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? We 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 to 2007 mortgage credit boom on the level of urban and school segregation. Matching a national dataset 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.
1 Introduction

While the availability of mortgage credit is an important determinant of housing options for households, the link between mortgage credit market conditions, neighborhood choice, and the resulting level of urban segregation has been, so far, neglected. 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 U.S. (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 choose to 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 was multiplied five-fold during the 1995-2007 period; The number of mortgage originations to black households doubled during the same period; 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 on average 1.9 times his income, whereas in 2004 the average homeowner borrowed 2.4 times his income. Because this expansion of the supply of mortgage credit did not benefit all races equally, we expect it to change the patterns of racial segregation.

Does easier access to credit and higher leverage lead to a fall racial segregation? To understand the effects of a relaxation of credit standards on racial segregation, we develop a model of neighborhood choice (Benabou 1996, Epple, Filimon & Romer 1984) where households value neighborhoods differently based on the quality of housing and the quality of 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. In our model, households need to borrow to buy a house, and their loan-to-income ratio plays a critical role in the decision of banks to originate loans. 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 affects whites’ and minorities’ ability to purchase houses in desirable neighborhoods differentially since they have different incomes and value neighborhoods differently. Segregation could go up or down depending on depending 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 minorities, and if the white-minority income gap is not too large, segregation will go up. If whites’ valuation of local

1There is, of course, extensive literature on discrimination in mortgage applications at the micro level (Munnell, Tootell, Browne & McEnaney 1996) and extensive literature on redlining, i.e. discrimination by geography at the micro level (Tootell 1996).
amenities and/or white neighbors is lower or only slightly higher than minorities’ valuation of local amenities, or if the income gap is high, looser lending standards will lead to lower segregation.

The paper then tests empirically whether a relaxation of credit standards in a typical Metropolitan Statistical Area causes an increase or a reduction 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 Common Core of Data to combine measures of segregation at annual frequency that can be geographically matched with a comprehensive annual dataset on individual mortgage origination compiled by the Federal Financial Institutions Examination Council (FFIEC) in application of the Home Mortgage Disclosure Act (HMDA).

The focus of this paper is the estimation of the causal effect of credit standards on segregation controlling for borrowers’ income shocks, racial demographics, and other drivers of demand shocks. Using controls for MSA fixed effects, MSA demographics, risk measures, and an instrumental variable strategy that relies on the initial mortgage market structure in each MSA, we show that higher loan-to-income ratios have led to an increased isolation of black students and of Hispanic students. An increase in the median loan-to-income ratio from twice borrowers’ income to three times borrowers’ income, increases the isolation of African-American students by 3 percentage points. An increase by 1 of the extreme (90th percentile) loan-to-income ratio, holding constant the median loan-to-income 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 at the juncture of two strands of the literature: the literature on mortgage credit standards and the literature on urban and school segregation. On one hand, the first literature has insisted on the role of credit supply factors in explaining the relaxation of lending standards. This finance literature has explored the consequence 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 do so first theoretically by introducing credit market frictions in neighborhood choice models and assessed their roles in shaping urban segregation and second empirically by showing how supply-driven mortgage expansion - along with lending standard relaxations - has lead 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 the 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 code with a historically high share of
subprime mortgages support the credit-supply hypothesis. According to Mian & Sufi (2009), these “subprime” zip codes experienced a fall in denial rates and in suprime-prime interest rate spread. Favara & Imbs (2010) also confirm the role of a credit-supply channel by relating the increase in loan volume, loan-to-income ratio and fall in denial rates in mortgage credit market to a policy index of inter-state 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 lead to both an increase in the supply of mortgages and a decline in lending standards.

On the segregation side, this paper builds on an extensive literature which shows how market prices reflect differences in neighborhoods’ racial composition and local public good quality. Cutler, Glaeser & Vigdor (1999) shows 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 quality, and this paper demonstrates how credit constraints affect prices and racial segregation in a residential location choice model.

Finally, a major focus of the literature so far has been active desegregation policies, such as busing (Angrist & Lang 2004), school reassignment programs (Hoxby & Weingarth 2006), or court-ordered desegregation plans (Reber 2005, Boustan 2010). In contrast with the literature, this paper focuses on 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; 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 above and beyond the effect of busing or school reassignment programs.

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.

\[\text{As we shall see in Section 3, our strategy for instrumenting mortgage credit supply builds on such findings.}\]

\[\text{Furthermore these patterns hold in zip codes with very elastic housing supply ruling out the possibility that mortgage expansion was driven by expectations of future housing price increase.}\]

\[\text{See also (Mian & Sufi 2009, Levitin & Wachter 2010)}\]
2 A model of residential choice with credit constraints.

We present here a model where 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 enough to bring 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 \( r \in \{ \text{whites, minorities} \} \). Minority racial groups represent a share \( s \) and white homeowners represent a share \( 1 - s \) of total population density \( N \).

Households

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

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

where \( v_{j,r} \) 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 homeowner (renter) in neighborhood \( j \), \( \zeta \) represents the utility derived from homeownership, and \( e_{ij} \) an idiosyncratic preference shock that we assume extreme-value distributed. For the sake of simplicity, \( U \) will be assumed isoelastic, \( U(c) = \frac{1}{1-\gamma} c^{1-\gamma} \), but none of the mechanisms of the model rely on this specific functional form.

Households receive a constant wage income specific to their ethnic group \( \omega_r \). A 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. Borrowers are however screened out during an origination process that will be specified below.

The intertemporal budget constraint of a household of race \( r \) leaving 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 \( \pi_j \) is the payment for housing services. \( \pi_j \) is either equal to the rent \( \chi_j \) or to the mortgage payment \( \rho D_j \) 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 \( \rho D_j = \frac{p_j}{1+\rho} \). Assuming \( \beta = \frac{1}{1+\rho} \), 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 to finance their home purchase and are subject to a screening process by competitive lenders. Based on the characteristics of the household and the price of the house, lenders decide to originate or not a mortgage loan. Households can apply for a loan in both neighborhoods. If they are rejected in both, they have 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:

\[
O_{i,j} = 1 \text{ if } y_{i,j} = \alpha_r(i) + \beta \frac{p_j}{\omega_r(i)} + \eta_{i,j} \geq 0, \quad O_{i,1} = 0, \text{ otherwise}
\]

where \( \alpha_r \) is an ethnic group specific constant term, Loan-to-income \( \frac{p_j}{\omega_r(i)} \) is the loan to income ratio and \( \eta_{i,j} \) summarizes non-observable random characteristics that determines creditworthiness. \( \eta_{i,j} \) is logistically distributed across households and therefore the origination probabilities can be summarized as:

\[
\Pr(O_{i,j} = 1) = \frac{\exp(\alpha_r(i) + \beta \frac{p_j}{\omega_r(i)})}{1 + \exp(\alpha_r(i) + \beta \frac{p_j}{\omega_r(i)})} \tag{1}
\]

The model assumes that the idiosyncratic terms \( e_{i,j} \) and \( \eta_{i,j} \) are independent. The parameters \( \alpha_r(i) \) and \( \beta \) capture the severity of the lending standards that lenders choose to impose in order to insure repayment.\(^5\) For simplicity, we assume further that conditional on observable characteristics, origination decisions are independent across neighborhood, \( \text{corr}(\eta_{i,1}, \eta_{i,2}) = 0 \).\(^6\)

**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 unit in neighborhood \( j \) is given by:

\[
MC(H_j) = H_j^{1/\epsilon_j}
\]

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:

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

Under marginal cost pricing, we have \( p_j = H_j^{1/\varepsilon_j} \) where \( \varepsilon_j \) is the price elasticity of neighborhood \( j \), for \( j = 1,2 \), and 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 a housing status compatible with lenders’ decisions on loan applications \( O_{i,j} \). Observing that \( I^h(i,j) = O_{i,j} \), the problem can expressed as

\[ J(i) = \arg\max_j V_{i,j} = \frac{1}{1 - \gamma} \left( \omega_r(i) - \frac{1}{1 + 1/\rho} p_j \right)^{1-\gamma} + v_{j,r(i)} + O_{i,j} \cdot \zeta + e_{i,j} \]

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

\[ \{J(i) = 1\} \iff U_{1,r} + e_{1,i} \geq U_{2,r} + e_{2,i} \iff U_{1,r} - U_{2,r} \geq e_{i,2} - e_{i,1} \tag{2} \]

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

\[ \Pr(J(i) = 1) = \frac{\exp(U_{j,r(i)})}{\sum_j \exp(U_{j,r(i)})} \tag{3} \]

**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.

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

\[ + \Pr(J(i) = 1|O_{i,1} = 0 \text{ and } O_{2,1} = 1, r = \text{minority}) \Pr(O_{i,1} = 0) \Pr(O_{i,2} = 1)]di \]
\[ d_{\text{ownership}}(p_1, p_2) = \int \left[ \Pr(J(i) = 1 | O_{i,1} = 1 \text{ and } O_{2,1} = 1, r = \text{minority}) \Pr(O_{i,1} = 1) \Pr(O_{i,2} = 1) \\
+ \Pr(J(i) = 1 | O_{i,1} = 1 \text{ and } O_{2,1} = 0, r = \text{minority}) \Pr(O_{i,1} = 1) \Pr(O_{i,2} = 0) \right] di \]

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

\[ d_j(p_1, p_2) = d_{j,\text{minority}}(p_1, p_2) + d_{j,\text{ownership}}(p_1, p_2) + d_{j,\text{rental}}(p_1, p_2) + d_{j,\text{rental}}(p_1, p_2) \]

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

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.
- Housing market clears at prices \( (p_1, p_2) = (\tilde{p}_1, \tilde{p}_2) \).

With these assumptions, neighborhood choice probabilities and origination probabilities are implicitly defined by the following fixed point mappings.

\[ d_1(p_1^*, p_2^*) = s_1(p_1^*) \]
\[ d_2(p_1^*, p_2^*) = s_2(p_2^*) \]

The appendix provides the 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 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, on average
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, for instance in standard models with linear-in-means peer effects specification (Manski 1993, Hoxby 2001).\footnote{Take for instance a peer-effects specification where an outcome of interest depends on peers’ race, and other characteristics. Outcome, \( o_i = x_i' \gamma + Neighbors’ Race + \varepsilon_i \). The isolation and exposure indices, multiplied by \( \beta \), measure the effect of segregation on the outcome.}

The isolation of whites in the metropolitan area is:

\[
\text{Isolation(whites)} = \sum_j \frac{white_j}{white} \cdot \frac{white_j}{population_j}
\]

(5)

where \( white_j \) is the number of white students in neighborhood \( j \), \( white \) is the overall number of whites, and \( population_j \) is overall population in the metropolitan area.

The isolation of whites goes down if white households are more exposed to minority neighbors. The exposure of whites to minorities is:

\[
\text{Exposure(minorities|whites)} = \sum_j \frac{white_j}{white} \cdot \frac{minorities_j}{population_j}
\]

(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:\footnote{In the empirical section of the paper, we extend the measures to more than two racial groups.}

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

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

\[
\begin{align*}
\text{Isolation(whites, } p_1, p_2, \alpha, \beta) &= \sum_{j=1,2} \frac{d_{j,whites}(p_1, p_2, \alpha, \beta)}{N \cdot (1-s)} \cdot \frac{d_{j,whites}(p_1, p_2, \alpha, \beta)}{s_j(p_j)} \\
\text{Isolation(minorities, } p_1, p_2, \alpha, \beta) &= \sum_{j=1,2} \frac{d_{j,minorities}(p_1, p_2, \alpha, \beta)}{N \cdot s} \cdot \frac{d_{j,minorities}(p_1, p_2, \alpha, \beta)}{s_j(p_j)}
\end{align*}
\]

where \( j \) indexes neighborhoods, \( N \cdot s \) is total minority population, \( N \cdot (1-s) \) is total white population, and other notations are as before. The next section looks at the effect of a change of \( \alpha \) or \( \beta \) 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. Since the model combined several stochastic distributions - one for the unobserved valuation of each neighborhood \( e_{i,j} \) and one for the unobserved determinants \( \eta_{i,j} \) of the
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 in cases not covered by the current analytical section.

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

Two parameters $\alpha$ and $\beta$ measure the severity of lending standards in neighborhood 1. An increase in $\alpha$ corresponds to a relaxation of overall lending standards while an increase in $\beta$ captures more specifically a relaxation of leverage constraints as this parameter measures the sensitivity of the likelihood of origination to a change in the loan-to-income or price-to-income ratio. From now on, $\alpha = \alpha_{\text{minority}} = \alpha_{\text{white}}$ 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 presented below consider each of them in turn.

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

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

The first term is the leverage effect of a change in $\beta$ on isolation. This effect is typically negative, i.e. a higher $\beta < 0$ lowers racial segregation. The second term is the general equilibrium effect of a change in $\beta$ on prices times the effect of prices on isolation. The sign and magnitude of this second effect depends on races’ incomes and valuations for the two neighborhoods.

The following two propositions show that, depending on incomes and valuations, 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:

1. A relaxation of leverage constraints - a higher $\beta$ - reduces isolation.
2. If the probability of origination is insensitive to the loan-to-income ratio ($\beta = 0$), there is no segregation, i.e. 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 (a higher $\alpha$) reduces isolation.

Proof. Proofs for both proposition 1 and 2 are presented in the appendix, on page 49.

Because minorities’ income is lower, they face higher denial rates in their application for mortgage credit. Buying in the same neighborhood as whites requires a higher leverage which mechanically higherers denial rates. However, at a given price, minorities benefit more than whites from the leverage effect.

A relaxation of overall lending standards (a higher $\alpha$), while not affecting 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 higher loan-to-income ratio and supply is fixed, a relaxation of 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 and the general equilibrium effect. Proposition 1 states that when neighborhoods are equally valued by both group, the leverage effect dominates and segregation is reduced when leverage constraints are relaxed. A similar result holds for a relaxation of the overall lending standards if the difference between neighborhood valuations is not too large. When the relative valuation of neighborhoods is equal across groups, a relaxation of the lending standards shifts the demand for the best neighborhood by both group upward 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, any relaxation of lending standards - a higher $\alpha$ or a higher $\beta$ - 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; segregation changes only because of the general equilibrium effect. While the relaxation of lending standards allows both racial groups to enjoy a higher leverage, white households value neighborhood 1 relatively more, and hence increase their demand for neighborhood 1 using additional leverage. As a consequence whites’ demand for neighborhood 1 shifts by more than minorities’ demand for neighborhood 1. As a result, a relaxation of leverage constraints leads to higher segregation.

2.5 Simulation Results.

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

The simulations presented here are based on a relaxation of the leverage constraint, that is an increase in $\beta$. Very similar results are obtained with a relaxation of the overall lending standards - an increase of $\alpha$ - .

**Model Calibration.**

**Baseline Simulations**

The simulations are based on a 2-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 neighborhood faces severe geographical constraints to expansion - typically an inner-city neighborhood - and thus exhibits low housing supply elasticity ($\varepsilon = 0.3$) while the other - typically a suburban neighborhood - exhibits a much higher supply elasticity ($\varepsilon = 3$).\(^10\) The parameters of the model kept constant across the two scenarios are summarized in the table below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>0.05</td>
<td>interest rate</td>
</tr>
<tr>
<td>$N$</td>
<td>150,000</td>
<td>population</td>
</tr>
<tr>
<td>$s$</td>
<td>0.2</td>
<td>share of minority</td>
</tr>
<tr>
<td>$\omega_w$</td>
<td>60,000</td>
<td>whites’ annual income</td>
</tr>
<tr>
<td>$\omega_b$</td>
<td>40,000</td>
<td>minorities’ annual income</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.0001</td>
<td>risk neutrality</td>
</tr>
<tr>
<td>$\alpha_w = \alpha_b$</td>
<td>2.5</td>
<td>no discrimination.</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>1000</td>
<td>standard deviation of the idiosyncratic valuation $\varepsilon_{i,j}$</td>
</tr>
<tr>
<td>$\varepsilon_1$</td>
<td>0.3</td>
<td>housing supply elasticity in neighborhood 1</td>
</tr>
<tr>
<td>$\varepsilon_2$</td>
<td>3</td>
<td>housing supply elasticity in neighborhood 2</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>10000</td>
<td>utility value of homeownership</td>
</tr>
</tbody>
</table>

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

The two scenarios are summarized in the following table:

---

\(^9\) According to the CES survey of the BLS, median annual earnings in 2009 are $44,397 for blacks and $64,800 for whites.

\(^10\) The average between 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 this section.
In each scenario, we look at the effect of an increase in the “looseness” of leverage constraints on the equilibrium variables with a special attention for its consequences on urban segregation. In order to do so, we increase the parameter $\beta$ that links the loan (or price) to income ratio to the origination probability in neighborhood 1 from -0.75 to 0.

**Scenario 1: A Relaxation of Leverage Constraints reduces Urban Segregation.**

This scenario extends the results of proposition 1 to the general model. Figure 3, panel (a) plots neighborhood 1’s relative price of housing, $p_1/p_2$. Independently of credit conditions, neighborhood 1 is more expensive for both demand and supply fundamental reasons: neighborhood 1 is more valued by both ethnic groups and its supply elasticity is lower. The relative price of housing is however constrained by higher denial rates for credit, 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 between neighborhood 1 and 2’s quality. Figure 3, panel (b) plots denial rates in both neighborhoods (1-the probability of originations) as a function of the severity of leverage constraints. Minorities have a lower income. When minorities buy they ask for a higher loan-to-income ratio than whites and therefore face higher denial rates. When the borrowing constraint is relaxed, both groups can simultaneously enjoy higher loan-to-income ratios and lower denial probabilities. When $\beta = 0$, the denial rates becomes constant for both group as income does not play any role in the origination decision. Because neighborhood 1 is more expensive than neighborhood 2 for fundamental reasons, the relaxation of the leverage constraint has much more pronounced effect in this neighborhood. Denial rates in neighborhood 2 are in fact close or below 10% for most of the range of variation of $\beta$.\(^{11}\)

Since households put a premium on homeownership over rental, a consequence of the fall in denial rates is an increase in homeownership. Figure 3, panel (c) plots the rate of homeownership in both groups and show that a relaxation of borrowing constraints lead to both a reduction and a convergence of ownership rates across both groups.

Figure 3, panel (d) contrasts the probability of a minority household to live in neighborhood 1 with the share of this neighborhood in the total population size. In absence of any segregation - i.e. if household were randomly assigned to neighborhoods - the two figures would coincide. When leverage constraints are severe $\beta = -0.75$, minorities have only 48 percent change to live in neighborhood 1 while the neighborhood hosts 62 percent of the population. As leverage constraints get relaxed, this gap is gradually reduced. When $\beta = 0$, segregation no longer exists. This simulated results confirm the analytical results of the previous section: when relative valuations are identical across ethnic groups, it is enough to relax the borrowing conditions to desegregate cities.

\(^{11}\) This feature gives some support to the simplification made in the previous section that origination constraints only affected the most valued neighborhood.
Figure 4 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 to access neighborhood 1, whites and minorities isolation indexes are reduced and the interracial exposure increases.

**Scenario 2: A 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 the minorities. For example, they are able to benefit more from given school quality maybe because they are better educated themselves or they 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 to demand housing in neighborhood 1 and, as a result, isolates themselves further.

Figure 5 is the counterpart of Figure 4 for the second scenario. The plots exhibit a similar pattern in terms of neighborhood relative prices, denial rates and homeownership. Figure 5, panel (d), plots the probability of a minority household living in neighborhood 1 and points to a striking difference with scenario 1. As borrowing constraints get relaxed, minority household are gradually priced out of neighborhood 1 despite the fact that this neighborhood is extending in population size. When $\beta = -0.75$, the probability for a minority household to live in the good neighborhood is equal to 22%. When $\beta = 0$, this percentage falls to about 10%. As before a relaxation of the borrowing constraints shifts the demand of both groups upwards but it now shifts whites’ demand curve of by much more. In this case the general equilibrium effect through higher prices dominates the leverage effect. Figure 6 shows the large consequences of this increase in urban segregation using standard measures. As $\beta$ 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, households’ valuation of neighborhood 1 and of neighborhood 2 does not depend on its 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:

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

where $\frac{d_{j,white}}{H_j}$ is the fraction of households of the same race as $i$ in neighborhood $j$. $v_{r(i)}^2$ measures

---

\(^{12}\)Note that while the change in minorities probability of living in neighborhood 1 goes in opposition directions but with similar magnitude in scenario 1 and scenario 2, the effect on isolation measures is stronger in scenario 2. This is a consequence of the initial level of segregation being much higher in scenario 2.
the importance of social interactions in households’ valuation of neighborhood 1 and 2. Only white households benefit from social interactions \( v_{w}^{2} = 0 \) and the strength of white households’ preferences for whites neighbors \( v_{w}^{2} \) is not too large, which rules out multiple equilibria. Figure 7 contrasts baseline scenario 2 with an alternative scenario in which white households derive additional utility \( v_{w}^{2} = \$2,500 \) 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 the model, housing supply elasticity affects urban segregation through both a price effect and a size effect. The last numerical scenario (Figure 8) shows these two effects. This scenario simulates the baseline economy of scenario 2 for a small \( \varepsilon_{1} = 0.1 \) and a high \( \varepsilon_{1} = 0.5 \) value of supply elasticity in neighborhood 1. Panel (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. This, combined with a higher relative price, lowers minorities’ probability of living in neighborhood 1 (panel b).

The level and the 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 with high elasticity when leverage constraints are relaxed (panel (c) and panel (d)). Therefore, the relaxation of borrowing constraints has a stronger positive effect on segregation with high than with low elasticity.  

3 Empirics

Scenario 1 and scenario 2 of the theory part (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 on (ii) income inequalities. In this section, we empirically assess whether the mortgage credit boom of 1995-2007 and the associated relaxation of lending standards has increased or decreased urban and school segregation.

The empirical analysis of the effect of credit standards on segregation faces several challenges. The first challenge is the lack of data availability on neighborhood composition at annual frequency, described in section 3.1. While (almost) exhaustive information on mortgage origination is available annually for the entire sample period (1995-2007), urban segregation based on decennial Census data can only be computed in 2000 for the period of observation.

We measure instead racial segregation using an annual comprehensive dataset of school demographics, which provides the racial composition of each of the 90,000 public schools, matched with

\[13\text{Note that when leverage constraint are relaxed enough, isolation measures indicate a higher segregation with high than with low elasticity. In this case even if the probability for minority to live in neighborhood 1 is higher with high than with low elasticity, the probability gap is now small relative to the difference in neighborhood size and this results in isolation measures being higher.}\]
their corresponding census tracts. The second challenge is to control for several confounding effects, the most important one being that the relaxation of credit standards occurred at the same time as the large increase in Hispanic population in the United States. This is addressed in section 3.2. The third challenge is to disentangle the relaxation of credit standards from demand shocks. We use an instrumental variable strategy in section 3.3 to address this last issue. Finally, section 3.4 shows that the relaxation of lending standards affects segregation across school districts – thus mortgage credit affects segregation over and above school districts’ racial integration plans.

3.1 Data

Mortgage data is from the Home Mortgage Disclosure Act (HMDA) data from 1995 to 2007. The data is 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 the information to the FFIEC. Reporting is mandatory for all depository institution and for non-depository institutions, i.e. for-profit lenders regulated by the Department of Housing and Urban Development which either have combined assets above $10 million or originated 100 or more home purchase loans (including refinancing of home purchase loans) in the preceding calendar year. HMDA covers close to 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.

The annual school data provides us with the racial demographics and the geographic location of each school, while Census data is only decennial at this level of disaggregation. Schools can be geographically matched to neighborhood. Schools can therefore act as a proxy for the composition of census tracts and urban segregation.

School demographics come from the Department of Education’s Common Core of Data, Public and Private School Universe, from 1995 to 2007. The Public School Universe is a comprehensive annual dataset of public school 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 annual frequency, we restrict the analysis to public schools. This does not affect the analysis as in section 4 we show that credit standards have no significant effect on sorting between public and private schools. Each school is identified by a unique number, its secondary or unified school district, its geographic position – latitude, longitude, and 5-digit zip code – and is matched to Metropolitan Statistical Areas with stable borders from 1995 to 2007.

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

15 A census tract is an contiguous set of blocks with a few thousand inhabitants.

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 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 we match the school using the Geocorr file and the 5-digit zip code.
To see how much of census tract racial composition can be explained by 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. Table 1 shows that closer schools predict census tract composition more closely. A 10 percentage point increase in the fraction black in the nearest school is correlated with an increase in the fraction black in the census tract by 3.5 percentage points if the school is one mile away from the census tract, and by 3.1 percentage points if the school is two miles away from the census tract. The racial demographics of the 9 nearby schools explain approximately 60% of the variance of census tract racial demographics.

Micro data is aggregated up to 2003 MSAs. Measures of racial demographics and racial segregation across schools are constructed for each metropolitan as in section 2.3. In contrast with the theory part of the 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 Loan-to-Income (LTI) ratio, 90th percentile LTI ratio, acceptance rate, and number of applications in the MSA.

Finally, our dataset 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 elasticity is 2.5, the 90th percentile of the elasticity is 4.6.

3.2 School Segregation and Credit Conditions 1995-2007

The major driving force of changing racial demographics is the growth of Hispanic population. Hispanic population grew 36% between the 2000 and the 2010 census. In our dataset of 363 MSAs, Hispanics make up 13% of the population in 1995, and 18.1% in 2005. Hence, mechanically, the exposure of students to Hispanic students increases and isolation goes down, 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 goes up as they tend to move to Hispanic areas – while the exposure of whites to Hispanics goes up, the exposure of Hispanics to whites goes down. These trends are also observed on the between school district segregation measures. The exposure of blacks to white households goes down by 4 percentage points at the same time, indicating that something else than the pure migration shock is at play.

The specification is \( \frac{\text{Race}_{r,j}}{\text{Population}_j} = \sum_{k=1}^{9} \frac{\text{Students}_{r,s(j,k)} \cdot \text{Enrollment}_{s(j,k)}}{\text{Enrollment}_{s(j,k)} + (a + b \cdot \text{Distance}_{s(j,k)})} + X_{r,j} \cdot \beta_j + \epsilon_j \) where \( \text{Race}_{r,j} \) is the number of individuals of race \( r \) in census tract \( j \), \( \text{Population}_j \) is the population of census tract \( j \), \( \text{Students}_{r,s} \) is the number of students of race \( r \) in school \( s \), \( s(j,k) \) 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 9 closest schools. The average distance to the closest school is 1.16 miles, the distance to the 9th closest school is 3.423 miles. Adding more than 9 schools did not significantly increase the explanatory power of school composition. \( \text{Enrollment}_s \) is the number of students in school \( s \). \( \text{Distance}_{s(j,k)} \) is the distance in miles between school \( s \) and census tract \( j \). \( X_{r,j} \) is a set of controls for outliers – dummies for schools that are more than 15 miles and 30 miles from the census tract.

17 The specification is \( \frac{\text{Race}_{r,j}}{\text{Population}_j} = \sum_{k=1}^{9} \frac{\text{Students}_{r,s(j,k)} \cdot \text{Enrollment}_{s(j,k)}}{\text{Enrollment}_{s(j,k)} + (a + b \cdot \text{Distance}_{s(j,k)})} + X_{r,j} \cdot \beta_j + \epsilon_j \) where \( \text{Race}_{r,j} \) is the number of individuals of race \( r \) in census tract \( j \), \( \text{Population}_j \) is the population of census tract \( j \), \( \text{Students}_{r,s} \) is the number of students of race \( r \) in school \( s \), \( s(j,k) \) 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 9 closest schools. The average distance to the closest school is 1.16 miles, the distance to the 9th closest school is 3.423 miles. Adding more than 9 schools did not significantly increase the explanatory power of school composition. \( \text{Enrollment}_s \) is the number of students in school \( s \). \( \text{Distance}_{s(j,k)} \) is the distance in miles between school \( s \) and census tract \( j \). \( X_{r,j} \) is a set of controls for outliers – dummies for schools that are more than 15 miles and 30 miles from the census tract.

18 The acceptance rate is the ratio of originations to applications.
The inflow of Hispanics did not affect the public/private school choice as much as segregation. 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 change tremendously (Figure 2, subfigures (a) to (e)): the volume of originations grows fourfold for Hispanics, doubles for blacks, and increases by 50% for whites. The median loan-to-income ratio grows by 0.4, with very similar trends for the different racial groups. The 90th percentile LTI grows 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, $\text{Corr}(\Delta \text{Isolation}, \Delta \text{LTI}) < 0$. However, this correlation is not necessarily an indication of a causal effect of leverage on segregation as the single largest mortgage credit boom in U.S. history happened at the same time as the increase in Hispanic population. There are overall at least five confounding factors in the identification of the effect of a change in lenders’ leverage policy. These factors 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, $\text{Corr}(\Delta \text{Hispanics}, \Delta \text{LTI}) > 0$. If the inflow of Hispanics causes a fall in isolation, a simple positive correlation of the growth in the loan-to-income ratio and the change in isolation might be due to the migration inflows.

- **Borrowers’ creditworthiness**: Hispanic population grew more in areas which experienced a larger decline in borrowers’ creditworthiness, $\text{Corr}(\Delta \text{LTI}, \Delta \text{Past Due}) > 0$.\(^{19}\) The increase in LTI happened alongside a deterioration of 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 happened in MSAs which are relatively elastic ($\text{Corr}(\Delta \text{Hispanics}, \Delta \text{Elasticity}) > 0$). If MSAs that are more elastic are MSAs where the inflow of Hispanics causes a less significant change in isolation – because 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 loan-to-income ratio underestimates the true effect of the loan-to-income ratio on segregation.

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

\(^{19}\)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.
• **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 going through 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 *beyond* changes in segregation that are due to migrations, demand shocks, changes in borrowers’ creditworthiness, and correlation between migrations and the elasticity of housing supply.

MSA-level segregation is determined by prices, racial demographics, national trends, credit standards, and other MSA-specific factors.

\[
\text{Segregation}_{j,t} = \text{Price}_{j,t} + \text{Credit Standards}_{j,t} + \text{Year}_{t} + \text{MSA}_{j} + \text{Racial Demographics}_{j,t} + \text{Demand Shocks}_{j,t} + e_{j,t}
\]

where \( j \) indexes MSAs, and \( t \) indexes years. The effect of credit standards conditional on prices is the *leverage effect* of section 2.4 of the theory part of the paper.\(^{20}\) The effect of prices on segregation is documented in Cutler, Glaeser & Vigdor (2008) and theoretically grounded in section 2.4 on page 9 of the theory part of our paper.\(^{21}\) In many MSAs there are large increases in Hispanic population over the period, and some MSAs, such as Austin-Round Rock, TX grow substantially (+40%) over the period 1995-2007 because of a large influx of Hispanic population. These changes have an impact \( \beta \) 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 dummies \( \text{Year}_{t} \), 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.

Also, the price of housing is determined by Segregation, Racial Demographics, national trends, credit conditions, and other factors.

\[
\text{Price}_{j,t} = \text{Segregation}_{j,t} + \text{Credit Standards}_{j,t} + \text{Year}_{t} + \text{MSA}_{j} + \text{Racial Demographics}_{j,t} + \text{Demand Shocks}_{j,t} + e_{j,t}
\]

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 currently debated and analyzed in Glaeser, Gottlieb & Gyourko (2010).\(^{22}\) The effect \( a \) of segregation on prices is indirectly determined

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\(^{20}\)It corresponds to the term \( \partial \text{Isolation}/\partial \beta \) in equation 7 on page 10.

\(^{21}\)This effect corresponds to the terms \( \partial \text{Isolation}/\partial p^{j\alpha}, j = 1,2 \) in equation 7 on page 10.

\(^{22}\)It corresponds to the term \( dp^{j\alpha}/\partial \beta \) in equation 7 on page 10.
by households’ valuation of segregation. Combining (8) and (9), the reduced-form model is:

\[
\text{Segregation}_{j,t} = \text{Credit Standards}_{j,t} \left( \frac{c\delta + \gamma}{1 - a\delta} \right) + \text{Year}_t + \text{MSA}_j + \text{Racial Demographics}_{j,t} \left( \frac{b\delta + \beta}{1 - a\delta} \right) + \text{Demand Shocks}_{j,t} \left( \frac{h\delta + \eta}{1 - a\delta} + \frac{e^s_{j,t}\delta + e^p_{j,t}}{1 - a\delta} \right)
\]

where \( \text{Year}_t = (\text{Year}_t^w + \text{Year}_t^p)/(1 - a\delta) \) and \( \text{MSA}_j = (\text{MSA}_j^w\delta + \text{MSA}_j^p \delta)/(1 - a\delta) \). 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 on segregation \((c\delta)/(1 - a\delta)\) and the leverage effect \(\gamma/(1 - a\delta)\) of credit conditions on segregation (see section 2.4 on page 9).

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 Credit Standards into measures of the loan-to-income ratio and measures of applicants’ creditworthiness:

\[
\text{Segregation}_{j,t} = \text{Loan-To-Income}_{j,t} \cdot C + \text{Racial Demographics}_{j,t} \cdot B + \text{Creditworthiness}_{j,t} \cdot D + \text{MSA}_j + \text{Year}_t + u_{j,t}
\]

where the residual \( u_{j,t} = \text{Demand Shocks}_{j,t} \left( \frac{h\delta + \eta}{1 - a\delta} + \frac{e^s_{j,t}\delta + e^p_{j,t}}{1 - a\delta} \right) \). The dependent variable Segregation\(_{j,t}\) is a measure of segregation – isolation of whites, Hispanics, blacks and Asians, or the exposure of a racial group to another racial group. LTI\(_{j,t}\) is the median loan-to-income ratio (LTI) and the difference between the 90th percentile and the median loan-to-income ratio in the MSA. Creditworthiness\(_{j,t}\) is a vector that includes the fraction of subprime loans\(^{26}\), the fraction of jumbo loans\(^{27}\) in year \( t \), the fraction of delinquencies, foreclosures, and mortgages that 90+ days past due\(^{28}\), 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, etc.)

\(^{23}\)To see that, consider a simple form of the hedonic equation \( p_i = \text{white}_i + \text{white}_i \cdot \text{minority}_{j(i)} + \epsilon_i \) where \( i \) indexes houses, \( \text{white}_i \) is a dummy for white individuals, and \( \text{minority}_{j(i)} \) is the fraction of minority neighbors in neighborhood \( j(i) \). Then the average price is \( E(p_i) = E(\text{white}) \cdot (\alpha - \gamma + \gamma \text{Isolation(white)}) \), which makes it clear that prices are a function of isolation and hence of segregation.

\(^{24}\)In the model, this corresponds to the term \( \sum_{j=1,2} \frac{\partial \text{solution}}{\partial p_i^j} \cdot \frac{dp_i^j}{dt} \) of equation 7 on page 10.

\(^{25}\)This specification augments the specification of Cutler et al. (2008) with measures of credit conditions and controls for households’ creditworthiness.

\(^{26}\)We identify subprime loans as loans that have been originated by a subprime lender. The department of Housing and Urban Development provides a list of lenders that specialize in subprime or manufactured home lending.

\(^{27}\)A jumbo loan is a loan whose amount is above the conformable loan limit. A loan above the conformable loan limit is typically not bought by the Government Sponsored Enterprises. We use the limits provided by the Department of Housing and Urban Development.

\(^{28}\)This Data comes from an MSA-level aggregation from Haver Analytics data.
and as a function of the characteristics of the loan (loan-to-income ratio, loan amount), as well as 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. Racial Demographics$_{j,t}$ is a vector of the fraction of each racial and ethnic group in the MSA: fraction white non-Hispanic, fraction Hispanic nonwhite, fraction black (non-Hispanic), fraction asian, and fraction 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 Loan-to-Income ratio and impacting segregation. In this case, regression (11) is overestimating the true effect of the Loan-to-income ratio on segregation. To potentially alleviate this issue, we add controls for the 10, 25 and 50th percentile of income by racial group, as well as the fraction of mortgage with missing income by race.

Finally, we address the endogeneity issue through an instrumental variable strategy. Our instrument is constructed in the following way. Building up on Mian and Sufi (2010), we construct an index of subprime lending activity prior to the crisis by considering the share of mortgages provided by banks specialized in subprime lending prior to 1995. 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 that had a high fraction of subprime lenders in 1995 may disproportionately benefit from the national developments affecting mortgage finance that occur during the subsequent mortgage credit boom. These national developments include macro-level factors such as the high demand for high yield U.S. asset from the rest of the world (Caballero, Farhi & Gourinchas 2008), loose monetary policy in the aftermath of the dot- come bubble. They also include nationwide mortgage market transformations such as the shift from bank-based to market-based mortgage finance (Adrian and Shin, 2010) or the emergence of a new mortgage securitization chain through “Private Label Securitizers” which has fueled the origination and securitization of non-prime and non-conventional mortgage loans (Levitin & Wachter 2010). These macro-level developments are also likely to be independent of MSA-specifies demand shock.

Therefore we can obtain a MSA-varying time-varying instrument by interacting the MSA-specific market share of subprime lenders in 1995 - which capture the cross-sectional difference of pre-crisis prevalence of subprime activity - with year dummies - capturing 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 variable strategy, the Loan-to-income ratio is regressed on the subprime market share in 1995 interacted with each year dummy from 1996 to 2007.

$$LTI_{j,t} = \phi_0 \text{Subprime Market Share } 1995_j + \text{MSA}_j + \eta_{j,t}$$

$^{29}$The list of mortgage lenders is provided by the Department of Housing and Urban development.

$^{30}$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 regulations regarding mortgage brokerage activity. In order to grant mortgage broker licenses, states put different requirement 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).
where Subprime Market Share 1995 \( j \) is the subprime market share in 1995 in MSA \( j \). \( \phi_t \) is the effect of the 1995 market structure on leverage in year \( t \). The first-stage (Table 4) 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.

The main regressions (equation 11) both in OLS and IV, 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,\(^{31}\) our estimator of the effect of credit conditions is 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. The MSA is likely to be the appropriate level of clustering. There are 355 MSAs overall, so the number of clusters is large, and there are 13 years of observations, hence 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).\(^{32}\)

Finally, we checked that the results we obtained were robust by replicating the results dropping extreme observations, regressing on subsets of years, or dropping MSAs one by one. Thus no particular year or MSA is driving the results.

### 3.4 Results

#### Baseline Regression

Tables 5 to 7 present results of the estimation of baseline regression (11) for the segregation of blacks, whites and Hispanic students respectively.\(^{33}\) Column 1 of each table presents estimates controlling for demographics and MSA fixed effects. Column 2 introduces controls for the characteristics of demand – distribution of applicants’ income – and controls 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 an arguably exogenous predictor of increases in the loan-to-income ratio, as described in the previous subsection. In Columns 1 to 4, segregation is measured by the isolation index. Column 5 onwards presents 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

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\(^{31}\)We should expect the effect of credit conditions to be different across MSAs. The theory part of the paper emphasizes that the effect of credit conditions depends on households’ valuations of housing, the elasticity of supply of housing, relative incomes, and other parameters. In the paper we measure the average effect of credit conditions on segregation.

\(^{32}\)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 results using multi-way clustering since 13 years of observation with 355 observations per year is far from the asymptotics.

\(^{33}\)For Asians, results are mostly non significant and small, results are available on request.
of Hispanics to blacks (Table 7). Overall, across the 3 tables, coefficients 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, both the median loan-to-income ratio and the difference between the 90th percentile loan-to-income ratio and the median loan-to-income 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 measures of credit conditions captures the increase in the most extreme loan-to-income ratios, which arguably benefited low-income and minority applicants relatively more than high-income and white applicants.34

Overall, results suggest that a relaxation of the leverage constraint increased segregation significantly for blacks and Hispanics. A increase of the median LTI by 1 increases black students' isolation by 3 percentage points (Table 5, columns 1 to 4). Income and creditworthiness controls make the effect of the difference between the 90th and the 50th percentile of the loan-to-income ratio distribution non significant (Table 5, Columns 2 to 4), suggesting that the relaxation of the leverage constraint for the most highly leveraged borrowers was not due to a relaxation of the leverage constraint 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 loan-to-income ratio increases by 1. Given the increase of the median loan-to-income ratio by 0.4 over the 1995-2005 period, this amounts to an effect of 2.4 percentage points for the exposure of black students to whites, and an effect of 1.3 percentage on isolation.

The effect of the median loan-to-income ratio on the isolation of whites is not significant (Table 6, columns 1 to 4). This lack of effect on isolation masks two underlying effects revealed by exposure measures: a higher median loan-to-income 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 loan-to-income ratio increases by 1, table 6, column 5), and a higher median loan-to-income ratio makes whites less likely to be exposed to black students (The exposure of white students to African-American peers decreases by 0.708 when the median loan-to-income ratio increases by 1, table 6, column 6).

Table 7 presents results for Hispanic isolation. Results for Hispanic students are of special importance because of the role played by the increase in Hispanic population in the decline in 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 ratios increases by 1, the isolation of Hispanic students increases by 2.5 (Column 1) to 2.9 (Column 3). This is in

34Figures (c) and (d) of figure 2 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.
part due 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.

All in all, leverage increases significantly 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.

**Effect of Leverage by Elasticity**

Metropolitan areas differ significantly in their restrictions on land use and the geographical constraints on the supply of housing. MSAs which have a very 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 the last theoretical scenario of section 2.5, a larger expansion of 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 the difference P90-P50 loan-to-income ratio with metropolitan area elasticity. As in column 4 of the previous tables, regressions control for demographics, income and creditworthiness measures, as well as MSA and year fixed effects. Table 8 reports uninstrumented results, since the instrumental variable estimates yielded similar results as the non instrumented regression.

Results support the theoretical scenario of section (2.5), in which the effect of a relaxation of 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 the median loan-to-income ratio by 1 does not have a significant impact for low-elasticity metropolitan areas, but this increase in the loan-to-income ratio causes an increase in Hispanic isolation by 1.4 percentage points in MSAs with median elasticity (2.55). The effect of the median loan-to-income ratio is also stronger in highly elastic metropolitan areas. An increase of the difference between the 90th percentile and the median loan-to-income ratio by 1 increases Hispanic isolation by 1.7 ($= 0.282 + 0.559 \cdot 2.55$) in the metropolitan area with the median elasticity of 2.55, and by 2.9 percentage points in the metropolitan area which has the 90th percentile elasticity of 4.6.

Finally, one potential concern may be that lower elasticity MSAs experienced higher increases in house prices, and that therefore it may not be possible to identify the effect of elasticity separately from the effect of rising prices. However, results available from the authors suggest that controlling for a housing price index estimate does not change the coefficients of interest.\(^{35}\)

**Between School District Segregation**

In contrast with the literature emphasizing the effect of desegregation policies, this paper focuses on market driven forces - the relaxation of leverage constraints in mortgage credit markets - on

\(^{35}\)We used the Office of Federal Enterprise Oversight (OFHEO) annual house price index.
segregation. In general, desegregation policies can act within the boundaries of school districts but do not operate across school district boundaries. As a consequence and in order to better isolate the mortgage credit channel, we look at whether the effect of the relaxation of the leverage constraint can affect segregation across school districts.

In each metropolitan statistical area (MSA), we calculate between-school district segregation using the between school-district isolation index. The between school district isolation of white students is the average fraction of white peers for white students.

\[
\text{Between School District Isolation}_j(\text{Whites}) = \sum_{k=1}^{K_j} \frac{\text{whites}_{k,j}}{\text{whites}_j} \cdot \frac{\text{whites}_{k,j}}{\text{students}_{k,j}}
\]

where \( k = 1, 2, \ldots, K_j \) indexes school districts in MSA \( j \), \( \text{whites}_{k,j} \) is the number of white students in school district \( k \) in MSA \( j \) and \( \text{students}_{k,j} \) is the total number of students in school district \( k \) in MSA \( j \). \( \text{whites}_j \) 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%, the between-school-district isolation of blacks declines from 44.7% to 42.6% and 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. Results are presented in table 9.

An increase in the median loan-to-income ratio by 1 increases the between school district isolation of blacks by 2.5 percentage points (Table 9, column 1). This is very similar to the result of the main table for blacks (Table 5, column 3). Thus, for blacks, the increase in isolation due to an increase in leverage is mostly due to a change in between-school district isolation. Table 9, column 2, shows that a higher median loan-to-income 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 goes up when the median loan-to-income ratio goes up: the coefficients on black isolation (column 1) and exposure (column 2) are close and of opposite signs.

Column 6 shows that a higher median loan-to-income ratio increases the between school district isolation of Hispanics (+1.5), rather than higher 90th percentile loan-to-income ratios as in the previous results mixing between and within school districts. Easier credit access measured by median leverage helps hispanic households to move into predominantly hispanic school districts.

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

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36Since the *Milliken v. Bradley* 1974 Supreme Court ruling, court-ordered desegregation plans are constrained by school district boundaries.
Counterfactual Analysis: Segregation Trends without the Credit Boom

The previous discussion shows that increases in the loan-to-income ratio – median and the 90th percentile loan-to-income ratio – positively affect the segregation of Hispanics and blacks. Other determinants of segregation include the other measures of credit conditions – applicants’ creditworthiness, 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 change in the actual isolation. We use the point estimate of the effect of the median LTI on isolation controlling for MSA fixed effects, demographic controls, income and creditworthiness measures, year dummies. The effect is 3.265 for blacks, with a standard error of 1.202 (Table 5 on page 43, column 3). Hence, for blacks,

\[
\text{Counterfactual Isolation}_{t} = \text{Counterfactual Isolation}_{t-1} + \Delta\text{Isolation}_{t} - 3.265 \cdot \text{Median LTI}_{t}
\]

and, in 1995 the counterfactual isolation is equal to 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, it is the 90th percentile of the loan-to-income ratio which has an impact on isolation (Table 7, columns 1 to 4). Hence, to compute the counterfactual isolation of Hispanics, we replace the median LTI by the P90 LTI and 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).

The bold lines of Figure 9 shows the actual isolation of black and Hispanic students from 1995 to 2007, as in the upper part of table 2 on page 40. What is novel in this figure is that the dashed lines also show the counterfactual isolation of Hispanic and black students.

The upper graph of figure 9 shows the isolation and the counterfactual isolation of blacks. Other factors than the leverage make black isolation fall by 2.9 percentage points. On the same period, the median loan-to-income ratio increases by 0.4. Without this increase in the Loan-to-income 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 our confidence intervals are correct.

The bottom graph of figure 9 shows a similar graph for Hispanic students. Other factors than the loan-to-income ratio make isolation increase by 2.6 percentage points from 1995 to 2007. Over the same period the 90th percentile of the loan-to-income ratio increases by 1, from 2.96 to 3.96, and the difference between the 90th percentile LTI and the median LTI increases by 1.6. The effect of the difference P90-P50 is 2.866 in the regression of column 3 (Table 7), and Hispanic isolation would have been 1 and 1.3 percentage points lower without the relaxation of the leverage constraint, using the 90% confidence intervals of the IV estimate. This is again conditional on a correct identification

\[37\]In the IV regression, the point estimate is 2.074 with a standard error of 1.146, significant at 10%. Since 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. For blacks, with the IV estimate, the effect is stronger. In this case, the estimate of column 3 is conservative.
and inference strategy.

In sum, the 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, has 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 other racial groups for housing in desirable neighborhoods. Higher leverages increase the isolation of blacks and Hispanics across schools and neighborhoods. This has made segregation decline at a slower pace than what the inflow of Hispanic migrants and other factors would have implied.

Viewed through the lenses of a neighborhood choice model augmented with leverage constraints, these empirical results offer indirect evidence that households’ valuations of neighborhoods significantly differed across races so that general equilibrium effects outweighed leverage effects. These results carry important implications for any type of policy designed to foster cheaper access to credit as way to increase 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 point toward another set of unintended consequences which materialize before the financial crisis: while the relaxation of credit standards did increase home ownership for the poor and for minorities, it also significantly aggravated racial segregation.

Literature has shown that segregation has negative impacts on low human capital households (Cutler, Glaeser & Vigdor 2007), which are arguably the most credit-constrained households. Segregation increases black-white test score gaps (Card & Rothstein 2007), 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, low human capital households’ welfare was negatively affected by the relaxation of lending standards, even before 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 estimate households’ preferences using transaction-level micro data with detailed creditworthiness and neighborhood measures.
References


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

Figure 1: Volume of Mortgage Originations – By Race, Normalized as 1 in 1995
LTI: Loan-to-income ratio. Source: Home Mortgage Disclosure Act data from 1995 to 2007. All racial groups are non-Hispanic members of those races. Hispanics are shown as a separate category.

Figure 2: Credit Standards – By Race
The looseness of the leverage constraint is the parameter $\beta$ in the acceptance/rejection decision.

Figure 3: Scenario 1
The looseness of the leverage constraint is the parameter $\beta$ in the acceptance/rejection decision. For definitions of isolation and exposure, see section 2.3, equations 5 and 6.

Figure 4: Scenario 1 – Segregation and Credit Constraints
The looseness of the leverage constraint is the parameter $\beta$ in the acceptance/rejection decision.

Figure 5: Scenario 2
The looseness of the leverage constraint is the parameter \( \beta \) in the acceptance/rejection decision. For definitions of isolation and exposure, see section 2.3, equations 5 and 6.

Figure 6: Scenario 2 – Segregation and Credit Constraints
Figure 7: The Role of Social Interactions
Figure 8: The Role of Elasticity
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
<table>
<thead>
<tr>
<th>Year</th>
<th>1995</th>
<th>1997</th>
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<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
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<td>50.4</td>
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Source: Public and Private School Universe, K12 schools.

Table 2: School Segregation in Metropolitan Statistical Areas, 1995-2007
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<th>Δ Isolation Blacks</th>
<th>Δ LTI</th>
<th>Δ log(price)</th>
<th>Δ Acceptance Rate</th>
<th>Δ Income P50</th>
<th>Δ Jumbo</th>
<th>Past Due</th>
<th>Inflow Hispanics</th>
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<td>Δ LTI</td>
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<td>Δ log(price)</td>
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<td>-0.191</td>
<td>-0.225</td>
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<td>Δ Acceptance Rate</td>
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<td>(0.000)</td>
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<td>Δ Income P50</td>
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<tr>
<td>Inflow Hispanics</td>
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<td>0.134</td>
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<td>0.244</td>
<td>-0.208</td>
<td>-0.150</td>
<td>0.168</td>
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<td>Supply Elasticity</td>
<td>-0.120</td>
<td>0.161</td>
<td>0.257</td>
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<td>(0.000)</td>
<td>(0.000)</td>
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<td>(0.000)</td>
<td>(0.010)</td>
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<td>Subprime Share</td>
<td>-0.065</td>
<td>-0.017</td>
<td>0.420</td>
<td>-0.309</td>
<td>0.793</td>
<td>0.081</td>
<td>-0.065</td>
<td>0.336</td>
<td>0.287</td>
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<tr>
<td>in 1995</td>
<td>(0.094)</td>
<td>(0.070)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.025)</td>
<td>(0.070)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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Table 3: Correlation Table
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Median LTI Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 1996</td>
<td>0.292**</td>
</tr>
<tr>
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<td>(0.033)</td>
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<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 1997</td>
<td>0.364**</td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 1998</td>
<td>0.426**</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 1999</td>
<td>0.458**</td>
</tr>
<tr>
<td></td>
<td>(0.034)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2000</td>
<td>0.467**</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2001</td>
<td>0.468**</td>
</tr>
<tr>
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<td>(0.036)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2002</td>
<td>0.456**</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2003</td>
<td>0.477**</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2004</td>
<td>0.564**</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2005</td>
<td>0.645**</td>
</tr>
<tr>
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<td>(0.041)</td>
</tr>
<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2006</td>
<td>0.793**</td>
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<tr>
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<td>(0.048)</td>
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<tr>
<td>1995 Subprime Lenders’ Market Share × Year = 2007</td>
<td>0.718**</td>
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<td>(0.045)</td>
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</tbody>
</table>

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

42
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Isolation</th>
<th>(2) Isolation</th>
<th>(3) Isolation</th>
<th>(4) Isolation</th>
<th>(5) Exposure to White</th>
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</thead>
<tbody>
<tr>
<td>Median LTI Ratio</td>
<td>3.042*</td>
<td>3.205**</td>
<td>3.265**</td>
<td>7.546**</td>
<td>-6.608*</td>
</tr>
<tr>
<td></td>
<td>(1.304)</td>
<td>(1.204)</td>
<td>(1.153)</td>
<td>(2.508)</td>
<td>(2.653)</td>
</tr>
<tr>
<td>P90-P50 LTI Ratio</td>
<td>2.745+</td>
<td>0.119</td>
<td>0.400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.590)</td>
<td>(1.561)</td>
<td>(1.486)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptance rate</td>
<td></td>
<td></td>
<td></td>
<td>0.119*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.047)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
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<td>4,552</td>
<td>4,552</td>
<td>4,552</td>
<td>4,552</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.532</td>
<td>0.582</td>
<td>0.591</td>
<td>0.473</td>
<td>0.632</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Demand Controls</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Instrument</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>F Statistic</td>
<td>43.02</td>
<td>43.40</td>
<td>39.92</td>
<td>25.18</td>
<td>44.20</td>
</tr>
</tbody>
</table>

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
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

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
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<tr>
<td>Median LTI Ratio</td>
<td>0.208</td>
<td>0.559</td>
<td>0.571</td>
<td>0.370</td>
<td>1.375**</td>
<td>-0.708+</td>
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<td>(0.361)</td>
<td>(0.404)</td>
<td>(0.409)</td>
<td>(0.513)</td>
<td>(0.293)</td>
<td>(0.375)</td>
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<tr>
<td>P90-P50 LTI Ratio</td>
<td>0.319</td>
<td>-0.104</td>
<td>-0.085</td>
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</tr>
<tr>
<td></td>
<td>(0.440)</td>
<td>(0.412)</td>
<td>(0.403)</td>
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<tr>
<td>Acceptance rate</td>
<td>0.006</td>
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<td></td>
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<td>(0.011)</td>
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<td>4,552</td>
<td>4,552</td>
<td>4,552</td>
<td>4,552</td>
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<tr>
<td>R-squared</td>
<td>0.894</td>
<td>0.898</td>
<td>0.898</td>
<td>0.896</td>
<td>0.933</td>
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<td>Demographics Controls</td>
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<td>yes</td>
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<tr>
<td>Demand Controls</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>F Statistic</td>
<td>154.6</td>
<td>195.7</td>
<td>188.3</td>
<td>170.3</td>
<td>293.2</td>
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<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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</table>

Robust standard errors in parentheses

** p<0.01, * p<0.05, + p<0.1
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Isolation</th>
<th>(2) Isolation</th>
<th>(3) Isolation</th>
<th>(4) Isolation</th>
<th>(5) Exposure to Blacks</th>
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<tbody>
<tr>
<td>Median LTI Ratio</td>
<td>0.576</td>
<td>0.776</td>
<td>0.980</td>
<td>0.953</td>
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<td>(0.605)</td>
<td>(0.667)</td>
<td>(0.620)</td>
<td>(0.726)</td>
<td>(0.345)</td>
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<tr>
<td>P90-P50 LTI Ratio</td>
<td>2.525**</td>
<td>2.736**</td>
<td>2.866**</td>
<td>2.074+</td>
<td>-0.854</td>
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<td>(0.924)</td>
<td>(0.693)</td>
<td>(0.630)</td>
<td>(1.146)</td>
<td>(0.828)</td>
</tr>
<tr>
<td>Acceptance rate</td>
<td>0.049*</td>
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<tr>
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<td>(0.021)</td>
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<td>4,550</td>
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<td>4,550</td>
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<td>R-squared</td>
<td>0.832</td>
<td>0.847</td>
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<td>yes</td>
<td>yes</td>
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<tr>
<td>Demand Controls</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Instrument</td>
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<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>F Statistic</td>
<td>133.5</td>
<td>340.2</td>
<td>313.7</td>
<td>186.0</td>
<td>29.53</td>
</tr>
</tbody>
</table>

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
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Isolation of Blacks</th>
<th>(2) Isolation of Whites</th>
<th>(3) Isolation of Hispanics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median LTI Ratio</td>
<td>2.620*</td>
<td>0.300</td>
<td>0.282</td>
</tr>
<tr>
<td></td>
<td>(1.044)</td>
<td>(0.320)</td>
<td>(0.487)</td>
</tr>
<tr>
<td>P90-P50 LTI Ratio</td>
<td>0.996</td>
<td>0.181</td>
<td>1.829**</td>
</tr>
<tr>
<td></td>
<td>(1.304)</td>
<td>(0.389)</td>
<td>(0.566)</td>
</tr>
<tr>
<td>Median LTI Ratio × Elasticity</td>
<td>-0.004</td>
<td>0.071</td>
<td>0.559*</td>
</tr>
<tr>
<td></td>
<td>(0.472)</td>
<td>(0.183)</td>
<td>(0.278)</td>
</tr>
<tr>
<td>P90-P50 LTI Ratio × Elasticity</td>
<td>1.329</td>
<td>-0.215</td>
<td>0.699</td>
</tr>
<tr>
<td></td>
<td>(0.844)</td>
<td>(0.269)</td>
<td>(0.496)</td>
</tr>
<tr>
<td>Acceptance rate</td>
<td>0.112*</td>
<td>0.003</td>
<td>0.036+</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.011)</td>
<td>(0.021)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
<th>4,614</th>
<th>4,614</th>
<th>4,612</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>0.593</td>
<td>0.906</td>
<td>0.848</td>
</tr>
<tr>
<td>F Statistic</td>
<td>59.75</td>
<td>198.2</td>
<td>113.6</td>
</tr>
</tbody>
</table>

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
### Table 9: Credit Standards and Segregation - Segregation between School Districts Across MSAs

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

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.
Figure 9: Actual and Counterfactual Isolation

(a) Black Isolation

(b) Hispanic 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, \(r(i) = \text{white}\) or \(r(i) = \text{minority}\). 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 \(j\).

\[
V_{i,j} = \frac{1}{1 - \gamma} \left( \frac{\omega_{r(i)} - 1}{1 + 1/r P_j} \right)^{1-\gamma} + v_{j,r(i)} + \varepsilon_{i,j}
\]

- 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.

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

**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,
\[
\frac{dD_r(P)}{dP} = \frac{P(J(i) = 1|r)[1 - P(J(i) = 1|r)]}{P(O_{i,1} = 1|r)} \frac{dU_{i,1}}{dP} + \frac{P(J(i) = 1|r)P(O_{i,1} = 1|r)}{1 + e^{\frac{\beta}{\omega}}} \frac{\beta/\omega}{1 + e^{\frac{\alpha + \beta P/\omega}{\omega}}}
\]

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

\[\square\]

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

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

**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. \(\square\)

**Expansion of Credit Volume**

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

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:

\[sf_m(\alpha, p) + (1 - s)f_w(\alpha, p) = 1\]

An increase in \( \alpha \) 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

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

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

\[
\frac{d}{d\alpha} f_m(\alpha, p) \geq 0
\]

i.e.

\[
\frac{\partial f_w/\partial \alpha}{\partial f_m/\partial \alpha} \geq \frac{\partial f_w/\partial p}{\partial f_m/\partial p}
\]

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:

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

(13)

**Proposition 2 on page 11: 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 \( \alpha \) increases segregation if and only if:

\[
-\partial \log P(J(i) = 1|m)/\partial p \geq -\partial \log P(J(i) = 1|w)/\partial p
\]

(14)

With \( \Lambda \) the c.d.f. of the logit distribution and logit the density function of the logit, notice that \( P(J(i) = 1|r) = \Lambda \left( \frac{1}{1+1/p} (1 - p_1) + v_{1,r} - v_{2,r} \right) \), and \( -\partial \log P(J(i) = 1|r)/\partial p = \frac{1}{1+1/p} \log \left( \frac{1}{1+1/p} (1 - p_1) + v_{1,r} - v_{2,r} \right) / \Lambda (\frac{1}{1+1/p} (1 - p_1) + v_{1,r} - v_{2,r}) \), strictly decreasing in \( v_{1,r} - v_{2,r} \). Since \( v_{1,w} - v_{2,w} > v_{1,m} - v_{2,m} \), a higher \( \alpha \) increases segregation.

**Proposition 1 on page 10: 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, \( -\partial \log P(J(i) = 1|r)/\partial p = -\frac{d}{dp} \Lambda (\frac{1}{1+1/p} (1 - p_1) + v_{1,r} - v_{2,r}) \) is independent of \( r \). Intuitively, both racial groups’ utilities react equally to a change in the price \( p_1 \).

Now \( \partial \log P(O_{i,1} = 1|m)/\partial \alpha = \frac{d}{d\alpha} \log \Lambda (\alpha - \beta p_1/\omega_r) = \logit (\alpha - \beta p_1/\omega_r)/\Lambda (\alpha - \beta p_1/\omega_r) \) is a decreasing function of income \( \omega_r \). Hence \( \partial \log P(O_{i,1} = 1|m)/\partial \alpha > \partial \log P(O_{i,1} = 1|w)/\partial \alpha \) and \( 1/\partial \log P(O_{i,1} = 1|m)/\partial \alpha - 1/\partial \log P(O_{i,1} = 1|m)/\partial \alpha > 0 \).
Since both the left-hand side and the right-hand side of 13 are positive, the effect of an increase in $\alpha$ 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 $\alpha$ increases. The intuitive explanation is that minorities outbid some white households for housing in neighborhood 1.

**Higher Leverages**

A higher $\beta$ 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:

$$\frac{dp}{d\beta} > 0$$

**Response of the probability of living in neighborhood $j$ to a change in $\beta$**

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:

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

An increase in $\beta$ 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:
\[ \frac{d}{d\beta} f_m(\beta, p) \geq 0 \]

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 11: 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 (\( \beta \) increasing) increases segregation.

**Proposition 1 on page 10: 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
\[ \frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} = \frac{1 + \exp(\alpha + \beta p/\omega_m) p/\omega_w}{1 + \exp(\alpha + \beta p/\omega_w) p/\omega_m} \]

when \( \beta \) tends to zero, this expression collapses to
\[ \lim_{\beta \to 0} \frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} = \frac{\omega_m}{\omega_w} < 1 \]

which is less than one and
\[ \lim_{\beta \to 0} \frac{\partial f_w/\partial p}{\partial f_m/\partial p} = 1 \]

therefore \( \frac{\partial f_w/\partial \beta}{\partial f_m/\partial p} \geq \frac{\partial f_w/\partial \beta}{\partial f_m/\partial \beta} \). An increase in \( \beta \) 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 \( \beta \) 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.
<table>
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<th>VARIABLES</th>
<th>(1) Whites</th>
<th>(2) Blacks</th>
<th>(3) Hispanics</th>
<th>(4) Asians</th>
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<td></td>
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<td>P90-P50 LTI Ratio</td>
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<td>0.010</td>
</tr>
<tr>
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<td>(0.023)</td>
<td>(0.024)</td>
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<td>(0.477)</td>
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<td>R-squared</td>
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<td>0.577</td>
<td>0.730</td>
<td>0.775</td>
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</table>

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.

Table 10: Public/Private