Credit Standards and Segregation*

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Abstract

How do credit standards on the mortgage market affect neighborhood choice and the resulting level of urban segregation? To answer this question, we first develop a model of neighborhood choice with credit constraints. The model shows that a relaxation of credit standards can either increase or decrease segregation, depending on racial income gaps and on races' preferences for neighborhoods. We then estimate the effect of the relaxation of credit standards that accompanied the 1995–2006 mortgage credit boom on the level of school segregation. Census tract racial composition is strongly correlated with the racial composition of the 10 closest schools in the cross section. Matching a national data set of mortgage originations with annual racial demographics of each of the public schools in the United States from 1995 to 2006, we find that the relaxation of credit standards has caused an increase in the segregation of blacks through a lower exposure of blacks to hispanics and whites.

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1 Introduction

Although the availability of mortgage credit is an important determinant of housing options for households, the links between mortgage credit market conditions, neighborhood choice, and the resulting level of urban segregation have so far been neglected.[1] This paper analyzes theoretically and empirically how changes in credit standards affect segregation levels. Introducing mortgage credit and liquidity constraints in a neighborhood choice general equilibrium model, we show how a relaxation of mortgage lending standards can either increase or decrease segregation depending on the income gap and neighborhood valuation differences across different ethnic groups. The paper then empirically estimates the effect of a relaxation of lending standards on segregation during the pre-crisis mortgage credit boom in the United States (1995–2006). 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 white students.

We use the mortgage credit boom of the late 1990s until 2006 as a large-scale experiment to analyze how mortgage credit markets affect racial segregation across schools and neighborhoods. Figure 1 shows that the number of mortgage originations to Hispanic households increased five fold during the 1995–2006 period; the number of mortgage originations to black households doubled during the same period, and the number of mortgage originations to white households increased by 50%. Borrowers were also allowed much higher loan-to-income ratios. In 1995, the average new homeowner borrowed 1.9 times his income, whereas by 2004 this ratio has risen 2.4 times annual income. Also, the fraction of mortgage originations with missing income[2] increased from 2 percent of overall originations in 1995 to 7 percent of originations in 2006. Because this expansion of the supply of mortgage credit did not benefit all races equally, we expect potential changes in segregation patterns.

Does easier access to credit and higher leverage lead to reduced racial segregation? To understand the effects of a relaxation of credit standards on racial segregation, we develop a model of neighborhood choice (cf. Benabou (1996) and Epple, Filimon & Romer (1984)) in which households value neighborhoods differently based on the quality of housing and the quality of associated public goods (e.g., schools). We contribute to the literature by emphasizing the role of credit constraints in the choice of neighborhood and ownership status. Households in our model must borrow in order to buy a house, and their loan-to-income (LTI) ratio plays a critical role in the decision of banks to originate loans. Homeowners choose optimally between rental and homeownership. A relaxation of lending standards leads to a greater number of originated loans and higher loan-to-income ratios. This effect differentially influences whites' and minorities' ability to purchase houses in desirable neighborhoods because these groups have different incomes and value neighborhoods differently.

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

[2] In the dataset, mortgage applicant income is missing when the lender did not ask for the applicant's income or rely on it in the credit decision (FFIEC 2011).

Segregation could increase or decrease depending on who benefits from an increased availability of mortgage credit and who values living in desirable neighborhoods. If whites value local amenities or white neighbors much more than do minorities and if the white–minority income gap is not too large, then there will be more segregation. If whites' valuation of local amenities and/or white neighbors is lower or only slightly higher than minorities' valuation of local amenities or if the income gap is high, then looser lending standards will lower segregation.

The paper tests empirically whether a relaxation of credit standards in a typical Metropolitan Statistical Area (MSA) causes an increase or a decrease in school segregation within that MSA over the period 1995–2006. An innovation of this paper is to use school demographics for every public and private school from the US Department of Education's Common Core of Data to combine measures of segregation at *annual frequency* that can be geographically matched with a comprehensive annual data set on individual mortgage origination compiled by the Federal Financial Institutions Examination Council applying the Home Mortgage Disclosure Act of 1975. [3]

The focus of this paper is on estimating of the causal effect of credit standards on segregation while controlling for borrowers' income shocks, racial demographics, and other drivers of demand shocks. Using controls for MSA fixed effects, MSA demographics, and risk measures, we show that higher loan-to-income ratios have led to the increased isolation of both Black and of white students. An increase in the median LTI ratio from two times to three times the income of borrowers increases the isolation of Black students by 2.2 percentage points. An increase of 5 percentage points in the fraction of mortgages with missing income – the fraction of mortgages for which the lender did not rely on income – increases the isolation of black students by 1 percentage point. Consistently with the predictions of our model, we show that the effect of credit conditions on whites' school segregation is amplified in Metropolitan Statistical Areas with strong preferences for segregation and in MSAs with high elasticity of housing supply.

This paper is positioned at the juncture of two strands of the literature: that on mortgage credit standards and that on urban and school segregation. On the one hand, the literature on mortgage credit has insisted on the role of supply factors in explaining the relaxation of lending standards. This finance literature has explored the effect of greater mortgage credit availability on housing prices and mortgage default risk but not on the social or racial composition of neighborhoods. On the other hand, the literature on segregation has extensively analyzed the effects of public policies but has ignored how credit markets can affect the level and dynamics of aggregate urban and school segregation. This paper is, to our knowledge, one of the first that combines these two literatures in order to explore the consequences of credit market development on the racial transformation of neighborhoods. We begin theoretically by introducing credit market frictions in neighborhood choice models and we then assess their roles in shaping urban segregation. We then show empirically that higher leverages and looser lending standards have led to an increase in urban and school segregation.

[3] The paper does not claim that there is a constant correlation between neighborhood composition and school composition, e.g. there is indeed a large amount of literature on desegregation and integration plans, see for instance Reber (2005). Rather, section 3.1 shows that a regression of census tract racial composition on the racial composition of the ten nearby schools explains about 60% of the variance of census tract racial composition.

On the credit market side, this paper builds on a recent literature that shows how the growth in mortgage originations during the pre-crisis boom was, in large part, due to a relaxation of credit standards in the mortgage market. Mian & Sufi (2009), using disaggregated data at the ZIP code level, demonstrate that a supply-based channel is the most likely explanation for the mortgage expansion during the pre-crisis era. The negative correlation (observed during the peak of the boom 2003–2004) between income growth and credit growth in ZIP codes with a historically high share of subprime mortgages support the credit supply hypothesis. According to Mian & Sufi (2009), these "subprime" ZIP codes experienced a fall in denial rates and in spread between the prime and the subprime interest rates.[4] Favara & Imbs (2010) confirm the role of a credit supply channel by relating the increased loan volume, rising LTI ratios, and faling denial rates in the mortgage credit market to a policy index of interstate branching deregulation. Dell'Arriccia, Igan & Laeven (2009) document the link between mortgage expansion and the relaxation of lending standards by showing that the increase in the number of mortgage applicants has been systemically associated with a decrease in lending standards. Keys, Mukherjee, Seru & Vig (2010) demonstrate how securitization led both to an increase in the supply of mortgages and a decline in lending standards.[5].

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

Research on racial segregation across neighborhoods has largely focused on the measurement of segregation (Massey & Denton 1988), and on the effect of active desegregation policies such as busing (Angrist & Lang 2004), school reassignment programs (Hoxby & Weingarth 2006), which can be part of court-ordered desegregation plans (Reber 2005, Boustan 2010). In contrast, this paper deals with the effect of market-driven forces — the relaxation of leverage constraints in mortgage credit markets — on segregation. Since the *Milliken v. Bradley* (1974) Supreme Court decision, court-ordered desegregation plans are constrained by the boundaries of school districts; this holds even though racial segregation across school districts accounts for a large share of school segregation (Clotfelter 1999). Changes in lending standards affect households' residential location choices and may allow them to cross school district boundaries. The paper shows that a large share of the increase in the isolation of black students caused by changes in credit standards can be attributed to an increase in between-school-district isolation.

The rest of the paper is structured as follows. In Section 2, we present the theoretical framework.

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

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

In Section 3, we present stylized facts, the identification strategy, and the empirical results. Section 4 concludes.

2 A model of residential choice with credit constraints.

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

2.1 The environment

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

Households

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

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

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

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

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

$$\sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} c_{j,r,t} = \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} \omega_r - \sum_{t=0}^{\infty}\left(\frac{1}{1+\rho}\right)^{t} \pi_j,$$

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

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

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

The origination process

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

The origination decision variable $O_{i,j}$ is equal to one if the application is accepted and to zero if the application is rejected. The origination decision in each neighborhood follows a logit latent variable model:[6]

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

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

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

The model assumes that the idiosyncratic terms $e_{i,j}$ and $\eta_{i,j}$ are independent. The parameters $\alpha_{r(i)}$ and β capture the severity of the lending standards that lenders choose to impose when seeking to ensure repayment.[7] For simplicity we also assume that, conditional on observable characteristics, origination decisions are independent across neighborhoods, $corr(\eta_{i,1}, \eta_{i,2}) = 0$.[8]

[6] The unobserved $O^*_{i,j}$ is interpreted as the lender's benefit minus cost of lending to homeowner i in neighborhood j.

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

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

Housing supply

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

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

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

$$p_j = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \chi_j \Longleftrightarrow \chi_j = \frac{p_j}{1+\rho^{-1}}$$

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

Neighborhood choice

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

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

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

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

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

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

Aggregate housing demand and market clearing

We derive aggregate demand for each neighborhood by aggregating the individual probabilities of neighborhood choice (equation (3)), conditional on origination decisions, multiplied by the probabilities of origination (equation (1)). Minority and white demand for housing in neighborhood

1 is thus equal to the sum of the demand for homeownership and the demand for rentals in that neighborhood.

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

$$\begin{aligned} d^{ownership}_{1,minority}(p_1,p_2) &= \int_i [\Pr(J(i)=1|O_{i,1}=1 \text{ and } O_{2,1}=1, r=\text{minority})\Pr(O_{i,1}=1)\Pr(O_{i,2}=1) \\ &\quad +\Pr(J(i)=1|O_{i,1}=1 \text{ and } O_{2,1}=0, r=\text{minority})\Pr(O_{i,1}=1)\Pr(O_{i,2}=0)]di \end{aligned}$$

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

$$\begin{aligned} d_j(p_1,p_2) &= d^{rental}_{j,minority}(p_1,p_2) + d^{ownership}_{j,minority}(p_1,p_2) + d^{rental}_{j,whites}(p_1,p_2) + d^{ownership}_{j,whites}(p_1,p_2) \\ &= s_j(p_j) = p_j^{\varepsilon_j} \end{aligned}$$

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

2.2 The equilibrium

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

- households choose consumption, neighborhood and housing status optimally;
- competitive developers supply housing in order to maximize profits;
- competitive lenders break even on loans originated; and
- the housing market clears at prices $(p_1,p_2) = (p_1^*,p_2^*)$.

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

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

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

parameter values.

2.3 Equilibrium segregation

Among the many available segregation measures (Massey & Denton 1988), we choose the isolation and exposure indices. Isolation and exposure have been extensively used in recent literature (Cutler et al. 1999). The isolation index is the average fraction of neighbors of the same race across neighborhoods. For instance, the isolation of whites is the average fraction of white neighbors for white households. The isolation index is a particularly relevant measure when the effect of neighbors on outcomes is considered— as in, for example, standard models with linear-in-means peer effects specification (Manski 1993, Hoxby 2001).[9]

The isolation of whites in the metropolitan area is:

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

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

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

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

where $minorities_j$ is the density of minorities in neighborhood j. In the case of two racial groups, isolation increases when the exposure to other racial groups decreases:[10]

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

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

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

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

[9] Take a peer-effects specification in which the outcome of interest, such as test scores, depends on peers' race and other characteristics: Then $outcome = x_i'\beta + \gamma \text{Neighbors' Race} + \varepsilon_i$. The isolation and exposure indices, multiplied by γ, measure the effect of segregation on average outcome.

[10] In the empirical part, in Section 3, we extend the measures to more than two racial groups.

the equilibrium isolation for whites and minorities.

2.4 Analytical results

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

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

Two parameters, α and β, measure the tightness of lending standards in neighborhood 1. An increase in α corresponds to a relaxation of *overall lending standards* whereas an increase in β captures more specifically a relaxation of *leverage constraints,* since β measures the sensitivity of the likelihood of origination to a change in the loan-to-income or price-to-income ratio. Hereafter we put $\alpha = \alpha_{\text{minority}} = \alpha_{\text{white}}$, which means that our analysis abstracts from the role of racial discrimination in lending practices.[11]

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

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

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

The first term on the right-hand side is the leverage effect of a change in β on isolation. This effect is typically negative, that is, a higher $\beta < 0$ lowers racial segregation. The second term is the *general equilibrium effect* of a change in β on prices multiplied by the effect of prices on isolation. The sign and magnitude of this second effect depend on races' incomes and valuations of the two neighborhoods.

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

[11] Thus there are theoretical effects of credit standards on segregation even without any discrimination in mortgage lending. For empirical evidence on discrimination in mortgage lending, see Ross & Yinger (2002).

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

1. *A relaxation of leverage constraints (i.e., a higher β) reduces isolation.*
2. *If the probability of origination is insensitive to the LTI ratio ($\beta = 0$), there is no segregation; in other words, the isolation of whites is equal to the fraction of whites in the metropolitan area.*

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

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

Proof. See Appendix. □

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

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

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

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

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

2.5 Simulation results

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

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

Model calibration.

Baseline simulations

The simulations are based on a two-neighborhood economy populated by two racial groups: whites (which form the larger group) and racial or ethnic minorities. In our baseline simulation, minorities account for 20% of the population. White households' income is set at 60,000 USD per year and minority households' income at 40,000 USD.[12] We consider an MSA in which one (typically inner-city) neighborhood faces severe geographical constraints to expansion and thus exhibits low housing supply elasticity ($\epsilon = 0.5$) while the other (typically suburban) neighborhood exhibits a much higher supply elasticity ($\epsilon = 2.5$).[13] The parameters of the model that remain constant across the two scenarios are summarized in the following table.

Parameter	Value	Definition
r	0.05	Interest rate
N	$150,000$	Population
s	0.2	Minority share of population.
ω_w	$60,000$	Whites' annual income
ω_b	$40,000$	Minorities' annual income
γ	0.0001	Risk neutrality
$\alpha_w = \alpha_b$	2.5	No discrimination
σ	1000	Standard deviation of the idiosyncratic valuation $\varepsilon_{i,j}$
ε_1	0.5	Housing supply elasticity in neighborhood 1
ε_2	2.5	Housing supply elasticity in neighborhood 2
ζ	$10,000$	Utility value of homeownership

[12] Median annual earnings in 2009 were 44,397 USD for blacks and 64,800 USD for whites (Current Population Survey, US Bureau of Labor Statistics).

[13] The elasticity in this neighborhood is equal to the median supply elasticity of housing across MSAs calculated by Saiz (2010). The robustness of our results to a setup where the more highly valued neighborhood is more elastic is discussed later in the section.

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

The two scenarios may be summarized as follows.

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

In each scenario, we look at the effect of an increase in the "looseness" of leverage constraints on the equilibrium variables, with special attention given to its consequences on urban segregation. Toward that end, we increase from -0.7 to 0 the parameter β, which links the ratio of loan (or price) to income to the origination probability in neighborhood 1.

Scenario 1: Relaxation of leverage constraints reduces urban segregation.

This scenario extends the results of proposition 1 to the general model. Figure (2)(a) plots neighborhood 1's relative price of housing, p_1/p_2. Independently of credit conditions, neighborhood 1 is more expensive for reasons of both demand and supply fundamentals: neighborhood 1 is more valued by both ethnic groups and its supply elasticity is lower. However, the relative price of housing is constrained by higher denial rates for credit as occurs when housing becomes more expensive. Thus, higher prices lead to higher denial rates, which reduces the total demand for housing. As leverage constraints are relaxed, the relative price of neighborhood 1 increases and, at $\beta = 0$, fully reflects the difference in quality between the two neighborhoods. Figure (2)(b) plots denial rates (i.e., one minus the probability of origination) in both neighborhoods as a function of the severity of leverage constraints. Minorities have a lower income. Thus, minorities seeking loans ask for higher LTI ratio than do whites and therefore face higher denial rates. When the borrowing constraint is relaxed, both groups can simultaneously enjoy higher LTI ratios and lower denial probabilities. When $\beta = 0$, the denial rates is the same for both group because income no longer plays any role in the origination decision. Because neighborhood 1 is more expensive than neighborhood 2 for fundamental reasons, relaxing the leverage constraint has a more pronounced effect in this neighborhood. In fact, denial rates in neighborhood 2 are in fact close to (or below 10%) for most of the range of variation in β.[14]

Households put a premium on homeownership over rental, so a consequence of the fall in denial rates is an increase in homeownership. Figure (2)(c) plots the rate of homeownership in both groups

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

and shows that a relaxation of borrowing constraints leads to both an increase and a convergence of ownership rates across both groups.

Figure (2)(d) contrasts the probability of a minority household of living in neighborhood 1 with the share of this neighborhood in the total population. Absent any segregation (i.e., if households were randomly assigned to neighborhoods) the two figures would coincide. When leverage constraints are severe ($\beta = -0.7$) , minorities have only a 52 percent chance of living in neighborhood 1 even though that neighborhood hosts 65% of the population. As leverage constraints are relaxed, this gap is gradually reduced, and when $\beta = 0$, segregation no longer exists. These simulated results confirm the analytical results of the previous section: if relative valuations are *identical* across ethnic groups, then a relaxation of credit standards is enough to desegregate cities.

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

Scenario 2: Relaxation of leverage constraints increases urban segregation.

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

Figure (4) is the analog of Figure (2) for the second scenario. The plots exhibit a similar pattern in terms of neighborhood relative prices, denial rates, and homeownership. However, figure (4)(d), which plots the probability of a minority household living in neighborhood 1, points to a striking difference with scenario 1. As lending standards are relaxed, minority households are gradually priced out of neighborhood 1 even though this neighborhood is growing in population. When $\beta = -0.7$, there is a 27% probability that a given minority household lives in the good neighborhood; when $\beta = 0$, this probability falls to 12%. As before, relaxing borrowing constraints shifts the demand of both groups upward but now it shifts whites' demand curve by much more. In this case, the general equilibrium effect, resulting from higher prices, dominates the leverage effect. Figure (5) reveals the consequences of this increase in urban segregation via isolation and exposure indexes. As β is reduced from -0.7 to 0, the isolation of minorities increases from 0.29 to 0.53 and the isolation of whites from 0.82 to 0.88.[15]

The role of social interactions and preferences for racial segregation.

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

In the baseline model, a household's valuation of neighborhoods 1 and 2 does not depend on their racial composition. In line with the literature on neighborhood choice (Benabou 1996) and the empirical evidence on preferences for racial segregation (Farley, Steeh, Krysan, Jackson & Reeves 1994), we introduce preferences for racial segregation in neighborhood choice. We rewrite the valuation of neighborhood j for individual i of race r as the sum of an exogenous component and an endogenous component depending on the interaction between the racial composition of neighborhood j and the value of social interactions:

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

here $\frac{d_{j,white}}{H_j}$ is the fraction of households of the same race as i in neighborhood j and $v^2_{r(i)}$ measures the importance of social interactions in households' valuation of neighborhoods 1 and 2.

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

Robustness

In our model, an alternative way of relaxing credit conditions is to increase the parameter α which measures the overall lending standards. Figure 10 and Figure 11 in the appendix simulate the baseline economy of scenario 2 for an increase in α from 1.5 to 3.5. The parameter β is set to -0.5. The results are very similar to the ones obtained through an increase in β since a relaxation of the overall lending standards indirectly reduces the importance of leverage in the decision to originate a loan.

Our baseline model economy assumes that the more valued neighborhood (neighborhood 1) exhibits the lowest supply elasticity of housing. We consider here the reverse scenario is which neighborhood 1 is suburbian and exhibits and high elasticity ($\varepsilon_1 = 2.5$) while the other neighborhood is an inner city neighborhood and exhibits low elasticity ($\varepsilon_2 = 0.5$). Figure 12 and Figure 13 in the appendix simulate the baseline economy of scenario 2 for this alternative configuation of housing elasticity. The results obtained are very similar to the baseline results.

As an alternative test, we contrast two MSAs with different elasticities of neighborhood 1 ($\varepsilon_1 = 0.1$ and $\varepsilon_1 = 1.5$) holding constant the elasticity of neighborhood 2 ($\varepsilon_1 = 2.5$). Figure 7 presents the simulation results. When neighborhood 1 has a low elasticity of housing supply, housing prices increase more readily as leverage constraints fall, acting as a price barrier to non-white households. However, the quantitative extent of white inflows to neighborhood 1 is also be limited by the availability of housing. In contrast, if neighborhood 1 has a high elasticity of housing supply, housing prices will not increase as much with a relaxation of leverage; yet most white households who prefer to live in neighborhood 1 will be able to find a house there. Our simulation results

indicate that relaxing borrowing constraints has a stronger effect on segregation when the elasticity of housing supply in the inner city neighborhood is high.

3 Empirics

Scenario 1 and scenario 2, as described in Section 2.5, predict that a relaxation of credit standards can either increase or decrease urban segregation depending on (i) the relative preferences of racial groups for neighborhoods and (ii) income differences. In this section, we empirically assess whether the mortgage credit boom of 1995–2006 and the associated relaxation of lending standards have increased or decreased urban and school segregation.

An empirical analysis of the effect of credit standards on segregation faces several challenges. The first is the *lack of data availability on neighborhood composition at annual frequency*; this is addressed in Section 3.1. Whereas (nearly) exhaustive information on mortgage origination is available annually for the entire sample period (1995–2006), urban segregation based on decennial census data can be computed only in 2000 during this period. We therefore devise an alternative measure of racial segregation using a comprehensive annual dataset of school demographics that provides the racial composition of each of the 90,000 public schools matched with their corresponding census tracts. While we do not claim that there is a constant correlation between school segregation and urban segregation, school composition and neighborhood composition are strongly correlated in our 2000 school-census tract matched dataset.

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

3.1 Data

Mortgage data is that compiled in accordance with the Home Mortgage Disclosure Act (HMDA) for the years 1995–2007.[16] The data were collected by the Federal Financial Institutions Examination Council (FFIEC). Banks, savings associations, credit unions, and other mortgage lending institutions submit information on mortgage applications and mortgage originations to various federal agencies, which in turn report this information to the FFIEC. Reporting is mandatory for all depository institution as well as for non-depository institutions (i.e. for-profit lenders regulated by the Department of Housing and Urban Development that either have combined assets exceeding

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

10 million USD or originated 100 or more home purchase loans, including home refinancing loans, in the preceding calendar year). The HMDA covers nearly 90% of all mortgage applications and originations (Dell'Arriccia et al. 2009). Each mortgage is documented with the loan amount, the income of the applicant, the race and gender of the applicant, and the census tract of the house.[17]

The annual school data provides us with the racial demographics and the geographic location of each school but census data is only decennial at this level of disaggregation. Yet since schools can be geographically matched to neighborhoods, we turn to schools to see whether the racial segregation across schools is affected by changes in credit standards.

School demographics come from the US 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 data set of public schools in the United States; the Private School Universe is available every other year. In the paper we use secondary schools. In order to study the dynamics of segregation at an annual frequency, we restrict our attention to public schools. This should not affect the analysis because, as we show in section 4 credit standards have no significant impact on sorting between public and private schools. Each school is identified by a unique number, its secondary or unified school district, and its geographic position (latitude, longitude, and 5-digit zip code) and is then matched to Metropolitan Statistical Areas with stable borders from 1995 to 2007.[18]

The paper does not claim that there is a constant link between school composition and neighborhood composition.[19] However, at the national level, there is a statistical correlation between the racial demographics of each census tract and the racial demographics of the nearby schools. To see how much of racial composition by census tract can be explained in terms of the racial composition of nearby schools, we regressed census tract composition on the composition of the 10 closest schools 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).[20] Table 1 shows that the racial demographics of the nine nearby schools explain approximately 60% of the variance in census tract racial demographics.

Measures of racial demographics and racial segregation across schools are constructed for each

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

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

[19] There is a large amount of literature on desegregation and integration plans, see for instance Reber (2005).

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

MSA as in Section 2.3.[21] Unlike our approach in the theory part of this paper, within each metropolitan area we measure the segregation of students across schools (instead of the segregation of households across neighborhoods). Urban segregation at the MSA level in the 2000 census and school segregation at the MSA level in 2000 are strongly correlated.[22] We focus on the following MSA-level measures of credit conditions: median LTI ratio, and fraction of mortgage originations with missing applicant income.

The increase in the median LTI reflects the ability for the typical borrower to attain a greater debt leverage over their income. The increase in fraction of mortgage originations with missing applicant income proxies the increase in no-documentation loans. The HMDA glossary states that "The income reported is the total gross annual income an institution relied upon in making the credit decision. The income is missing when an institution does not ask for the applicant's income or rely on it in the credit decision."[23] Also, 2006 HMDA data shows that missing-income mortgages are more likely to be originated by independent mortgage brokers – which are directly and lightly regulated by HUD – (8.6% sold by independent mortgage brokers vs 4.77% in the overall 2006 sample), more likely to be sold to a non-government entity – private label securitizers – (40.1% sold to private label securitizers compared to 42.3% in the overall 2006 sample (Avery, Bhutta, Brevoort, Canner & Gibbs 2010)), and more likely to be originated to minorities (34.4% of minorities vs 30.1% in the overall 2006 sample).

Our data set is matched to the elasticity measures calculated by Saiz (2010), which take into account both the geographic and regulatory constraints on housing. Elasticity is available for the 258 largest MSAs. The average elasticity is 2.8, the median elasticity is 2.5, and the 90th percentile is 4.6.

Finally, the dataset is merged to data on whites' preferences for racial segregation from the General Social Survey. The question used in this paper pertains to whites' right to segregate. As in Charles & Guryan (2008), we use multiple waves (1972-2004) of the General Social Survey to compute means at the Census Division level. The possible answers are 1 (disagree strongly), 2 (disagree slightly), 3 (agree slightly), and 4 (agree strongly). Table 2 presents means by census division. Preferences for segregation are most severe in the southeastern portion of the country and least severe in New England and in the West.

3.2 School segregation and credit conditions 1995-2007

The major driving force of changing racial demographics is growth of the Hispanic population, which increased 36% between the 2000 and the 2010 census. In our data set of 363 MSAs, Hispanics make up 13% of the population in 1995, and 18.1% in 2005. Mechanically then, the exposure of other students to Hispanic students increases and isolation decreases: by 6.1 percentage points for whites, by 2.9 percentage points for blacks, and by 1 percentage point for Asians. The isolation of Hispanics

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

[22] Results available from the authors.

[23] The paper focuses on first lien single family dwellings, where income is missing only when the institution did not rely on income to make its decision.

tends to rise as they move to Hispanic areas; although the exposure of whites to Hispanics goes up, the exposure of Hispanics to whites goes down. These trends are also observed in the between-school district segregation measures. The exposure of blacks to white households decreases by 4 percentage points at the same time, indicating that something besides the pure migration shock is at play.

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

In the same period of time, lending standards changed tremendously (see Figure 8): the volume of originations grew fourfold for Hispanics, doubled for blacks, and increased by 50% for whites. The median loan-to-income ratio grew by 0.4, with similar trends for the different racial groups. Figure 8 (b) shows that the 90th percentile of the LTI ratio followed a similar trend. During the same time period, the fraction of mortgage originations with missing applicant income increased from 2% of overall originations to 6 to 8% of mortgage originations (see Figure 8(c)). This suggests that the growth of the volume of mortgage originations happenned partly through a growth in mortgage originations with missing income. Mortgage with missing applicant income are more likely to be sold to non-government entities, and more likely to be sold by independent mortgage brokers, as pointed out in section 3.1.

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

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

- **Borrowers' creditworthiness**:The increase in LTI occured alongside a deterioration in borrowers' credit quality $corr(\Delta\text{LTI}, \Delta\text{Past Due}) > 0$.[24] In this paper, the effect of interest is the effect of a relaxation of the leverage constraint on segregation, given borrowers' creditworthiness. Controlling for creditworthiness is specially important because Hispanic population grew more in areas that experienced a larger decline in borrowers' creditworthiness.

- **Demand shocks:** These may occur at the same time as changes in lending standards. However, we observe that the growth in the LTI ratio occurred primarily in areas where the median applicant income declined: $Corr(\Delta\text{LTI}, \Delta\text{Income}) < 0$. This indicates that an increase in de-

[24]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.

mand for credit or for housing is unlikely to be a full explanation for the trends. Lending standards declined over the period.

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

3.3 Identification strategy

Because credit conditions determine segregation both through its *direct effect* on segregation and through its *general equilibrium* effect on prices, which in turn affect segregation, we lay out here a simple two-equation model. This section shows that the paper estimates a single *reduced-form* coefficient that combines both effects into a single estimate. The two equations also highlight the main identification issues.

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

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

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

where k indexes MSAs and t indexes years. The effect of credit standards conditional on prices is the *leverage effect* of Section 2.4.[25] The effect of prices on segregation is documented in Cutler, Glaeser & Vigdor (2008) and is theoretically grounded in Section 2.4 of this paper.[26] In many MSAs there were large increases in Hispanic population over the period, and some MSAs (e.g. Austin–Round Rock, TX) grew substantially (more than 40%) over the period 1995–2007 owing to a large influx of Hispanic population. These changes have an impact β on segregation independently of credit conditions. Changes in racial demographics are also due to migrations in and out of the MSA, differential birth rates, and differential mortality rates across racial groups. The year dummy Year_t, which is common to all MSAs, captures secular declines or increases in segregation. Finally, demand shocks capture changes in segregation that are due to shifts in either the demand curve for credit or the demand curve for housing. Changes in households' expectations of future price increases or income shocks are part of this vector of covariates.

The second equation shows that the price of housing is determined by segregation, racial demo-

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

graphics, national trends, credit conditions, and other factors:

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

This equation is an aggregated version of the hedonic equation of Cutler et al. (2008). The general equilibrium effect c of credit conditions on prices is debated and analyzed in Glaeser, Gottlieb & Gyourko (2010).[27] The effect a of segregation on prices is indirectly determined by households' valuation of segregation.[28] If we combine equations (8) and (9), the reduced-form model is then:

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

where $\text{Year}_t = (\text{Year}_t^s\delta + \text{Year}_t^p)/(1-a\delta)$ and $\text{MSA}_k = (\text{MSA}_k^s\delta + \text{MSA}_k^p)/(1-a\delta)$. Hence the reduced-form effect of credit conditions $(c\delta+\gamma)/(1-a\delta)$ incorporates the two effects highlighted in the model: the *general equilibrium effect* of credit conditions on prices and on segregation $(c\delta)/(1-a\delta)$[29] and the *leverage effect* $\gamma/(1-a\delta)$ of credit conditions on segregation (cf. Section 2.4).

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

The main specification of the paper estimates the reduced-form equation (10) by decomposing the credit standards term into measures of the LTI ratio, measures of the fraction of loans with missing applicant income, and measures of applicants' creditworthiness:[30]

$$\begin{aligned}\text{Segregation}_{k,t} &= \text{LTI}_{k,t}\cdot C + \text{Missing Income}_{k,t}\cdot C' + \text{Racial Demographics}_{k,t}\cdot B \\ &\quad + \text{Creditworthiness}_{k,t}\cdot D + \text{MSA}_k + \text{Year}_t + u_{k,t}, \end{aligned} \tag{11}$$

where the residual $u_{k,t} = \text{Demand Shocks}_{k,t}\frac{h\delta+\eta}{1-a\delta} + \frac{e_{k,t}^s\delta+e_{k,t}^p}{1-a\delta}$. The dependent variable $\text{Segregation}_{k,t}$ is a measure of segregation (isolation of whites, Hispanics, blacks and Asians), or of the exposure of a racial group to another racial group. Here $\text{LTI}_{j,t}$ is the median loan-to-income ratio (LTI) and $\text{Missing Income}_{k,t}$ is the MSA-level fraction of mortgage originations with missing applicant income.

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

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

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

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

Creditworthiness$_{k,t}$ is a vector that includes the fraction of subprime loans;[31] the fraction of jumbo loans[32] in year t; the fraction of delinquencies, foreclosures, and mortgages at least 90+ days past due[33] in year $t+4$; and the fraction of high-risk loans. To identify high-risk loans, we estimate the probability of denial for 1995 mortgages as a function of demographic characteristics (race, gender) and characteristics of the loan (LTI ratio, loan amount), as well as between the interaction of the two sets of variables. We then use this prediction to estimate the fraction of high-risk loans in year $t \geq 1995$ using the credit standards of 1995. The term Racial Demographics$_{k,t}$ is a vector of the fraction of each racial and ethnic group in the MSA: fraction of white non-Hispanic, Hispanic nonwhite, black (non-Hispanic), of Asian, and of other racial groups.

The residual $e_{k,t}$ might not be free of endogeneity. The remaining unobservable demand factor, Demand Shocks$_{k,t}$, is still potentially correlated with the LTI ratio and may still affect segregation. In this case, regression (11) overestimates the true effect of the LTI ratio on segregation. To address this potential issue, we add controls for the 10th, 25th and 50th percentile of income by racial group.

Our main regressions (equation 11) are weighted by the number of students in the MSA in 1995. This gives more weight to large MSAs and less weight to very small MSAs. The rationale for the weighting is that the effect of credit conditions is likely to be different in small and large MSAs.[34]

In all specifications, residuals are clustered at the MSA level. There are 355 MSAs overall, so the number of clusters is large; there are 13 years of observations and thus 13 points per MSA. Hence, clustering by MSA is likely to yield good estimates of standard errors (Wooldridge 2003). We also performed "multi-way" clustering (Cameron, Gelbach & Miller 2006).[35]

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

3.4 Results

Baseline Regression

Tables 5, 6, and 7 present results of the estimation of baseline regression (11) for the segregation of black, white and Hispanic students respectively [36]. Column 1 of each table presents estimates of the effect of the loan-to-income ratio controlling for demographics, income and MSA fixed ef-

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

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

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

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

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

[36] For Asians, results are available on request.

fects. Column 2 of each table presents estimates of the effect of the fraction of missing applicant income controlling for demographics, income and MSA fixed effects. Column 3 uses the two measures of credit conditions together. Column 4 introduces controls for borrowers' creditworthiness. Coefficients are stable across the first four columns.

In columns 1 to 4, segregation is measured by the isolation index. Columns 5 and 6 present effects of the LTI statistics on measures of racial exposure to the other races. For instance, columns 5 and 6 of table 5 estimate the effect of credit standards on the exposure of blacks to whites and on the exposure of blacks to Hispanics.

Overall, the results suggest that a relaxation of the leverage constraint increased segregation significantly for blacks and whites. A increase of 1 in the median LTI increases black students' isolation by 2.2 percentage points (Table 5, column 4). Given the increase of 0.4 in the median LTI ratio over the 1995-2005 period, this amounts to an effect of 0.88 percentage points on isolation. The overall positive impact of the median loan-to-income ratio on segregation is consistent with the mobility of white and Hispanic households out of black neighborhoods, which is suggested by the effect of leverage constraints on racial exposure (column 5 and 6). For example, the exposure of black students to white peers declines by 1.3 percentage points when the LTI ratio increases by 1. Missing applicant income loans lead to higher segregation as well. An increase of the fraction of loans with missing applicant income by 10 percentage points increases the isolation of blacks by an effect that ranges from 1.7 percentage points in the specification without the LTI ratio (column 2, table 5), and by 2.69 percentage points in the specification with the LTI ratio and creditworthiness measures (column 4 of the same table). Similarly to the effect of the LTI, a higher fraction of missing income loans lowers the exposure of blacks to whites (column 5) and to Hispanics (column 6).

The effect of the median loan-to-income ratio on the isolation of whites is positive and significant at 95% (Table 6, columns 1–4). This effect seems to be driven by the mobility of whites out of black neighborhoods (column 6, negative effect of the LTI on the exposure to blacks).

Table 7 presents the results for Hispanic isolation. Even though results are non significant on average, results are suggestive of an increased exposure to whites and a lower exposure to blacks. Also, results for Hispanics are consistent with the results for whites and blacks: indeed, small changes in the mobility patterns of Hispanics may impact the exposure of blacks to Hispanics and the exposure of whites to Hispanics much more than it impacts the exposure of Hispanics to blacks and whites.

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

Between school district segregation

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

affect segregation. In general, desegregation policies can act within the boundaries of school districts but do not operate across school district boundaries.[37] As a consequence, and in order to better isolate the mortgage credit channel, we look at whether relaxing the leverage constraint can affect segregation *across school districts*.

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

$$\text{Between-School District Isolation}_k(whites) = \sum_{q=1}^{Q_k} \frac{whites_{q,k}}{whites_k} \cdot \frac{whites_{q,k}}{students_{q,k}},$$

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

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

To estimate the effect of credit standards on between school district segregation, we estimate specification (11) using the between-school district segregation measures as dependent variables. The results are presented in column 7 of Tables 5 to 7.

An increase of 1 in the median loan-to-income ratio increases the between-school district isolation of blacks by 3.1 percentage points, which is similar to the result of the main regression for blacks (Table 5, column 4). Thus, for blacks, an increase in isolation due to increased leverage is mostly the result of a change in between-school district isolation. Results available on demand show that a higher median LTI ratio lowers the between-school district exposure of blacks to whites. (The between-school district exposure of black students to white students is the average fraction of white students in the school district for an average black student.)

Column 6 of table 6 shows that a higher median LTI ratio increases the between-school district isolation of whites by 0.91 percentage points, a similar magnitude compared to effect on baseline isolation (column 4 of 6), which is the combination of the effects of the LTI on between-school and within school district segregation. Higher median leverages, helps white households move into predominantly white school districs. Interestingly, for whites, the increase in missing income mortgage originations lowers between school district isolation (-0.153, column 7 of table 6), indicating that different races are benefiting from higher leverages and from missing income loans.

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

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

Effects of Leverage by Preference for Segregation

The extension of the baseline model developed on page 14 of this paper introduced preferences for neighbors of the same race in addition to the exogenous utility of local amenities. Comparative statics for this extension suggested that metropolitan areas with stronger preferences for neighbors of the same race should experience larger effects of credit conditions on segregation (on page 14, the parameter $v^2_{r(i)}$ measures preferences for white neighbors; a larger $v^2_{r(i)}$ corresponds to stronger preferences for segregation).

Data from the General Social Survey suggests that there are indeed large variations in preferences for segregation across the nine Census divisions of the United States.[38] Column (8) of tables 5 to 7 interact the median LTI ratio with the difference between the preference for segregation measure and the average preference for segregation measure. Results for whites are suggestive: An increase of the LTI by 1 increases the isolation of whites in the MSA by 1.121 percentage points in the MSA with average preference for segregation. Effects are stronger in census divisions where there are stonger preferences for segregation.

Results for blacks indicate similar effects: The effect of an increase of the loan-to-income ratio by 1 increases the isolation of blacks by 2.54 percentage point in MSAs with average preferences for segregation, and increases the isolation of blacks by 3.77 percentage point in the MSAs with the strongest preferences for segregation. Effects are significant at 95%.

Effects of leverage by elasticity

Metropolitan areas differ significantly in their restrictions on land use and in their geographical constraints on the supply of housing. Those MSAs with an elastic supply of housing (i.e., where the supply of housing expands when the price of housing rises), may see a greater effect of credit conditions on segregation. This is because, as described in scenario 2 of Section 2.5, a greater expansion in the supply of housing makes it easier for households to segregate. The elasticity of housing supply is the parameter ε_j of the marginal cost on page 7.

Column 9 of tables 5 to 7 presents results of baseline specification (11) augmented with the interaction of the median LTI ratio with the difference $(\text{Elasticity-}\overline{\text{Elasticity}})$ between metropolitan area elasticity and the average MSA elasticity of 2.773. As in column 4 of the previous tables, regressions control for demographics, income, and creditworthiness measures in addition to MSA and year fixed effects.

These results support the theoretical scenario of Section (2.5), where the effect of relaxing the leverage constraint on the isolation of minorities is *stronger in highly elastic metropolitan areas.* The role of housing elasticity is specially relevant for Hispanics, whose population increased sharply during the period. An increase of 1 in the median loan-to-income ratio increases the Hispanic isolation by 1.125 percentage points more in MSAs where the elasticity is 100 percentage points higher.

[38] Census divisions are groupings of states.

Finally, one potential concern is that MSAs with lower elasticities experienced higher increases in house prices, which could make it impossible to identify the effect of elasticity separately from the effect of rising prices. However, additional results (available from the authors) suggest that controlling for an estimate of the housing price index does not change the coefficients of interest.[39]

Counterfactual analysis: segregation trends without the credit boom

The preceding discussion shows that increases in both the median and the fraction of missing income mortgage originations increases the isolation of black and white students. Other determinants of segregation include the other measures of credit conditions (applicants' creditworthiness measures, described in Section (3.3)) as well as shocks to applicants' incomes, demographics, MSA fixed effects, and unobservables.

As a final empirical exercise, we compute the counterfactual isolation of blacks by subtracting the effect of the change in the median loan-to-income ratio on isolation from the actual change in isolation. We use the point estimate of the effect of the median LTI ratio on isolation while controlling for MSA fixed effects, demographic controls, income and creditworthiness measures, and year dummies. The effect is 2.212 for blacks, with a standard error of 0.996 (Table 5, column 3). Hence, for blacks,

$$\begin{aligned}\text{Counterfactual Isolation}_t &= \text{Counterfactual Isolation}_{t-1} + \Delta\text{Isolation}_t \\ &\quad -2.212 \cdot \Delta\text{Median LTI}_t,\end{aligned}$$

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

The bold lines in Figure 9 show the actual isolation of black and white students from 1995 to 2007, as in the upper part of Table 3. What is novel in this figure is the dashed lines showing the counterfactual isolation of white and black students.

The upper graph of figure 9 plots the isolation and the counterfactual isolation of blacks. Factors other than the leverage make black isolation to fall by 2.9 percentage points. During the same period, the median loan-to-income ratio increased by 0.4. Without this increase in the LTI ratio, the isolation of blacks would have been between 0.2 and 2 percentage points lower than it was in 2007 — provided our identification strategy and confidence intervals are correct.

The lower part of Figure 9 plots a similar graph for white students. Factors other than the loan-to-income ratio caused isolation to drop by 6.1 percentage points from 1995 to 2007. Over this period, the median loan-to-income ratio increased by 0.4. The effect of the median loan-to-income ratio is 0.678 in the regression of column 4 (Table 6), and white isolation would have been between 0.3 and 0.4 percentage points lower without the relaxation of the leverage constraint. This is again conditional on a correct identification and inference strategy.

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

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

4 Conclusion

The increased availability of mortgage credit — fueled by financial sophistication, banking deregulation, and lenders' supply of credit — dramatically affected lending standards during the credit boom. The mortgage credit market appears to be a powerful driving force of segregation, mainly through its effect on leverage, which affects racial groups' ability to outbid each other for housing in desirable neighborhoods. Greater leverage increases the isolation of blacks and whites across schools and school districts. This means that segregation declined at a slower pace than would have occured solely from the inflow of Hispanic migrants and other factors.

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

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

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

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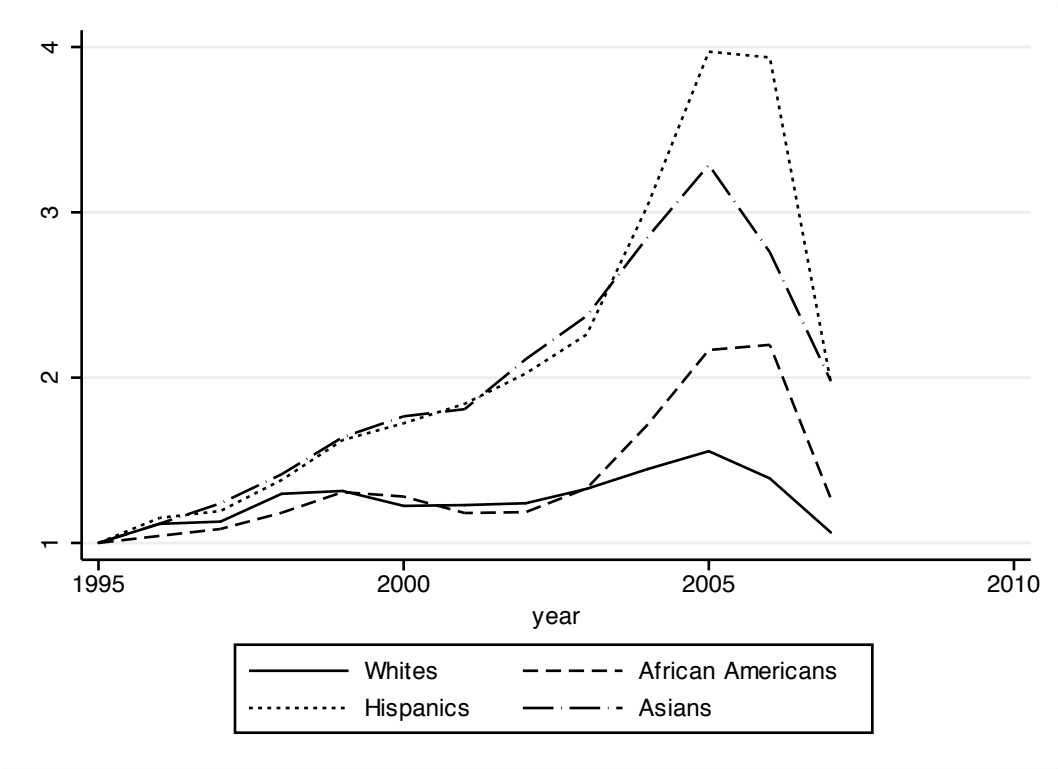
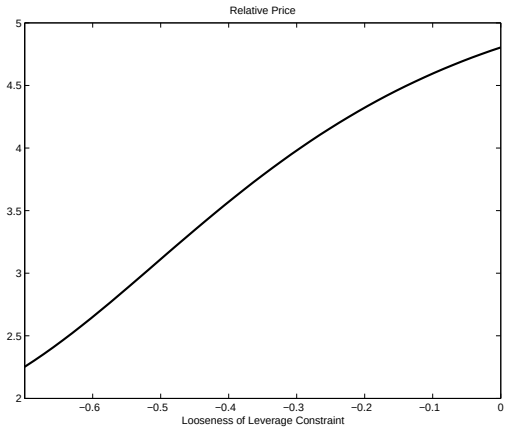
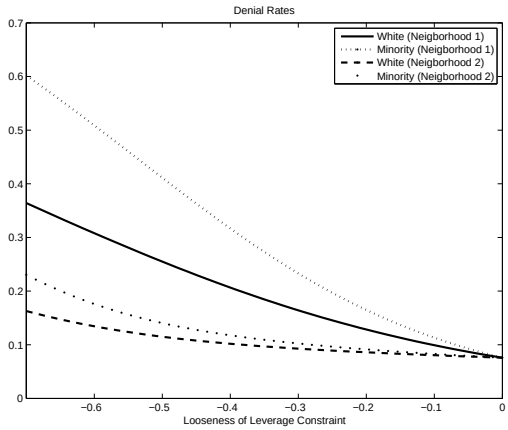


Notes: By race, volume is normalized to 1 in 1995. All racial groups are non-Hispanic members of those races. Hispanics are shown as a separate category.
Source: Home Mortgage Disclosure Act data, 1995 to 2007.

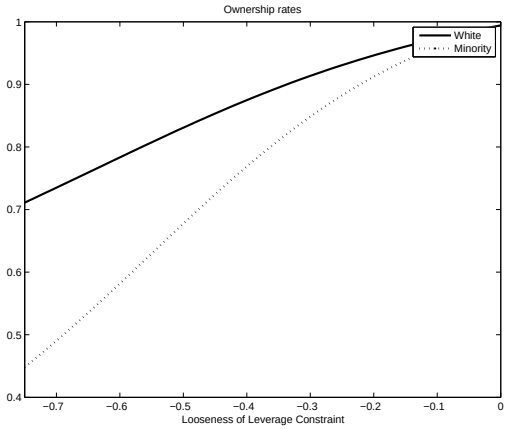
Figure 1: Volume of Mortgage Originations



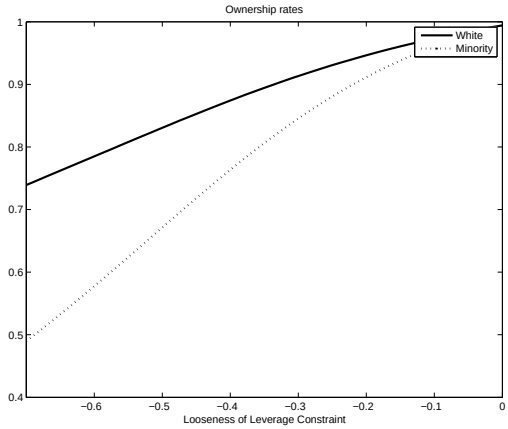
(a) Relative Price



(b) Denial Rate



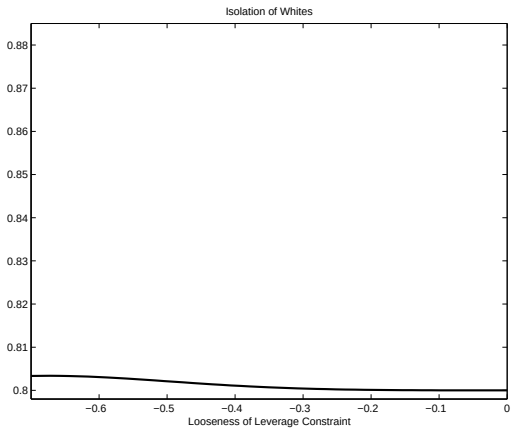
(c) Home Ownership



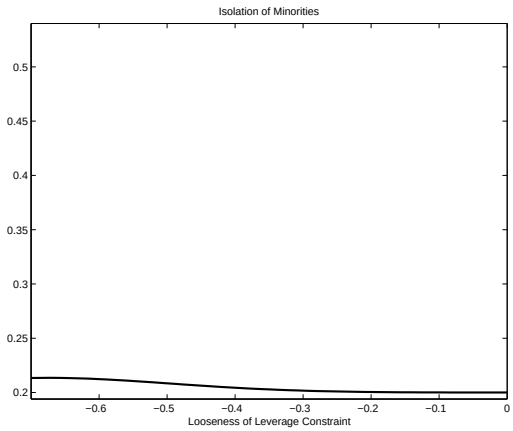
(d) Probability of Minorities Living in Neighborhood 1

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

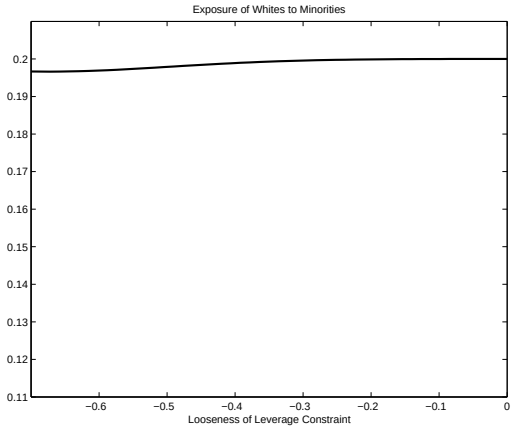
Figure 2: Scenario 1



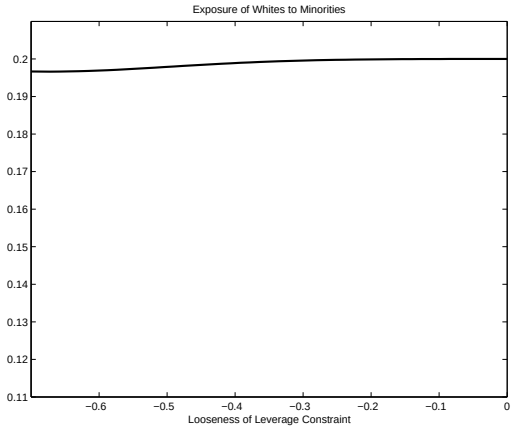
(a) Isolation of Whites



(b) Isolation of Minorities



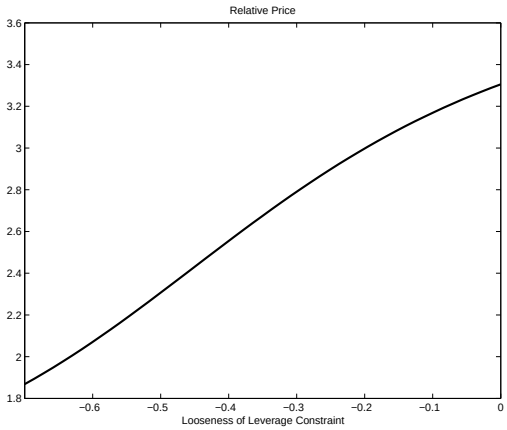
(c) Exposure of Whites to Minorities



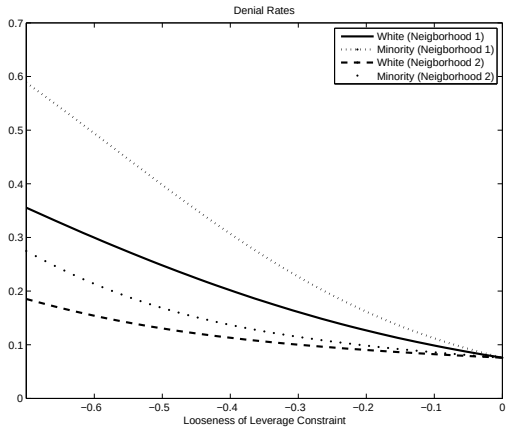
(d) Exposure of Minorities to Whites

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

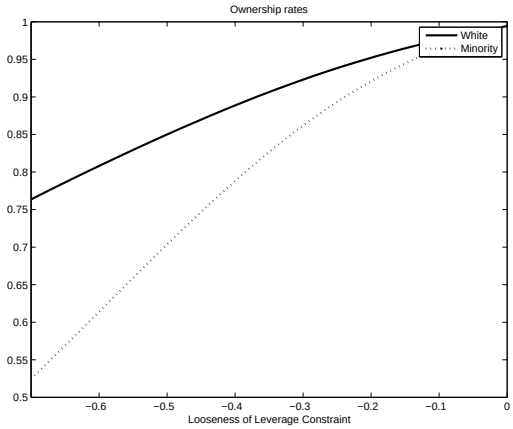
Figure 3: Scenario 1 — Segregation and Credit Constraints



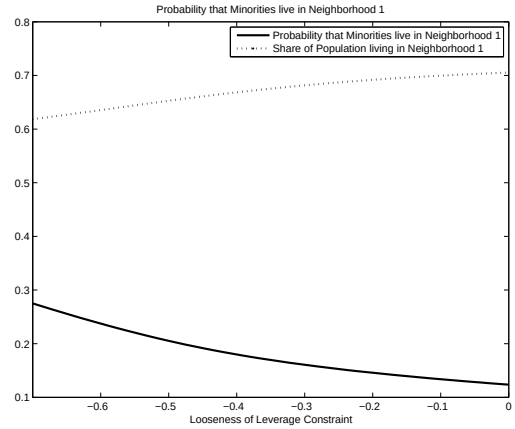
(a) Relative Price



(b) Denial Rate



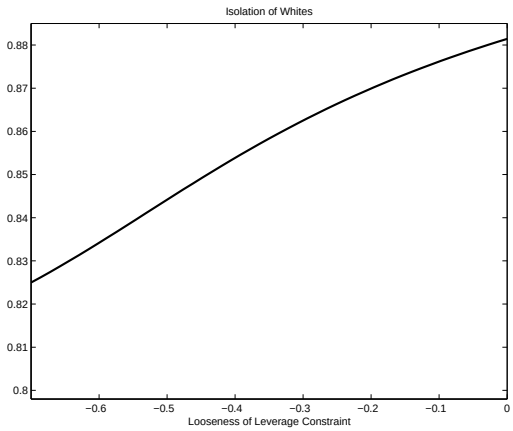
(c) Home Ownership



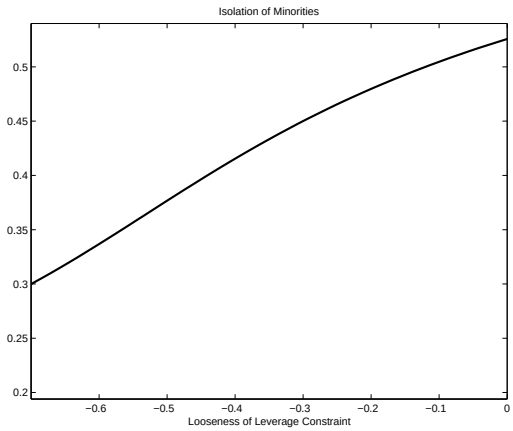
(d) Probability of Minorities Living in Neighborhood 1

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

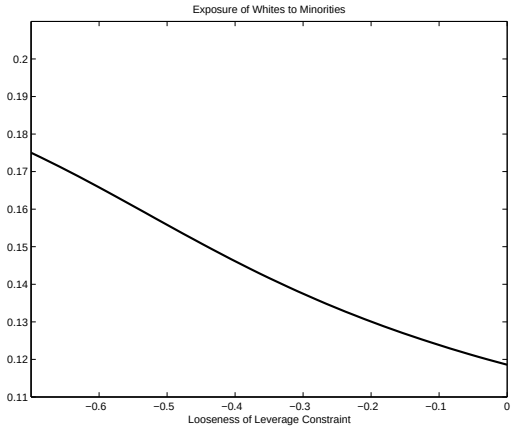
Figure 4: Scenario 2



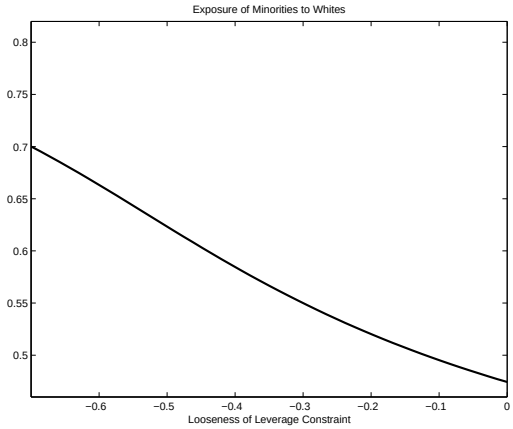
(a) Isolation of Whites



(b) Isolation of Minorities



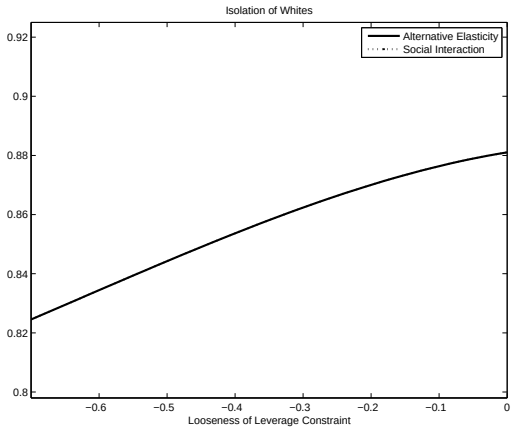
(c) Exposure of Whites to Minorities



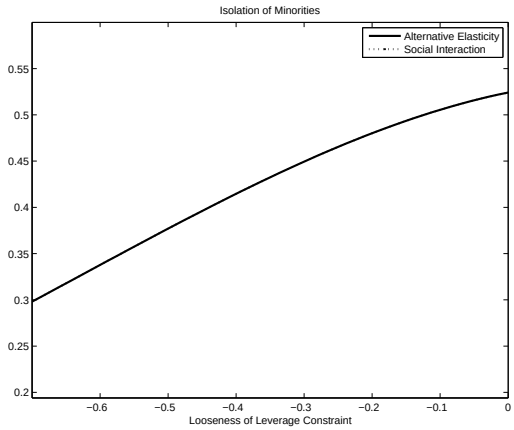
(d) Exposure of Minorities to Whites

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

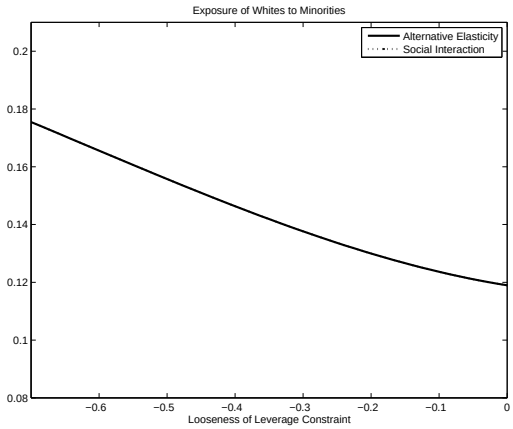
Figure 5: Scenario 2 — Segregation and Credit Constraints



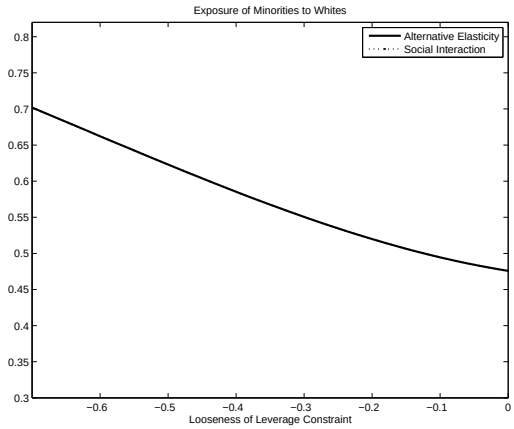
(a) Isolation of Whites



(b) Isolation of Minorities

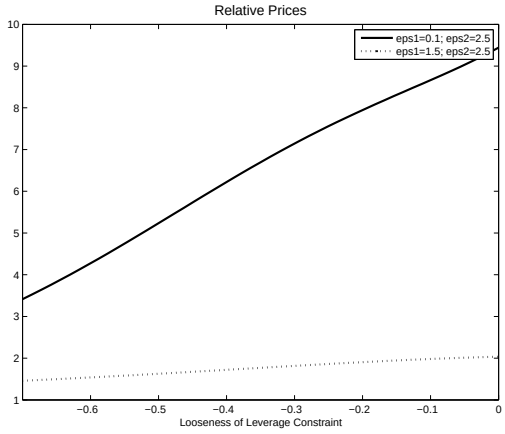


(c) Exposure of Whites to Minorities

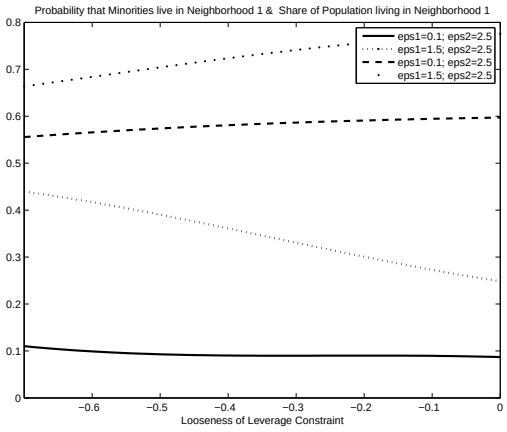


(d) Exposure of Minorities to Whites

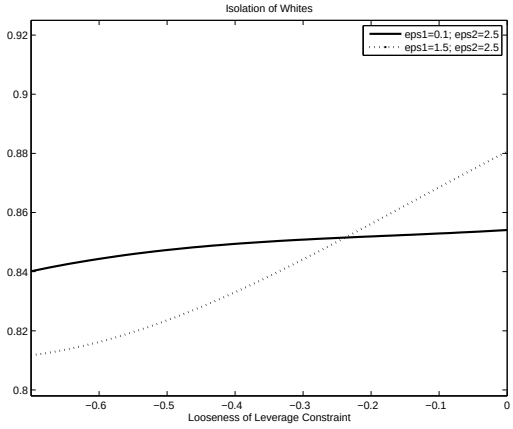
Figure 6: The Role of Social Interactions



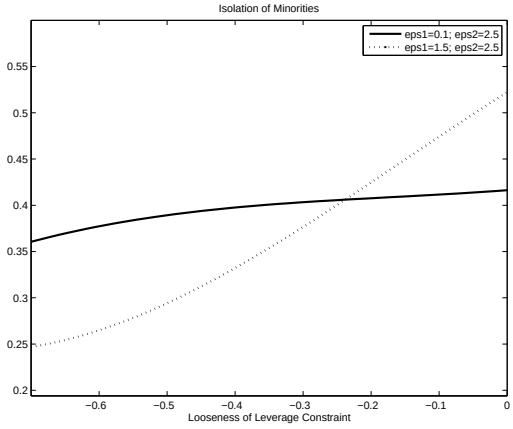
(a) Relative Prices



(b) Probability of Living in Neighborhood 1

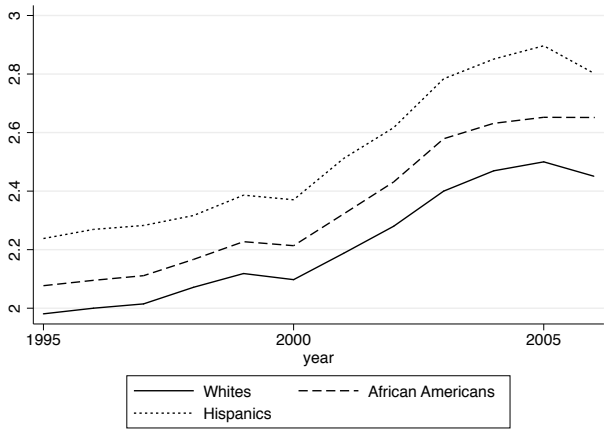


(c) Isolation of Whites

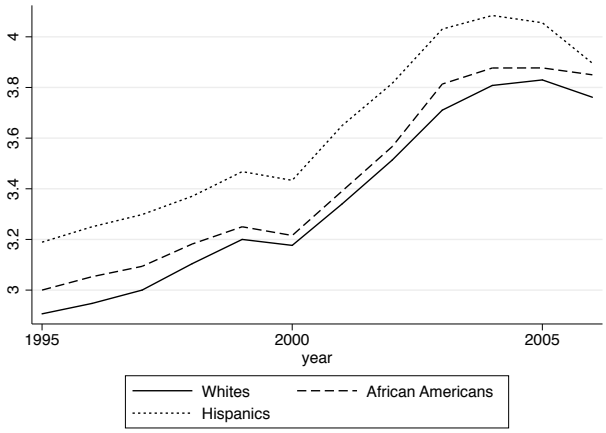


(d) Isolation of Minorities

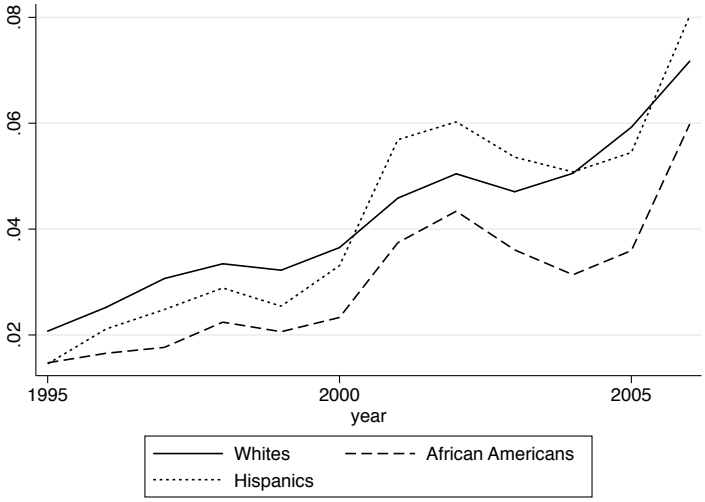
Figure 7: The Role of Housing Supply Elasticity



(a) Median LTI Ratio



(b) 90th Percentile LTI Ratio



(c) Fraction of Originations with Missing Income

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

Figure 8: Credit Standards by Race

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

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

The dependent variable is the fraction black in each census tract. Controls include the distance with each school, dummies for schools further than 15 miles and 30 miles from the census tract. Source: Common Core of Data 2000, Public School Universe, matched with Census 2000.
Reading: An increase in the fraction of black students in the nearest school by 10 percentage points predicts a 4 percentage point increase in the fraction black in the census tract.

Table 1: Predicting Census Tract Composition with School Composition

Census Division	Whites Have Right To Segregate Neighborhood
East South Central	2.356
South Atlantic	2.187
West South Central	2.011
East North Central	2.007
West North Central	1.930
Middle Atlantic	1.919
Mountain	1.642
New England	1.647
Pacific	1.628

Source: General Social Survey and Charles and Guryan (2008). The possible answers are 1 (disagree strongly), 2 (disagree slightly), 3 (agree slightly), and 4 (agree strongly).

Table 2: Prejudice Across Census Divisions

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

Source: Public and Private School Universe, K12 schools.

Table 3: School Segregation in Metropolitan Statistical Areas, 1995-2007

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

Table 4: Correlation Table

VARIABLES	(1) Isolation	(2) Isolation	(3) Isolation	(4) Isolation	(5) Exposure to whites	(6) Exposure to hispanics	(7) Between S.D. Isolation	(8) Isolation	(9) Isolation
Median LTI Ratio	1.851*		2.292**	2.212*	-1.282*	-1.000+	3.103**	2.540**	4.678**
	(0.853)		(0.887)	(0.996)	(0.647)	(0.576)	(0.845)	(0.986)	(1.422)
Median LTI Ratio × (Right to Seg. - $\overline{\text{Right to Seg.}}$)								3.092	
								(2.355)	
Median LTI Ratio × (Elasticity - $\overline{\text{Elasticity}}$)									0.192
									(0.364)
Fraction with Missing Income		0.171*	0.250**	0.269**	-0.199*	-0.119**	-0.023	0.268**	0.266**
		(0.085)	(0.088)	(0.085)	(0.081)	(0.027)	(0.198)	(0.088)	(0.084)
Observations	4,255	4,255	4,255	4,255	4,255	4,255	4,205	4,255	4,255
R-squared	0.580	0.577	0.585	0.590	0.614	0.901	0.443	0.591	0.597
Number of msa	359	359	359	359	359	359	359	359	359
Demographics Controls	x	x	x	x	x	x	x	x	x
Income measures	x	x	x	x	x	x	x	x	x
Creditworthiness Measures				x	x	x	x	x	x
MSA Fixed Effect	x	x	x	x	x	x	x	x	x
Year Fixed Effects	x	x	x	x	x	x	x	x	x
F	34.47	38.39	37.45	44.59	45.69	163.8	14.41	50.32	47.69

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

Demographic Controls: Fraction of Hispanic, black, and Asian students in the MSA. Creditworthiness 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. MSA: Metropolitan Statistical Area. Standard errors clustered by MSA. Regressions are weighted by the number of Black students in the MSA in 1995. $\overline{\text{Elasticity}}$ is the average elasticity of housing supply (2.773), hence (Elasticity-$\overline{\text{Elasticity}}$) is the difference between the elasticity of the MSA and the average elasticity. $\overline{\text{Right to Seg.}}$ is the average answer to the question on whites' right to segregate in the General Social Survey (1.958).
Reading: If the median LTI ratio increases from 2 to 3, the isolation of black students increases by 1.9 percentage points. If the fraction of mortgages with missing applicant income increases by 10 percentage points, the isolation of Black students increases by 1.71 percentage points.

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

VARIABLES	(1) Isolation	(2) Isolation	(3) Isolation	(4) Isolation	(5) Exposure to hispanics	(6) Exposure to blacks	(7) Between S.D. Isolation	(8) Isolation	(9) Isolation
Median LTI Ratio	0.609*		0.556*	0.678*	0.335*	-0.304	0.910+	1.121**	0.377
	(0.308)		(0.280)	(0.292)	(0.155)	(0.194)	(0.477)	(0.364)	(0.390)
Median LTI Ratio × (Right to Seg. - $\overline{\text{Right to Seg.}}$)								2.677**	
								(0.812)	
Median LTI Ratio × (Elasticity - $\overline{\text{Elasticity}}$)									-0.024
									(0.166)
Fraction with Missing Income		-0.055	-0.041	-0.033	0.042+	-0.043+	-0.153*	-0.038	-0.034
		(0.051)	(0.047)	(0.046)	(0.024)	(0.023)	(0.077)	(0.045)	(0.046)
Observations	4,255	4,255	4,255	4,255	4,255	4,255	4,213	4,255	4,255
R-squared	0.837	0.837	0.838	0.839	0.932	0.526	0.745	0.840	0.839
Number of msa	359	359	359	359	359	359	359	359	359
Demographics Controls	x	x	x	x	x	x	x	x	x
Income measures	x	x	x	x	x	x	x	x	x
Creditworthiness Measures				x	x	x	x	x	x
MSA Fixed Effect	x	x	x	x	x	x	x	x	x
Year Fixed Effects	x	x	x	x	x	x	x	x	x
F	120.8	119.1	126.2	116.6	280.0	28.67	92.03	118.8	111.3

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

Demographic Controls: Fraction of Hispanic, black, and Asian students in the MSA. Creditworthiness 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. MSA: Metropolitan Statistical Area. Standard errors clustered by MSA. Regressions are weighted by the number of white students in the MSA in 1995. $\overline{\text{Elasticity}}$ is the average elasticity of housing supply (2.773), hence (Elasticity-$\overline{\text{Elasticity}}$) is the difference between the elasticity of the MSA and the average elasticity. $\overline{\text{Right to Seg.}}$ is the average answer to the question on whites' right to segregate in the General Social Survey (1.958).
Reading (column 1): If the median LTI ratio in an MSA increases from 2 to 3, the isolation of white students increases by 0.609 percentage points, and the exposure to Hispanic students increases by 0.335 percentage points.

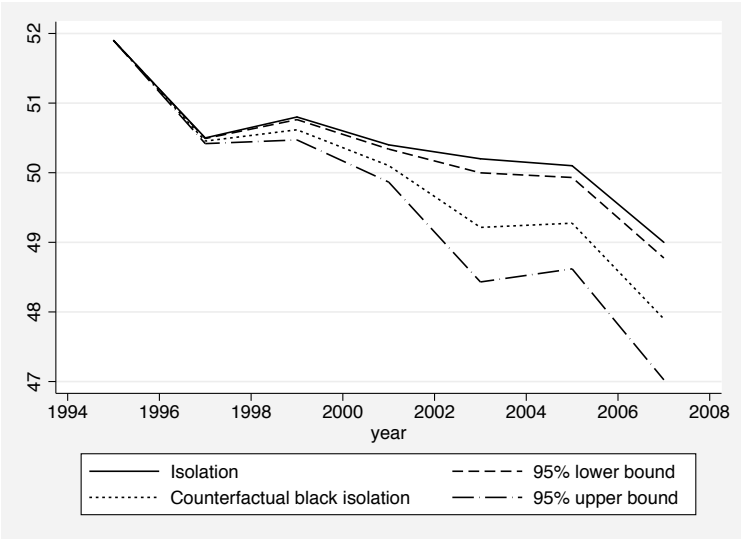
Table 6: Credit Standards and Segregation - Segregation of White Students

VARIABLES	(1) Isolation	(2) Isolation	(3) Isolation	(4) Isolation	(5) Exposure to whites	(6) Exposure to blacks	(7) Between S.D. Isolation	(8) Isolation	(9) Isolation
Median LTI Ratio	-0.396		-0.318	-0.581	0.538	-0.321	0.869	-0.547	1.916+
	(0.496)		(0.574)	(0.560)	(0.528)	(0.203)	(0.769)	(0.899)	(1.033)
Median LTI Ratio × (Right to Seg. - $\overline{\text{Right to Seg.}}$)								0.138	
								(2.132)	
Median LTI Ratio × (Elasticity - $\overline{\text{Elasticity}}$)									1.125*
									(0.573)
Fraction with Missing Income		0.049	0.033	0.022	-0.014	-0.056*	-0.239+	0.022	0.027
		(0.051)	(0.062)	(0.064)	(0.062)	(0.024)	(0.134)	(0.061)	(0.065)
Observations	4,253	4,253	4,253	4,253	4,253	4,253	4,207	4,253	4,253
R-squared	0.805	0.805	0.805	0.813	0.827	0.568	0.728	0.813	0.816
Number of msa	359	359	359	359	359	359	359	359	359
Demographics Controls	x	x	x	x	x	x	x	x	x
Income measures	x	x	x	x	x	x	x	x	x
Creditworthiness Measures				x	x	x	x	x	x
MSA Fixed Effect	x	x	x	x	x	x	x	x	x
Year Fixed Effects	x	x	x	x	x	x	x	x	x
F	55.25	49.15	50.06	66.80	65.04	51.62	93.06	64.13	56.90

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

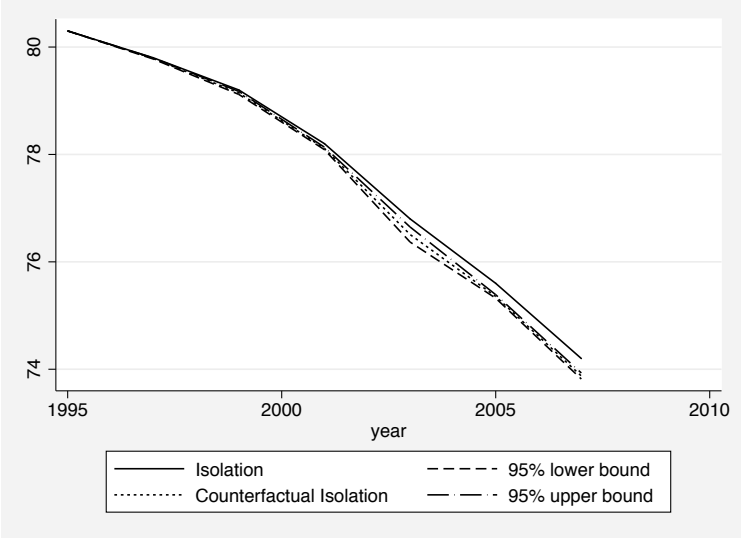
Demographic Controls: Fraction of Hispanic, black, and Asian students in the MSA. Creditworthiness controls: Measures of applicants credit worthiness (fraction jumbo, fraction subprime, fraction 90+ overdue and foreclosures 4 years after the year of observation, fraction of high risk loans as measured by 1995 credit standards). LTI: Loan-to-Income Ratio. MSA: Metropolitan Statistical Area. Standard errors clustered by MSA. Regressions are weighted by the number of Hispanic students in the MSA in 1995. $\overline{\text{Elasticity}}$ is the average elasticity of housing supply (2.773), hence (Elasticity-$\overline{\text{Elasticity}}$) is the difference between the elasticity of the MSA and the average elasticity. $\overline{\text{Right to Seg.}}$ is the average answer to the question on whites' right to segregate in the General Social Survey (1.958).
Reading (column 1): If the median LTI ratio in an MSA increases from 2 to 3, the isolation of Hispanic students increases by 1.916 percentage points in an MSA with average elasticity of housing supply, and by 3.0 percentage points in an MSA with an elasticity of 100 percentage points above the average elasticity.

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



(a) Black Isolation

Reading: Without the increase of the Loan-to-Income ratio from 1995 to 2004, the isolation of blacks would have decreased from 51.9 to 47.9. The actual isolation of blacks decreased from 51.9 to 49.



(b) White Isolation

Reading: Without the increase of the Loan-to-Income ratio from 1995 to 2004, the isolation of whites would have decreased from 80.3 to 73.8. The actual isolation of whites decreased from 80.3 to 74.2.

Figure 9: Actual and Counterfactual Segregation

Appendix: Analytical Results (Section 2.4)

The City

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

The Equilibrium

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

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

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

- Developers supply a density 1 of houses.
- Lenders supply credit to all borrowers in neighborhood 2, $\Pr(O_{i,2} = 1) = 1$, and supply credit to borrowers in neighborhood 1 with probability $\Pr(O_{i,1} = 1) = \frac{\exp(\alpha_{r(i)} + \beta p_1/\omega_{r(i)})}{1+\exp(\alpha_{r(i)} + \beta p_1/\omega_{r(i)})}$, $\beta < 0$.
- The market price in neighborhood 2 is normalized to 1.
- The market price in neighborhood 1 equates demand and supply.

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

Existence and uniqueness of the equilibrium

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

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

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

Because of the logit specifications of the two factors,

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

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

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

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

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

Expansion of Credit Volume

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

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

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

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

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

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

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

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

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

Hence

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

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

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

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:

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

Proposition 2 on page 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 α increases segregation if and only if :

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

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

Proposition 1 on page 11: Different incomes, Equal valuations of neighborhood 1

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

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

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

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

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

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

Higher Leverages

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

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

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

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

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

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

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

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

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

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

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

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 (β increasing) increases segregation.

Proposition 1 on page 11: Different Income, Equal valuations of neighborhood 1

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

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

when β tends to zero, this expression collapses to

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

which is less than one and

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

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

Appendix

Public and Private Schools

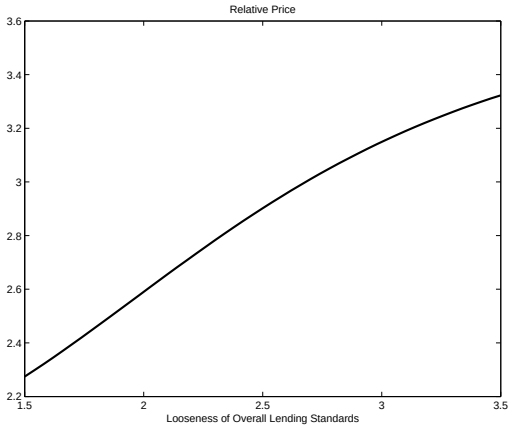
Finally, we look at the effect of credit conditions on sorting between private and public schools. We add data from the Private School Universe, which is only available every other year from 1995 to 2007. Table 3 shows that there has been little change in the fraction of students across public and private schools in the US over the period, for any racial group. Table 8 regresses the fraction of whites in public schools, the fraction of Blacks in public schools, the fraction of Hispanics in public schools and the fraction of Asians in public schools on credit conditions. Overall there is little effect of credit conditions on public/private school sorting. This is good for the identification strategy of the main specification (Equation 11), since adding private schools to the dataset would have little impact on our conclusions.

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

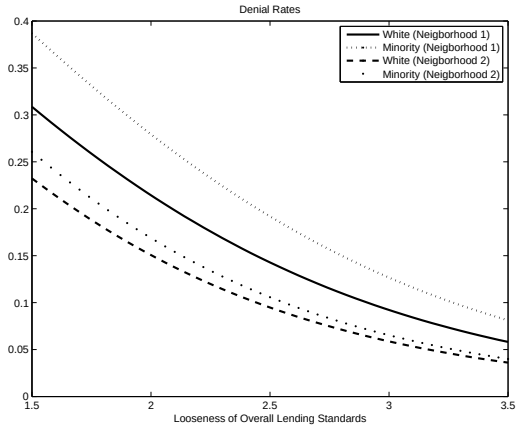
Robust standard errors in parentheses
** p<0.01, * p<0.05, + p<0.1

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.

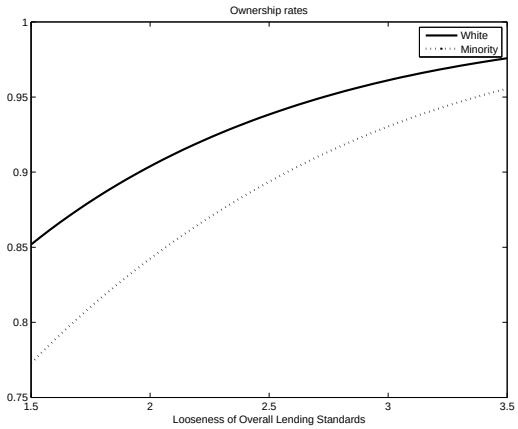
Table 8: Public/Private



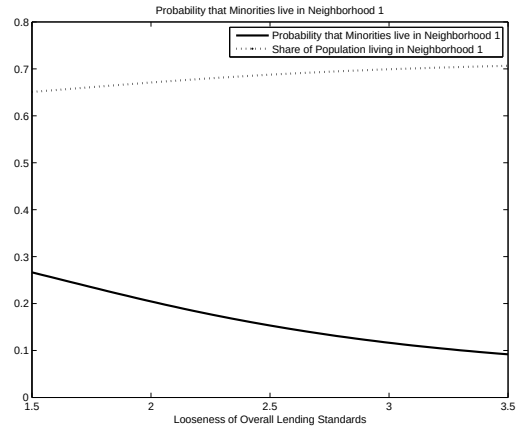
(a) Relative Price



(b) Denial Rate



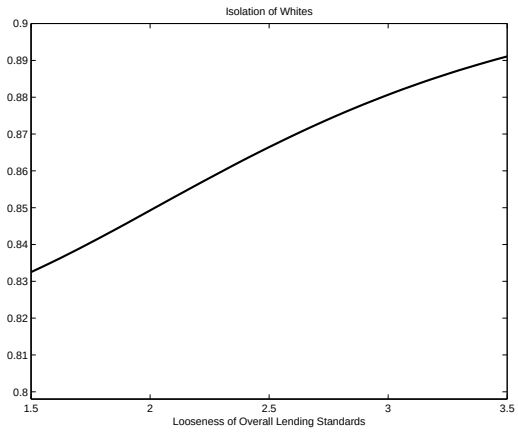
(c) Home Ownership



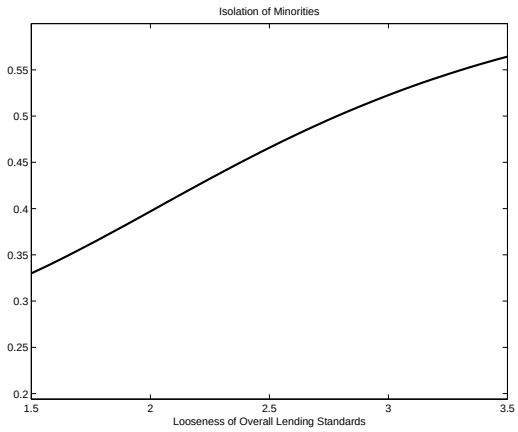
(d) Probability of Minorities Living in Neighborhood 1

Note: The looseness of overall lending standards is the parameter α in the acceptance/rejection decision.

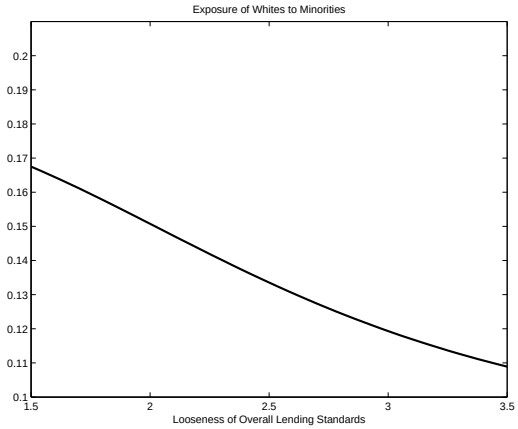
Figure 10: Robustness to Alternative Measures of Looseness of Lending Standards (Baseline Scenario 2)



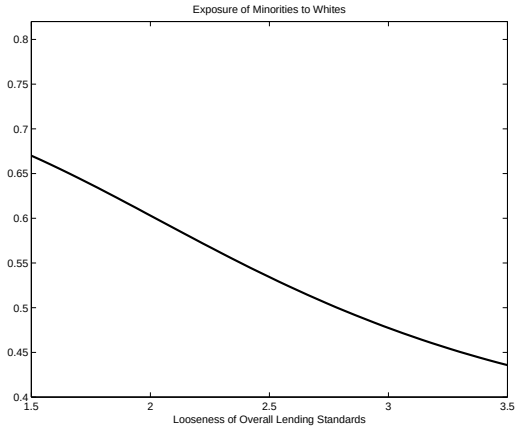
(a) Isolation of Whites



(b) Isolation of Minorities



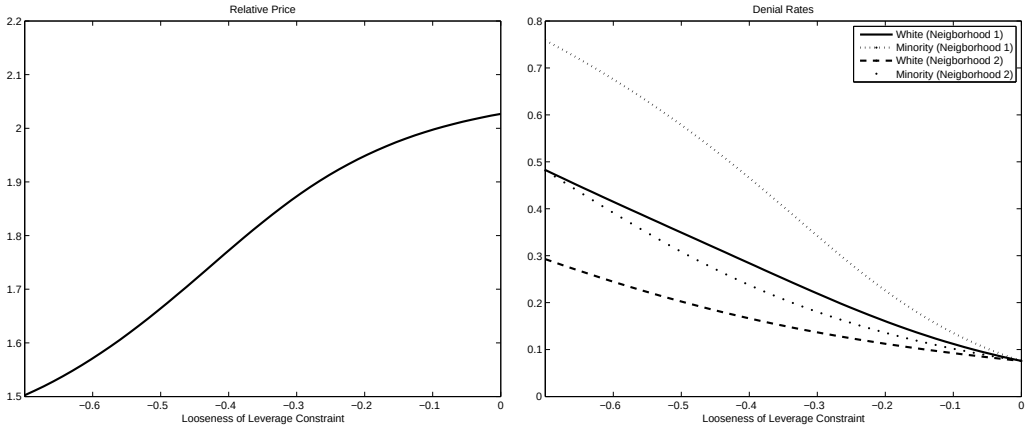
(c) Exposure of Whites to Minorities



(d) Exposure of Minorities to Whites

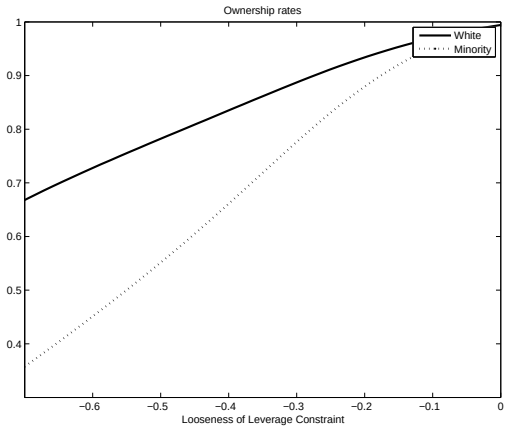
Note: The looseness of overall lending standards is the parameter α in the acceptance/rejection decision. . For definitions of isolation and exposure, see section 2.3, equations 5 and 6.

Figure 11: Robustness to Alternative Measures of Looseness of Lending Standards (Baseline Scenario 2)

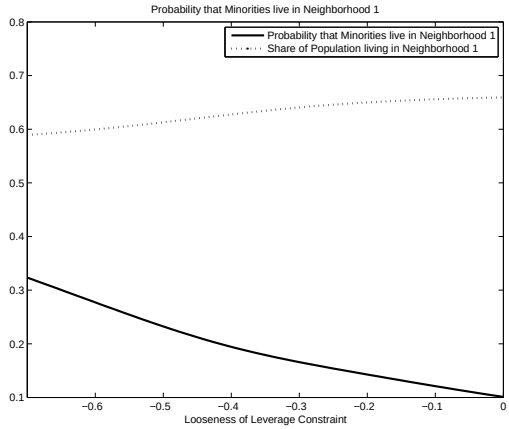


(a) Relative Price

(b) Denial Rate



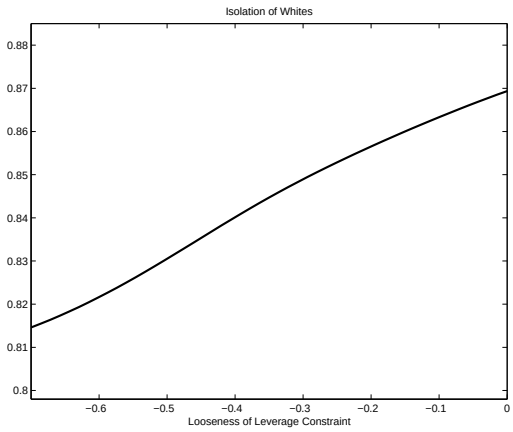
(c) Home Ownership



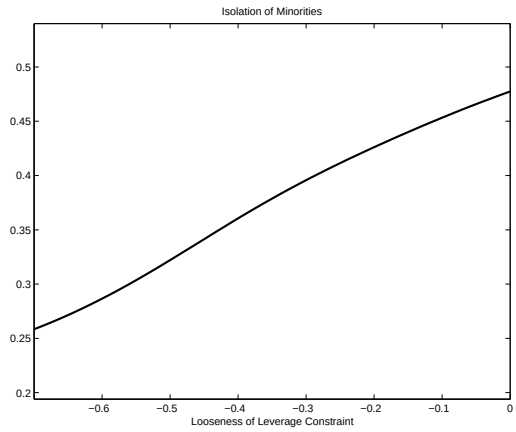
(d) Probability of Minorities Living in Neighborhood 1

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

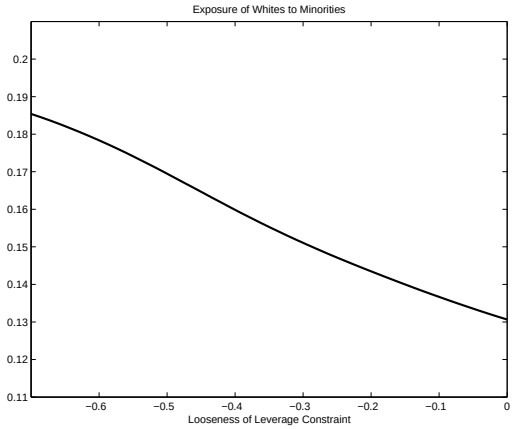
Figure 12: Robustness to Alternative Combinations of Housing Supply Elasticities (Baseline Scenario 2)



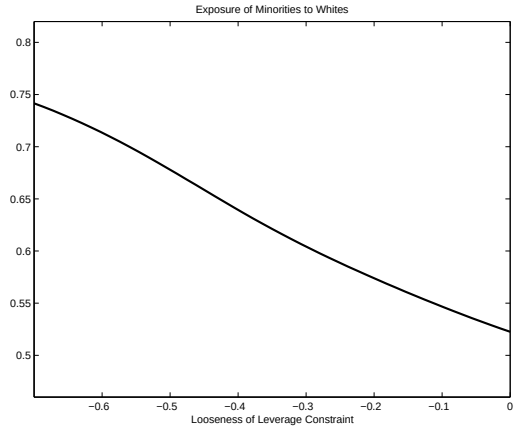
(a) Isolation of Whites



(b) Isolation of Minorities



(c) Exposure of Whites to Minorities



(d) Exposure of Minorities to Whites

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

Figure 13: Robustness to Alternative Combinations of Housing Supply Elasticities (Baseline Scenario 2)