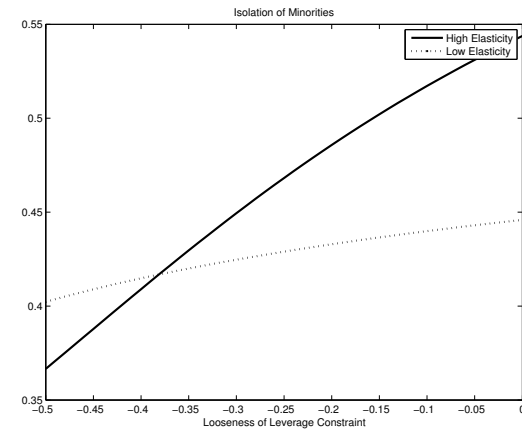
(d) Isolation of Minorities

Figure 7: The Role of Elasticity

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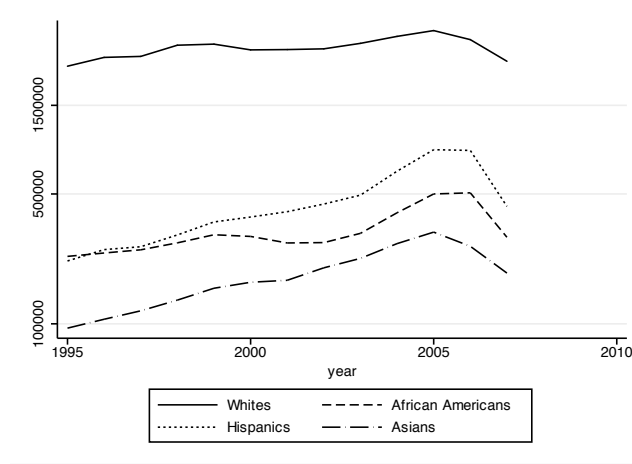
(a) Originations, Log Scale
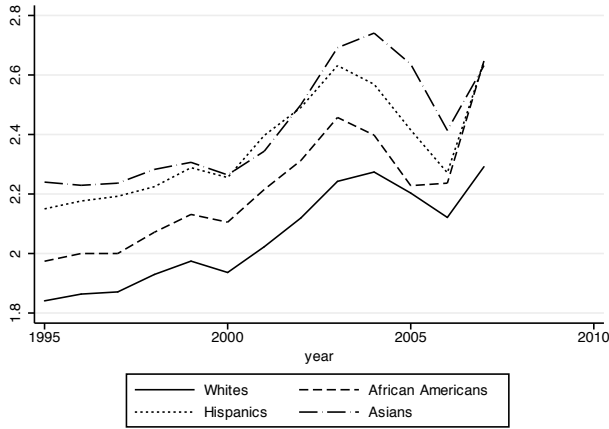
(b) Median LTI Ratio

(c) 90th Percentile LTI Ratio

(d) Acceptance Rate

(e) Acceptance Rate for LTI above 3.5

Note: All racial groups are non-Hispanic members of those races. Hispanics are shown as a separate category. LTI: Loan-to-income ratio.
Source: Home Mortgage Disclosure Act data, 1995 to 2007.

Figure 8: Credit Standards by Race

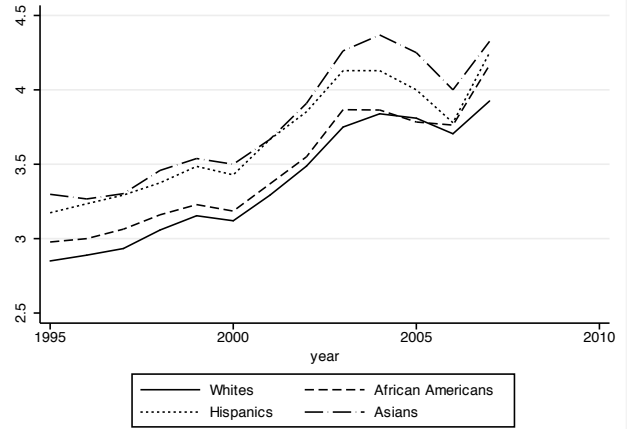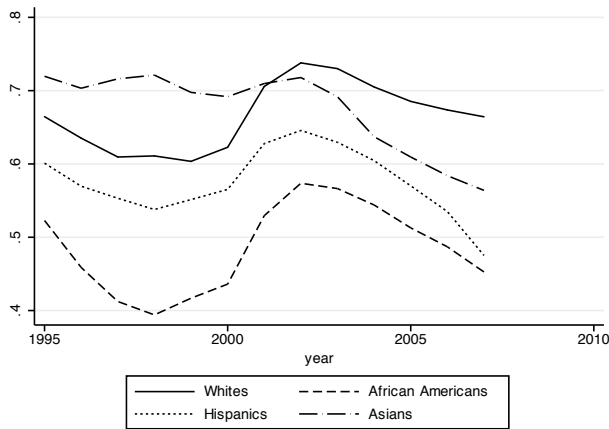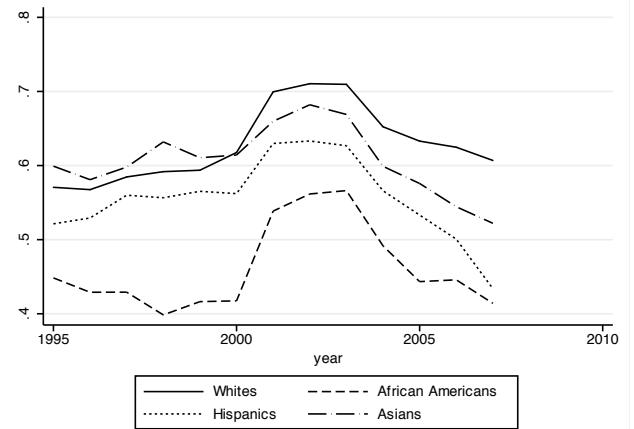|	(1)	(2)	(3)	(4)
		Fraction in Census Tract:		
	White	African American	Hispanic	Asian
Fraction in Closest School	0.506**	0.508**	0.299**	0.368**
	(0.019)	(0.015)	(0.019)	(0.021)
Fraction in 2nd Closest School	0.203**	0.273**	0.258**	0.163**
	(0.020)	(0.019)	(0.022)	(0.022)
Fraction in 3rd Closest School	0.144**	0.160**	0.125**	0.172**
	(0.021)	(0.018)	(0.021)	(0.022)
Fraction in 4th Closest School	0.146**	0.116**	0.066**	0.118**
	(0.020)	(0.016)	(0.023)	(0.021)
Fraction in 5th Closest School	0.021	0.047**	0.078**	0.075**
	(0.020)	(0.016)	(0.022)	(0.021)
Fraction in 6th Closest School	-0.011	0.041*	0.022	0.118**
	(0.021)	(0.016)	(0.022)	(0.022)
Fraction in 7th Closest School	-0.012	0.026	0.021	0.062**
	(0.021)	(0.016)	(0.022)	(0.022)
Fraction in 8th Closest School	0.022	-0.004	-0.022	0.040+
	(0.021)	(0.015)	(0.021)	(0.022)
Fraction in 9th Closest School	-0.133**	-0.107**	-0.111**	-0.004
	(0.020)	(0.015)	(0.020)	(0.022)
Fraction in 10th Closest School	-0.138**	-0.066**	-0.019	0.013
	(0.020)	(0.015)	(0.020)	(0.021)
Fraction in Closest School $\times$ Distance	-0.032**	-0.036**	-0.015+	-0.043**
	(0.004)	(0.004)	(0.007)	(0.010)
Fraction in 2nd Closest School $\times$ Distance	-0.007*	-0.016**	-0.013+	-0.001
	(0.003)	(0.004)	(0.007)	(0.007)
Fraction in 3rd Closest School $\times$ Distance	-0.011**	-0.016**	0.000	-0.010
	(0.003)	(0.004)	(0.005)	(0.005)
Fraction in 4th Closest School $\times$ Distance	-0.007**	-0.008**	0.007	-0.009+
	(0.002)	(0.003)	(0.005)	(0.005)
Fraction in 5th Closest School $\times$ Distance	-0.003	-0.004+	-0.002	-0.011*
	(0.002)	(0.003)	(0.004)	(0.004)
Fraction in 6th Closest School $\times$ Distance	0.001	-0.002	0.002	-0.011**
	(0.002)	(0.002)	(0.004)	(0.004)
Fraction in 7th Closest School $\times$ Distance	0.002	-0.001	0.006+	-0.007+
	(0.002)	(0.002)	(0.004)	(0.004)
Fraction in 8th Closest School $\times$ Distance	-0.001	0.001	0.002	-0.003
	(0.002)	(0.002)	(0.003)	(0.004)
Fraction in 9th Closest School $\times$ Distance	0.010**	0.008**	0.009**	0.003
	(0.002)	(0.002)	(0.003)	(0.003)
Fraction in 10th Closest School $\times$ Distance	0.008**	0.003*	0.003	0.005
	(0.002)	(0.002)	(0.003)	(0.003)
Observations	4,661	4,661	4,661	4,661
R-squared	0.597	0.597	0.557	0.514

Robust standard errors in parentheses

** $p<0.01$, * $p<0.05$, + $p<0.1$

The dependent variable is the fraction black in each census tract. Controls include the distance with each school, dummies for schools further than 15 miles and 30 miles from the census tract. Source: Common Core of Data 2000, Public School Universe, matched with Census 2000.

Reading: An increase in the fraction of black students in the nearest school by 10 percentage points predicts a 4 percentage point increase in the fraction black in the census tract.

Table 1: Predicting Census Tract Composition with School Composition

Year	1995	1997	1999	2001	2003	2005	2007
Isolation							
Isolation of Whites	80.3	79.8	79.2	78.2	76.8	75.6	74.2
Isolation of Blacks	51.9	50.5	50.8	50.4	50.2	50.1	49.0
Isolation of Hispanics	48.4	48.7	48.9	48.9	49.5	49.5	51.0
Isolation of Asians	21.1	21.7	21.9	21.3	21.5	21.6	22.1
Between School District Isolation							
Between LEA Isolation of Whites	77.8	77.4	76.7	75.5	74.0	72.7	71.1
Between LEA Isolation of Blacks	44.8	43.2	42.4	42.9	43.1	43.9	43.1
Between LEA Isolation of Hispanics	42.4	43.0	43.1	43.4	44.2	45.0	45.4
Between LEA Isolation of Asians	18.2	18.7	18.8	18.3	18.3	18.8	18.9
Exposure							
Exposure of Whites to Hispanics	6.6	6.9	7.6	8.2	8.9	9.4	10.3
Exposure of Hispanics to Whites	32.4	32.0	31.6	31.6	30.6	30.0	28.8
Exposure of Whites to Blacks	9.0	9.0	8.7	8.9	9.2	9.5	9.7
Exposure of Blacks to Whites	34.7	35.0	33.5	33.1	32.3	31.4	30.7
Exposure of Blacks to Hispanics	9.6	10.4	11.4	12.1	13.0	13.8	15.0
Exposure of Hispanics to Blacks	12.2	12.2	12.3	12.5	12.8	13.3	13.2
Fraction in Public Schools							
Overall	93.1	93.2	92.8	93.2	93.6	93.9	94.1
For Whites	90.9	90.8	90.1	90.6	90.9	91.1	91.3
For Blacks	97.2	97.1	96.8	96.9	97.0	97.1	97.0
For Hispanics	97.4	97.6	97.6	97.7	97.9	97.9	98.0
For Asians	94.1	94.4	94.4	93.9	94.7	96.0	95.0

Source: Public and Private School Universe, K12 schools.

Table 2: School Segregation in Metropolitan Statistical Areas, 1995-2007

Variables	Δ Isolation Hispanics	Δ Isolation Blacks	ΔLTI	Δlog(price)	ΔAcceptance Rate	Δ Income P50	ΔJumbo	Past Due	Inflow Hispanics	Supply Elasticity
Δ Isolation Hispanics	1.000									
Δ Isolation Blacks	-0.165	1.000								
	(0.000)									
Δ LTI	-0.220	0.082	1.000							
	(0.000)	(0.035)								
Δlog(price)	0.219	-0.191	-0.225	1.000						
	(0.002)	(0.007)	(0.001)							
ΔAcceptance Rate	-0.160	0.062	0.462	-0.331	1.000					
	(0.000)	(0.111)	(0.000)	(0.000)						
Δ Income P50	0.266	-0.180	-0.266	0.829	-0.120	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)					
Δ Jumbo	0.183	-0.142	-0.288	0.735	-0.215	0.756	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
Past Due	-0.179	0.033	0.467	-0.464	0.261	-0.325	-0.317	1.000		
	(0.000)	(0.402)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
Inflow Hispanics	0.116	0.134	0.168	-0.273	0.244	-0.208	-0.150	0.168	1.000	
	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Supply Elasticity	-0.120	0.161	0.257	-0.446	0.232	-0.372	-0.266	0.176	0.100	1.000
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)	
Subprime Share in 1995	-0.065	-0.017	0.420	-0.309	0.793	0.081	-0.065	0.336	0.287	0.160
	(0.094)	(0.670)	(0.000)	(0.000)	(0.000)	(0.025)	(0.070)	(0.000)	(0.000)	(0.000)

Table 3: Correlation Table

VARIABLES	(1) Median LTI Ratio
1995 Subprime Lenders' Market Share × Year = 1996	0.292** (0.033)
1995 Subprime Lenders' Market Share × Year = 1997	0.364** (0.033)
1995 Subprime Lenders' Market Share × Year = 1998	0.426** (0.035)
1995 Subprime Lenders' Market Share × Year = 1999	0.458** (0.034)
1995 Subprime Lenders' Market Share × Year = 2000	0.467** (0.035)
1995 Subprime Lenders' Market Share × Year = 2001	0.468** (0.036)
1995 Subprime Lenders' Market Share × Year = 2002	0.456** (0.037)
1995 Subprime Lenders' Market Share × Year = 2003	0.477** (0.037)
1995 Subprime Lenders' Market Share × Year = 2004	0.564** (0.038)
1995 Subprime Lenders' Market Share × Year = 2005	0.645** (0.041)
1995 Subprime Lenders' Market Share × Year = 2006	0.793** (0.048)
1995 Subprime Lenders' Market Share × Year = 2007	0.718** (0.045)
Observations	12,207
Number of msa	939
R-squared	0.652
Year Dummies	yes
MSA Fixed Effects	yes
F Statistic	373.1

Robust standard errors in parentheses
** $p<0.01$, * $p<0.05$, + $p<0.1$

Clustered at the MSA level. The subprime market share is the share of the market from banks that specialize in subprime mortgages. HUD identified subprime lenders looking at the structure of their mortgage supply: (i) subprime mortgages are less likely to be securitized by the Fannie Mae and Freddie Mac (ii) subprime lenders tend to have much lower acceptance rates (iii) home refinance loans generally account for higher shares of subprime lenders' total originations than prime lenders' originations.

Table 4: Effect of 1995 Market Structure on Later Leverage

VARIABLES	(1) Isolation	(2) Isolation	(3) Isolation	(4) Isolation	(5) Exposure to White
Median LTI Ratio	3.042*	3.205**	3.265**	7.546**	-6.608*
	(1.304)	(1.204)	(1.153)	(2.508)	(2.653)
P90-P50 LTI Ratio	2.745+	0.119	0.400		
	(1.590)	(1.561)	(1.486)		
Acceptance rate			0.119*		
			(0.047)		
Observations	4,604	4,552	4,552	4,552	4,552
R-squared	0.532	0.582	0.591	0.473	0.632
Demographics Controls	yes	yes	yes	yes	yes
Demand Controls	no	yes	yes	yes	yes
Instrument	no	no	no	yes	yes
F Statistic	43.02	43.40	39.92	25.18	44.20

Robust standard errors in parentheses
** $p<0.01$, * $p<0.05$, + $p<0.1$

Controls include MSA fixed effects, racial demographics of the MSA (that capture MSA-specific demographic trends), year dummies, measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. MSA: Metropolitan Statistical Area. Acceptance rate is from 0 to 100%. Clustered by MSA.
Reading: If the median LTI ratio increases from 2 to 3, the isolation of black students increases by 1.1 percentage points. If the acceptance rate to Hispanics increases by 10 percentage points, the isolation of Hispanic students increases by 0.2 percentage points.

Table 5: Credit Standards and Segregation - Segregation of black Students

VARIABLES	(1) Isolation	(2) Isolation	(3) Isolation	(4) Isolation	(5) Exposure to Hispanics	(6) Exposure to Blacks
Median LTI Ratio	0.208	0.559	0.571	0.370	1.375**	-0.708+
	(0.361)	(0.404)	(0.409)	(0.513)	(0.293)	(0.375)
P90-P50 LTI Ratio	0.319	-0.104	-0.085			
	(0.440)	(0.412)	(0.403)			
Acceptance rate			0.006			
			(0.011)			
Observations	4,604	4,552	4,552	4,552	4,552	4,552
R-squared	0.894	0.898	0.898	0.896	0.933	0.407
Demographics Controls	yes	yes	yes	yes	yes	yes
Demand Controls	no	yes	yes	yes	yes	yes
F Statistic	154.6	195.7	188.3	170.3	293.2	15.38
Instrument	no	no	no	yes	yes	yes

Robust standard errors in parentheses

** $p<0.01$, * $p<0.05$, + $p<0.1$

Regressions include MSA fixed effects and year dummies. Demographic Controls: Fraction of Hispanic, black white, and Asian students in the MSA. Demand controls: Measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. P90-P50: Difference between the 90th percentile loan-to-income ratio and the median loan-to-income ratio. MSA: Metropolitan Statistical Area. Acceptance rate is from 0 to 100%. Standard errors clustered by MSA. Regressions are weighted by the number of black students in the MSA.
In column 4, the instrument is the 1995 subprime market share in the MSA, interacted with year dummies from 1996 to 2007. The first stage is presented in table 4.
Reading (column 3): If the median LTI ratio in an MSA increases from 2 to 3, the isolation of black students increases by 3.265 percentage points.

Table 6: Credit Standards and Segregation - Segregation of white Students

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Isolation	Isolation	Isolation	Isolation	Exposure to Blacks
Median LTI Ratio	0.576	0.776	0.980	0.953	-0.132
	(0.605)	(0.667)	(0.620)	(0.726)	(0.345)
P90-P50 LTI Ratio	2.525**	2.736**	2.866**	2.074+	-0.854
	(0.924)	(0.693)	(0.630)	(1.146)	(0.828)
Acceptance rate			0.049*		
			(0.021)		
Observations	4,602	4,550	4,550	4,550	4,550
R-squared	0.832	0.847	0.848	0.835	0.415
Demographics Controls	yes	yes	yes	yes	yes
Demand Controls	no	yes	yes	yes	yes
Instrument	no	no	no	yes	yes
F Statistic	133.5	340.2	313.7	186.0	29.53

Robust standard errors in parentheses

** $p<0.01$, * $p<0.05$, + $p<0.1$

Regressions include MSA fixed effects and year dummies. Demographic Controls: Fraction of Hispanic, black white, and Asian students in the MSA. Demand controls: Measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. P90-P50: Difference between the 90th percentile loan-to-income ratio and the median loan-to-income ratio. MSA: Metropolitan Statistical Area. Acceptance rate is from 0 to 100%. Standard errors clustered by MSA. Regressions are weighted by the number of Hispanic students in the MSA.
In column 4, the instrument is the 1995 subprime market share in the MSA, interacted with year dummies from 1996 to 2007. The first stage is presented in table 4.
Reading (column 3): If the difference between the 90th percentile LTI ratio and the median LTI ratio in an MSA increases from 1 to 2, the isolation of Hispanic students increases by 2.074 percentage points.

Table 7: Credit Standards and Segregation - Segregation of Hispanic Students

VARIABLES	(1) Isolation of Blacks	(2) Isolation of Whites	(3) Isolation of Hispanics
Median LTI Ratio	2.620*	0.300	0.282
	(1.044)	(0.320)	(0.487)
P90-P50 LTI Ratio	0.996	0.181	1.829**
	(1.304)	(0.389)	(0.566)
Median LTI Ratio × Elasticity	-0.004	0.071	0.559*
	(0.472)	(0.183)	(0.278)
P90-P50 LTI Ratio × Elasticity	1.329	-0.215	0.699
	(0.844)	(0.269)	(0.496)
Acceptance rate	0.112*	0.003	0.036+
	(0.044)	(0.011)	(0.021)
Observations	4,614	4,614	4,612
R-squared	0.593	0.906	0.848
F Statistic	59.75	198.2	113.6

Robust standard errors in parentheses

** $p<0.01$, * $p<0.05$, + $p<0.1$

Regressions include MSA fixed effects and year dummies. Demographic Controls: Fraction of Hispanic, black white, and Asian students in the MSA. Demand controls: Measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. P90-P50: Difference between the 90th percentile loan-to-income ratio and the median loan-to-income ratio. MSA: Metropolitan Statistical Area. Acceptance rate is from 0 to 100%. Standard errors clustered by MSA. Regressions are weighted by the number of black students in the MSA.

Table 8: Credit Standards and Segregation - Elasticity Interactions

VARIABLES	(1) Isolation of Blacks	(2) Exposure of Blacks to Whites	(3) Isolation of Whites	(4) Exposure of Whites to Hispanics	(5) Exposure of Whites to Blacks	(6) Isolation of Hispanics	(7) Exposure of Hispanics to Blacks
Median LTI Ratio	2.456*	-2.314*	0.582	-0.033	-0.468	1.515*	0.109
	(0.960)	(0.966)	(0.418)	(0.146)	(0.365)	(0.667)	(0.535)
P90-P50 LTI Ratio	-0.746	0.211	-0.013	-0.015	-0.056	1.167	0.626
	(1.660)	(1.341)	(0.518)	(0.272)	(0.365)	(0.902)	(0.575)
Acceptance rate	0.019	-0.044	-0.026*	0.018**	0.011	-0.025	0.048**
	(0.035)	(0.034)	(0.012)	(0.006)	(0.008)	(0.021)	(0.018)
Observations	4,592	4,592	4,594	4,594	4,592	4,592	4,592
R-squared	0.564	0.889	0.885	0.843	0.764	0.875	0.862

Robust standard errors in parentheses

** $p<0.01$, * $p<0.05$, + $p<0.1$

Regressions include MSA fixed effects and year dummies. Demographic Controls: Fraction of Hispanic, black white, and Asian students in the MSA. Demand controls: Measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. P90-P50: Difference between the 90th percentile loan-to-income ratio and the median loan-to-income ratio. MSA: Metropolitan Statistical Area. Acceptance rate is from 0 to 100%. Standard errors clustered by MSA. Regressions are weighted by the number of black students in the MSA.

Table 9: Credit Standards and Segregation - Segregation between School Districts Across MSAs
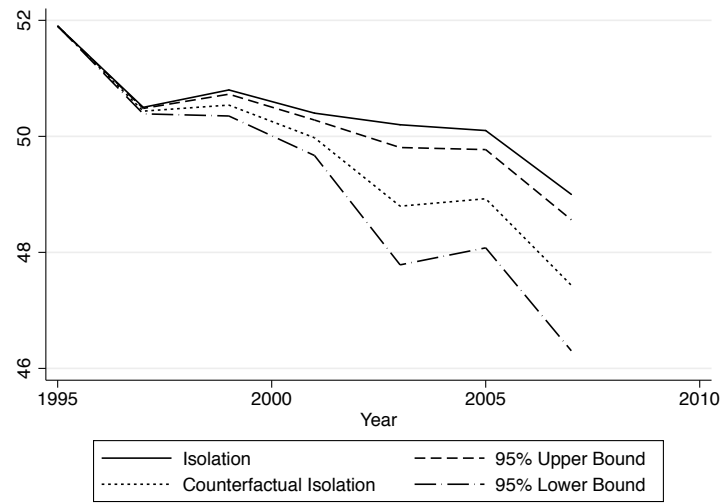
(a) Black Isolation
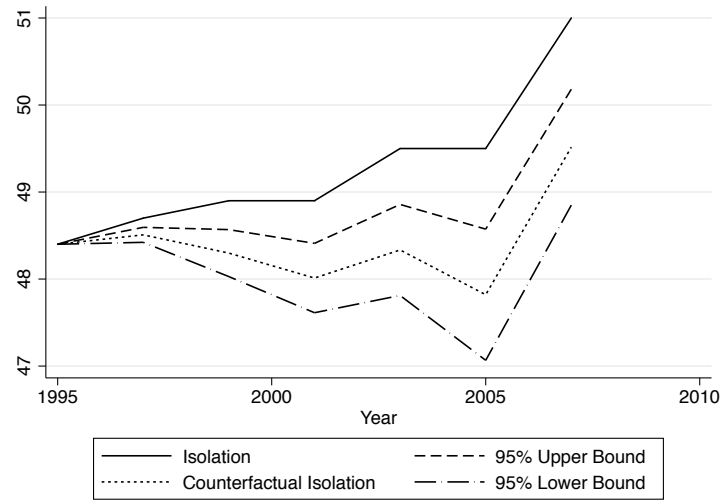
(b) Hispanic Isolation

Figure 9: Actual and Counterfactual Isolation

Appendix: Analytical Results (Section 2.4)

The City

This section proves analytical results for the model where the supply of housing is fixed at $N = 2$, and utility is linear in consumption $\gamma = 0$. There is a density $N = 2$ of consumers $i \in [0, 2]$. Each consumer is either white, $r(i) = $ white or $r(i) = $ minority. The income of consumer i is $\omega_{r(i)}$ and the utility derived from amenities in neighborhood j for consumer i is $v_{j,r(i)}$. Idiosyncratic utility for consumer i living in neighborhood j is $\varepsilon_{i,j}$.

The Equilibrium

Definition 3. The equilibrium of the city is such that:

- Consumer i get utility $V_{i,j}$ from living in neighborhood j.

$$V_{i,j} = \underbrace{\frac{1}{1-\gamma}\left(\omega_{r(i)} - \frac{1}{1+1/\rho}p_j\right)^{1-\gamma} + v_{j,r(i)}}_{U_{j,r(i)}} + \varepsilon_{i,j}$$

- Developers supply a density 1 of houses.

- Lenders supply credit to all borrowers in neighborhood 2, $\Pr(O_{i,2} = 1) = 1$, and supply credit to borrowers in neighborhood 1 with probability $\Pr(O_{i,1} = 1) = \frac{\exp(\alpha_{r(i)}+\beta p_1/\omega_{r(i)})}{1+\exp(\alpha_{r(i)}+\beta p_1/\omega_{r(i)})}$, $\beta < 0$.

- The market price in neighborhood 2 is normalized to 1.

- The market price in neighborhood 1 equates demand and supply.

$$s \Pr(J(i) = 1|r = \text{minority}; p_1 = p_1^*) \Pr(O_{i,1} = 1|r = \text{minority}; p_1 = p_1^*)$$
$$+(1-s) \Pr(J(i) = 1|r = \text{white}; p_1 = p_1^*) \Pr(O_{i,1} = 1|r = \text{white}; p_1 = p_1^*) = 1 \qquad (12)$$

Existence and uniqueness of the equilibrium

Proposition *There is at most one equilibrium of the city.*

Proof Demand for neighborhood 1 is downward sloping for both races. Indeed, let $D_r(P)$ be the demand for neighborhood 1 from race r.

$$D_r(P) = P(J(i) = 1|r; P) \cdot P(O_{i,1} = 1|r; P)$$

Because of the logit specifications of the two factors,

$$
\begin{aligned}
\frac{dD_r(P)}{dP} &= P(J(i)=1|r)\left[1-P(J(i)=1|r)\right]\frac{dU_{i,1}}{dP}P(O_{i,1}=1|r) \\
&\quad + P(J(i)=1|r)P(O_{i,1}=1|r)\frac{\beta/\omega}{1+exp(\alpha+\beta P/\omega)} \\
&= P(J(i)=1|r)P(O_{i,1}=1|r) \\
&\quad \cdot \left[\left[1-P(J(i)=1|r)\right]\frac{dU_{i,1}}{dP}+\frac{\beta/\omega}{1+exp(\alpha+\beta P/\omega)}\right]
\end{aligned}
$$

and since $dU_{i,1}/dP < 0$ and $\beta < 0$, we have proved that demand is strictly downward sloping. ☐

Proposition *There is exactly one equilibrium if and only if*

$$
s \cdot logit(v_{1,minority} - v_{2,minority}) + (1-s) \cdot logit(v_{1,white} - v_{2,white}) > 1
$$

Proof First notice that $D_r(P) \to 0$ as $P \to \infty$. The above condition guarantees that $D(0) > 1$, and that therefore there is an equilibrium. Since demand is downward sloping, the equilibrium is unique. If the condition is not satisfied, $D(0) < 1$ and there is no equilibrium. ☐

Expansion of Credit Volume

An increase in α increases the probability of origination for all applications. There is a general equilibrium effect since the market-clearing price increases when α increases.

$$
\frac{dp_1^*}{d\alpha} > 0
$$

which lowers both the relative utility of living in neighborhood 1 and the probability of origination in neighborhood 1 – through its effect on leverage.

For the sake of clarity, we will write p for p_1^* as the price of housing in neighborhood 2 is set to 1.

Response of the probability of living in neighborhood j to a change in α

Note $f_w(\alpha, p) = P(O_{i,1}=1|w)P(J(i)=1|w)$ the probability of whites living in neighborhood 1, and $f_m(\alpha, p)$ the same probability for minorities. The equilibrium condition is such that:

$$s f_m(\alpha, p) + (1 - s) f_w(\alpha, p) = 1$$

An increase in α causes the equilibrium price p to shift such that

$$s \frac{\partial f_m}{\partial \alpha} + (1 - s) \frac{\partial f_w}{\partial \alpha} + \left[s \frac{\partial f_m}{\partial p} + (1 - s) \frac{\partial f_w}{\partial p} \right] \frac{dp}{d\alpha} = 0$$

Hence

$$\frac{dp}{d\alpha} = - \frac{s \frac{\partial f_m}{\partial \alpha} + (1 - s) \frac{\partial f_w}{\partial \alpha}}{s \frac{\partial f_m}{\partial p} + (1 - s) \frac{\partial f_w}{\partial p}}$$

The probability of whites living in neighborhood 1 increases if and only if the total derivative of f_m with respect to α is positive.

$$\frac{d}{d\alpha} f_m(\alpha, p) \geq 0$$
$$\text{i.e. if } \frac{\partial f_w / \partial \alpha}{\partial f_m / \partial \alpha} \geq \frac{\partial f_w / \partial p}{\partial f_m / \partial p}$$

which intuitively corresponds to the idea that whites benefit relatively more from the expansion of credit than they are hurt by the increase in price.

Using the log-derivatives of f_w and f_m , segregation increases if and only if:

$$\beta \left(\frac{1}{\omega_m} - \frac{1}{\omega_w} \right) \geq \frac{\partial \log P(J(i) = 1 | m) / \partial p}{\partial \log P(O_{i,1} = 1 | m) / \partial \alpha} - \frac{\partial \log P(J(i) = 1 | w) / \partial p}{\partial \log P(O_{i,1} = 1 | w) / \partial \alpha} \tag{13}$$

Proposition 2 on page 13: Equal incomes, Different valuations of neighborhood 1

Whites have a relatively higher valuation for neighborhood 1, $v_{1,w} - v_{2,w} > v_{1,m} - v_{2,m}$. Incomes are equal, $\omega_w = \omega_m$, hence the probability of origination is equal for the two groups. With a bit of algebra from inequality 13, an increase in α increases segregation if and only if :

$$-\partial \log P(J(i) = 1 | m) / \partial p \geq -\partial \log P(J(i) = 1 | w) / \partial p \tag{14}$$

With Λ the c.d.f. of the logit distribution and logit the density function of the logit, notice that $P(J(i) = 1 | r) = \Lambda(\frac{1}{1+1/\rho}(1 - p_1) + v_{1,r} - v_{2,r})$, and $-\partial \log P(J(i) = 1 | r) / \partial p = \frac{1}{1+1/\rho} \text{logit}(\frac{1}{1+1/\rho}(1 - p_1) + v_{1,r} - v_{2,r}) / \Lambda(\frac{1}{1+1/\rho}(1 - p_1) + v_{1,r} - v_{2,r})$, strictly decreasing in

$v_{1,r} - v_{2,r}$. Since $v_{1,w} - v_{2,w} > v_{1,m} - v_{2,m}$, a higher α increases segregation.

Proposition 1 on page 12: Different incomes, Equal valuations of neighborhood 1

Here I assume that whites and minorities have equal relative valuations of neighborhood 1, $v_{1,w} - v_{2,w} = v_{1,m} - v_{2,m}$, but different incomes $\omega_w = \omega_m$.

In this case, $-\partial \log P(J(i) = 1|r)/\partial p = -\frac{d}{dp}\Lambda(\frac{1}{1+1/\rho}(1-p_1)+v_{1,r}-v_{2.r})$ is independent of r. Intuitively, both racial groups' utilities react equally to a change in the price p_1.

Now $\partial \log P(O_{i,1} = 1|r)/\partial \alpha = \frac{d}{d\alpha} \log \Lambda(\alpha - \beta\frac{p_1}{\omega_r}) = \text{logit}(\alpha - \beta\frac{p_1}{\omega_r})/\Lambda(\alpha - \beta\frac{p_1}{\omega_r})$ is a decreasing function of income ω_r. Hence $\partial \log P(O_{i,1} = 1|m)/\partial \alpha > \partial \log P(O_{i,1} = 1|w)/\partial \alpha$ and $1/\partial \log P(O_{i,1} = 1|w)/\partial \alpha - 1/\partial \log P(O_{i,1} = 1|m)/\partial \alpha > 0$.

Since both the left-hand side and the right-hand side of 13 are positive, the effect of an increase in α will depend on the values of the parameters, and, interestingly will depend on the relative valuation for neighborhood 1.

The relative valuation for neighborhood 1, $v_{1,r} - v_{2,r}$, affects only $-\partial \log P(J(i) = 1|r)/\partial p$. Also, $-\partial \log P(J(i) = 1|r)/\partial p$ is a decreasing function of the relative valuation $v_{1,r} - v_{2,r}$. Hence if $v_{1,r} - v_{2,r}$ is high, $-\partial \log P(J(i) = 1|r)/\partial p$ is low, and segregation will increase. The intuitive explanation is that whites, who have higher income, 'outbid' minorities for housing.

If $v_{1,r} - v_{2,r}$ is small on the other hand, $-\partial \log P(J(i) = 1|r)/\partial p$ is small, and segregation decreases when α increases. The intuitive explanation is that minorities outbid some white households for housing in neighborhood 1.

Higher Leverages

A higher β increases the probability of origination at a given price. There is a *general equilibrium effect* since the market-clearing price increases when the leverage constraint is relaxed:

$$\frac{dp_1^*}{d\beta} > 0$$

Response of the probability of living in neighborhood j to a change in β

Note $f_w(\beta, p)$ the probability of whites living in neighborhood 1, and $f_m(\beta, p)$ the same probability for minorities. The equilibrium condition is such that:

$$s f_m(\beta, p) + (1 - s) f_w(\beta, p) = 1$$

An increase in β causes the equilibrium price p to shift such that

$$\left[s\frac{\partial f_m}{\partial \beta} + (1-s)\frac{\partial f_w}{\partial \beta} \right] + \left[s\frac{\partial f_m}{\partial p} + (1-s)\frac{\partial f_w}{\partial p} \right] \frac{dp}{d\beta} = 0$$

The first term is the *leverage effect*. The second term is the *general equilibrium effect*, equal to the product of the effect of the price on demand for neighborhood 1, and of the effect of the leverage constraint on the price. Hence,

$$\frac{dp}{d\beta} = -\frac{s\frac{\partial f_m}{\partial \beta} + (1-s)\frac{\partial f_w}{\partial \beta}}{s\frac{\partial f_m}{\partial p} + (1-s)\frac{\partial f_w}{\partial p}}$$

Segregation, i.e. the probability of whites living in neighborhood 1, increases if and only if:

$$\frac{d}{d\beta}f_m(\beta, p) \geq 0$$
$$\text{i.e. if } \frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} \geq \frac{\partial f_w/\partial p}{\partial f_m/\partial p}$$

which intuitively corresponds to the idea that whites benefit relatively more from the expansion of credit than they are hurt by the increase in price.

Proposition 2 on page 13: Equal income, Different valuations of neighborhood 1

Because in this case $\frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} = 1$, the condition for an increase in segregation collapses to:

$$\frac{\partial f_w/\partial p}{\partial f_m/\partial p} \leq 1$$

which is the same as condition 14 of section 4 for a change in lending standard. Therefore the parametric conditions for an increase (decrease) of urban segregation are identical to the ones described in section 4. A less stringent constraint (β increasing) increases segregation.

Proposition 1 on page 12: Different Income, Equal valuations of neighborhood 1

We then look at the cases with equal valuation. In this case, the probability of living in neighborhood 1 is the same for both group and then

$$\frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} = \frac{1 + exp(\alpha + \beta p/\omega_m)}{1 + exp(\alpha + \beta p/\omega_w)} \frac{p/\omega_w}{p/\omega_m}$$

when β tends to zero, this expression collapses to

$$\lim_{\beta \to \mathbf{0}} \frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} = \frac{\omega_m}{\omega_w} < 1$$

which is less than one and

$$\lim_{\beta \to 0} \frac{\partial f_w/\partial p}{\partial f_m/\partial p} = 1$$

therefore $\frac{\partial f_w/\partial p}{\partial f_m/\partial p} > \frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta}$. An increase in β lowers segregation. Using the theorem of intermediate values, there exists a range $(\underline{\beta}, \overline{\beta})$ which includes 0, $0 \in (\underline{\beta}, \overline{\beta})$ so that segregation decreases when β increases and $\beta \in (\underline{\beta}, \overline{\beta})$, i.e. when the leverage constraint is relaxed.

Appendix, Not for publication

Public and Private Schools

Finally, we look at the effect of credit conditions on sorting between private and public schools. We add data from the Private School Universe, which is only available every other year from 1995 to 2007. Table 2 shows that there has been little change in the fraction of students across public and private schools in the US over the period, for any racial group. Table 10 regresses the fraction of whites in public schools, the fraction of Blacks in public schools, the fraction of Hispanics in public schools and the fraction of Asians in public schools on credit conditions. Overall there is little effect of credit conditions on public/private school sorting. This is good for the identification strategy of the main specification (Equation 11), since adding private schools to the dataset would have little impact on our conclusions.

VARIABLES	(1) Whites	(2) Blacks	(3) Hispanics	(4) Asians
Median LTI Ratio	-0.127	-0.695	-0.042	-0.699
	(0.735)	(0.791)	(0.897)	(0.969)
P90-P50 LTI Ratio	0.418	-1.390	0.892	0.768
	(1.222)	(1.636)	(1.458)	(1.997)
Acceptance rate	-0.011	0.014	0.024	0.010
	(0.015)	(0.018)	(0.023)	(0.024)
log Applications	0.356	0.471	-0.172	0.352
	(0.392)	(0.477)	(0.257)	(0.334)
Observations	2,559	2,559	2,559	2,558
R-squared	0.874	0.577	0.730	0.775

Robust standard errors in parentheses

** p<0.01, * p<0.05, + p<0.1

Table 10: Public/Private

Controls include MSA fixed effects, racial demographics of the MSA (that capture MSA-specific demographic trends), year dummies, measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. MSA: Metropolitan Statistical Area. Acceptance rate is from 0 to 100%. Clustered by MSA.