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The Simple Analytics of Observed Discrimination in Credit Markets*

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Controversial econometric studies of mortgage data show that mortgage loan applications by some minorities are denied more frequently than are applications by whites with similar observable default risk factors. But recent evidence indicates that minority borrowers also default more frequently than whites with similar observable risk. This paper presents a simple equilibrium model of discriminatory credit rationing and finds parametric restrictions consistent with both these empirical findings. However, in this model, proposed antidiscrimination policies have surprising side effects. Thus, policy analysts accepting this empirical evidence should not expect to derive model-free conclusions about the effects of proposed policies. *Journal of Economic Literature* Classification Numbers: G21, G28, D63.

1. INTRODUCTION

Discrimination on the basis of race and neighborhood is hotly debated in the popular press, among academic researchers, and among those charged with enacting and enforcing credit laws and regulations. While there has

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long been interest in the subject, as witnessed by the enactment of the Equal Credit Opportunity Act and the Community Reinvestment Act, the debate has intensified recently in light of new data revealing substantial gaps in white vs minority loan approval rates. Munnell *et al.* (1992) assembled a sample of loan applications from an assortment of Boston-area mortgage lenders and found that the loan approval rate for African-American and Hispanic applicants was lower than that for white applicants, even after adjustment for individual default risk factors.

Other empirical evidence has indicated that the default rate among African-American mortgage borrowers is higher than that for whites with similar observable risk factors (Berkovec *et al.*, 1994; Board of Governors of the Federal Reserve System, 1993). Using earlier theories of discrimination, e.g., Becker (1971) or Peterson (1981), some would interpret this as evidence against the presence of discrimination. For example, in the words of Berkovec *et al.* (1994, p. 25),

> Models of discrimination in credit markets suggest that under certain circumstances, discrimination in mortgage origination may be revealed in the differential performance of loans extended to the various groups. Specifically, it is hypothesized that systematic racial discrimination owing to lender bias may result in lenders holding minority applicants from minority neighborhoods to loan qualification standards well in excess of those required by objective assessments of default risk.... This implies that discriminatory behavior may result in higher returns to home loans, as evidenced by lower default rates or smaller dollar losses, among minority borrowers or neighborhoods than those observed for other borrowers.

Alternatively, Yinger (1994) conjectures that the finding of higher minority default rates may be due to lenders' (illegal) "statistical discrimination." Statistically discriminating lenders, i.e., those who believe that minority applicants' unobservable default risk factors are worse on average than those of other applicants, will approve relatively fewer of their loan applications; at the same time, the unobservable default risk factors of minority applicants who do receive loans will be worse than those of white borrowers receiving loans. The higher minority default rate would thus be viewed as evidence in support of statistical discrimination.

It is not our purpose here to debate the validity or robustness of these empirical findings. Rather, our purpose is to investigate questions that must still be answered if these findings hold up: Can a formal model of statistical discrimination endogenously predict these empirical findings and other claims often made by advocates for more effective antidiscrimination policies? What would be the policy implications of such a model?[1]

[1] While other papers have analyzed the welfare effects of government credit interventions in models of adverse selection and/or moral hazard (Williamson, 1994; Lacker, 1994; Gale, 1990), none of these models endogenously predicts the aforementioned empirical findings and claims of policy advocates. As such, these models, while valuable, did not address the

The next section of the paper presents a review of the empirical literature on mortgage discrimination. Section 3 presents a formal model of statistical discrimination consistent with the aforementioned empirical evidence and claims. More specifically, we examine the Wilson equilibrium (Hoy, 1982) of a mortgage market in which profit maximizing lenders compete for borrowers under conditions of adverse selection. We find that in the absence of an effective legal ban on lending discrimination, statistical discrimination will occur under reasonable parametric assumptions. That is, minority loan applicants will face a higher probability of rejection than observationally equivalent white applicants. Furthermore, it is shown that those minority applicants who are rejected are of relatively low default risk, leaving a pool of minority borrowers who have higher average default risk. Thus, the model explains the aforementioned possibilities that a higher fraction of loan applicants will be rejected, and that a higher fraction of African-American borrowers will default.[2] In Section 4, the formal model is used to analyze the effects of some popular antidiscrimination policies and programs. The analysis shows that some proposed antidiscrimination policies may have counterintuitive side effects. For example, even if the government could effectively enforce a ban on statistical discrimination, we show that the result would not be a Pareto improvement, because white borrowers are worse off. Alternatively, the government could subsidize lenders willing to make low interest loans to minority applicants who were denied private credit. However, we show that these subsidized loans will "crowd out" a

central question of this paper. Independent research by Calomiris, *et al.* (1994) provides another model consistent with higher rates of minority loan denial and default. In their model, creditworthiness depends on the probability that a borrower will believe her home is still worth more than the loan, after the loan is made. Their results depend on the desire of banks to invest in costly signals of this probability that are correlated with race and that are unavailable to applicants (that is, banks learn something about the aforementioned probability that borrowers themselves do not know). The model in this paper does not require this extra degree of complexity and will show that more orthodox adverse selection arguments can adequately explain the empirical evidence.

[2] An editor suggested that the empirical evidence for these results might alternatively be explained by assuming that the econometricians measured the default riskiness of loan applicants with error, so that it only appears that a higher fraction of observationally equivalent minority applications were denied. Assuming (as we do) that the average default risk of minority applicants is higher, it would not be surprising to additionally find that the default rate of minorities who did receive loans exceeded that of whites. An advantage of our model is that both the fraction of loans rejected and the interest rates of loans made are endogenous. That is, they are explained by an equilibrium in which expected profit maximizing lenders cope with an explicit adverse selection problem. Moreover, our paper conditionally accepts the validity of previous empirical papers, for the purpose of examining the ramifications of government policies predicated on those papers' findings. For this purpose, it is desirable that our model does not assume that there were measurement errors in those papers.

larger volume of private loans that would otherwise have been made. These findings highlight the need to conduct analyses of specific policies with explicit models grounded in well-established behavioral hypotheses and consistent with whatever empirical evidence might eventually be deemed definitive.

2. MORTGAGE DISCRIMINATION: EMPIRICAL EVIDENCE

2.1. *Race and Mortgage Origination*

The empirical literature examining racial disparities in mortgage lending includes many studies that focus on lending patterns across neighborhoods in particular cities.[3] In these studies[4] observed mortgage activity (as measured by mortgage originations per owner-occupied unit or by the ratio of mortgage originations to total housing transfers) generally increases with median family income and is inversely related to one or more of the following neighborhood characteristics; the percentage of households below the poverty level, the age of the housing stock, or the minority population percentage. Although these studies do not indicate whether reduced mortgage originations in poor and minority neighborhoods reflect discriminatory lending policies or a lack of mortgage demand among creditworthy households, these results have been interpreted as consistent with the view that minorities face reduced access to mortgage credit and/or higher costs of borrowing.[5]

2.2 *Race and Loan Approval Rates*

Since 1990, amendments to the Home Mortgage Disclosure Act (HMDA) have required residential mortgage lenders to disclose the disposition of each residential loan application (i.e., whether the application was accepted or rejected), the census tract location of the subject property, the loan amount, the loan type (i.e., FHA-insured vs conventional), and the race and income of the applicant. Avery *et al.* (1994) provided a detailed analysis of the disposition of the nearly 3.5 million residential loan applications reported under HMDA in 1990. They found that racial disparities in loan approval rates persisted after controlling for applicant income and loan amount, loan type, metropolitan area and census tract location of the prop-

[3] For detailed reviews, see Benston (1981), Canner (1982), and Yinger (1994).

[4] See Ahlbrandt (1977), Hutchinson *et al.* (1977), Digemans (1979), Avery and Buynak (1981), Canner (1981), Bradbury *et al.* (1989), and Calem (1993).

[5] See Avery (1989) for an earlier discussion of these studies' limitations. A recent FDIC study (Horne, 1994) suggests that errors in variables are an important problem.

erty, and identity of the lender. With the data disaggregated by metropolitan area (MSA), they found consistent racial disparities across MSAs.[6]

Individual default risk factors other than applicant income might account for these disparities. However, studies that have attempted to control for individual default risk factors observable by the lender when the mortgages were applied for still report racial disparities. In particular, Munnell *et al.* (1992) concluded that African-American and Hispanic mortgage applicants in the Boston area in 1990 were more likely to be turned down than white applicants with similar observable default risk factors.[7] The authors reached this conclusion after conducting a statistical analysis of some 3000 conventional mortgage applications.[8]

2.3. *Race and Mortgage Terms*

Evidence is scant on whether minority borrowers have received less favorable loan terms than white borrowers. As reported in Yinger (1994), the two most recent studies that directly addressed this issue are Schafer and Ladd (1981) and Black and Schweitzer (1985). Both studies reported that minority borrowers typically were charged higher interest rates. It is also possible that some lenders encouraged some minorities to apply for less desirable FHA loans. Several studies (Canner *et al.* 1989; 1992; Gabriel and Rosenthal, 1991) found that minority borrowers were more likely to receive FHA loans, other factors held constant. However, the authors acknowledged that their results may be due to omitted measures of credit risk or to borrower preferences for the lower down payment requirements characteristic of FHA loans.

[6] Similarly, they reported consistent findings across categories with the data disaggregated according to loan type and with the data grouped according to characteristics of the census tract where the property is located. In addition, they reported that loan approval rates for both white and minority applicants are lower in predominantly minority census tracts. Other analyses of HMDA data (Canner and Smith 1991, 1992) also reported a racial gap in approval rates.

[7] Schafer and Ladd (1981) and Duca and Rosenthal (1993) also found that minorities were less likely to be granted credit, other factors held constant. The latter study analyzed data from the Federal Reserve Bank's 1983 Survey of Consumer Finances to evaluate the extent to which borrowing constraints restrict access to all types of consumer credit. They found that minorities were more likely to be credit constrained than white families, even after controlling for household income, wealth, and many other variables.

[8] This study has been criticized for data errors and methodological problems (Leibowitz, 1993; Zandi, 1993; Horne, 1994). However, the findings are robust to further data work and to alternative specifications suggested by critics (Carr and Megbolugbe, 1993; Glennon and Stengel, 1994). Still, one should not dismiss the possibility that their findings were caused by omitted variable bias. For instance, the study may not have adequately controlled for applicant job history.

2.4. *Race and Default Rates*

Some studies have shown that minorities were more likely to default than white households, even after controlling for individual default risk factors observable when loans were applied for. In perhaps the most comprehensive study on this, the Board of Governors of the Federal Reserve System (1993) reported that after controlling for borrower age, income, and liquid assets, a dummy variable for minority borrowers was still a statistically significant predictor of higher default probability on FHA loans (also see Berkovec *et al.* (1994), Barth *et al.*, 1979; Galster, 1994; Van Order *et al.*, 1994; and Yezer *et al.*, 1994).

3. A SIMPLE MODEL OF DISCRIMINATORY CREDIT RATIONING

A formal model is developed that predicts that the loan approval rate for minority applicants will be lower, while the default rate among minority borrowers will be higher. Because these predictions are from a model of lender statistical discrimination, they are consistent with the empirical findings that controlled for individual default risk factors observable at the time of loan application.

A heuristic description of our model will aid the reader in interpreting the formal model to follow. Profit maximizing lenders use the information on loan applications to assess applicant risk (producing, say, a "Z score" or some other less quantitative assignment of applicants into risk classes). Lenders can most easily assess the default risk of those applicants who score either very high or very low, but some uncertainty about a particular applicant's default probability remains when that applicant has an intermediate score. This is a problem of adverse selection; among those with similar, intermediate scores, relatively higher risk applicants appear the same as lower risk applicants. The possibility of loan denial, though, can be used to combat this adverse selection problem and will be used if the adverse selection problem is serious enough. By definition, the relatively high-risk applicants have a greater chance of defaulting, thereby avoiding future loan payments, and it is not unreasonable to assume that these applicants have relatively more to lose in the event that their loan applications are denied (this assumption will be justified later). Both factors make these applicants relatively more willing to accept costlier loans (e.g., a higher interest rate, a larger down payment, or a shorter loan term) in return for obtaining a better (ex ante) chance of having their loans approved.

Now suppose that some lenders offer higher cost loans while other lenders offer lower cost loans. Also, suppose that applicants know that lenders

offering higher cost loans will approve a higher fraction of loan applications than will lenders offering lower cost loans, i.e., that higher cost lenders are less selective than lower cost lenders.[9] Then, because higher risk applicants have more to lose in the event that their applications are denied, they will voluntarily apply for these higher cost loans, which have a better chance of being approved. Because these are higher risk applicants, the higher cost of lending to them is economically justified. However, one outcome of adverse selection is that a lower fraction of applications for relatively low cost loans will be approved. As a result, credit is rationed most among those applying for lower cost loans, i.e., the relatively lower risk applicants in the intermediate risk class.

Of course, if there is little unobservable variation within the intermediate risk class, the market may not develop the variation in loan costs and approval rates needed to induce this self-selection. In this case, it is likely that lenders will offer uniform terms to all applicants from that risk class. But suppose lenders also think that most of the relatively high-risk borrowers in the risk class, few though they may be, are concentrated among the minority applicants. Then, in the absence of effectively enforced antidiscrimination policies, it is likely that competition in the lending industry would result in (unobservably) higher risk minority applicants applying for higher cost but more frequently granted loans from some lenders, while (unobservably) lower risk minority applicants apply for more selectively granted lower cost loans. White applicants, however, would receive frequently granted credit at some intermediate cost. If so, applications by minorities will be approved less frequently than applications by whites in the same risk class—consistent with the empirical evidence. Furthermore, because it is a fraction of the (unobservably) low-risk minority applicants who have their applications denied, this form of statistical discrimination (i.e., lenders acting on their beliefs about the fractions of high risks among both whites and minorities in the risk class) will result in a higher default rate among minority borrowers than would be the case in the absence of discrimination. Thus, the model predicts that discrimination is partly to blame for the observed higher minority default rate.

3.1. *Environment*

The model is a modification of the Smith and Stutzer (1989) model of credit rationing that incorporates the additional feature that lenders may condition their assessments of an individual applicant's risk (in part) on race. This feature was incorporated by adapting Hoy's (1982) model of insurance industry risk categorization to the lending industry. There are

[9] Consider, for example, the ease of obtaining a credit card relative to obtaining a lower interest bank line of credit.

two periods. In the first, all prospective borrowers are without resources to self-finance a home, the cost of which is normalized to 1. However, they may apply for a bank loan of 1 to purchase a home, which will be worth v to the applicant in the second period. Applicants do not know for sure whether their applications will be approved or denied. However, an applicant does know the probability π that her loan application will be approved; i.e., an applicant knows the lender's loan approval rate for the given type of loan. Applicants whose loans are approved become borrowers who contract to repay an amount R in the second period.

A borrower's ability to repay is stochastic. For simplicity in the algebraic and graphical analyses, it is assumed that a borrower's second-period income is either $Y = y > R$, in which case the borrower has the ability to repay the loan and keep the home, or $Y = 0$, in which case the borrower defaults.[10]

An adverse selection problem is created by imperfect information about an applicant's ability to repay the loan. We assume that lenders use observable creditworthiness data to assign applicants to risk classes (based on their estimated probabilities of insufficient income (i.e., $Y = 0$)), but that after having done so, applicants in the intermediate risk class still do not have identical probabilities of insufficient income. That is, it is assumed that credit scoring and other rational methods of assigning borrowers to risk classes are imperfect when credit scores are neither extremely high nor low. We assume that there are just two borrower types in the intermediate risk class, high-risk (type H) and low-risk (type L). High-risk borrowers, then, have $Y = 0$ with probability $1 - P_H$, while low-risk borrowers have $Y = 0$ with probability $1 - P_L$, and by definition $P_H < P_L$. While lenders do not know the probability of any particular applicant in the intermediate risk class, they do have a belief about the fraction of applicants in that risk class having each probability.

We will analyze an applicant's choice problem after first describing the possible choices lenders offer to them. This is determined by the adverse selection equilibrium concept employed, which is now briefly reviewed.

3.2. *Credit Market Equilibrium: Pooling vs Separating*

Following Hoy (1982) and Lacker (1994), we will adopt the Wilson modification of the Rothschild and Stiglitz (1976) notion of market equilibrium under adverse selection. Lenders set loan terms to maximize the

[10] As an alternative to the assumption of stochastic income, we could have assumed that the second-period value of the home may take two possible values, $V = 0$ or $V = v > R$, akin to assumption [2PD] of Calomiris *et al.* (1994, p. 658). Thus, if $V = v > R$, a borrower could choose to repay her loan (to prevent foreclosure) or could choose to rationally default if $V = 0$. However, a referee raised the possibility that this might lead to an optimal contract of a form different from that analyzed here. A third alternative would be to model discrimination as in commercial loan markets, where V is interpreted to be the verifiable revenues from the borrowers' investment of the 1 unit borrowed.

expected profit per loan approved, treating other lenders' offered terms parametrically—with one exception. A lender is assumed to have the foresight to avoid trying to "skim the cream" from other lenders (i.e., offer terms intended to lure other lenders' low-risk applicants), when those other lenders would, in response, withdraw their offers to all parties so that the skimmer will unavoidably get stuck unprofitably serving high-risk borrowers as well. Competition among lenders prevents them from earning excess profits, and expected utilities are maximized subject to this constraint. With these behavioral assumptions, equilibria may take either of two possible forms: pooling or separating. After describing these equilibria, we will show how the economic environment determines which of the two possible forms will prevail.

In a pooling equilibrium, all applicants in an observable group will face the same probability π of obtaining the same loan cost R. Only one combination of loan cost and approval rate will be observed in such a pooling equilibrium, and it will be offered by all lenders serving applicants in this group.

In a separating equilibrium, different combinations of loan cost and approval rate will be offered to applicants within an observable group, corresponding to the different types of applicants within the group. Thus, if a separating equilibrium occurs, some lenders will approve a fraction $\hat{\pi}_H$ of loan applications, with a stated loan cost of $\hat{R}_H$, while other lenders will approve a fraction $\hat{\pi}_L$ of applications charging $\hat{R}_L$.[11] The equilibrium combination $(\hat{R}_H, \hat{\pi}_H)$ offered will attract only high-risk applicants, while $(\hat{R}_L, \hat{\pi}_L)$ will attract only low-risk applicants.

An applicant will apply for the offer (R, π) that maximizes her expected utility. Formally, we assume that type i applicants have a utility function proportional to consumption in the second period. As noted in Section 3.1, the model is normalized by assuming borrowers have no initial resources to self-finance a home that costs 1 unit of consumption. Type i agents who apply for loans but are denied them will still receive β_i utils ex post, in addition to their (stochastic) income Y. The meaning and significance of β_i will be elaborated shortly. A type i agent who applies for a loan borrows

[11] Besanko and Thakor (1987) appear to be the first to use the loan approval probability as part of a separating equilibrium. Subsequently, Gale (1990) used this model to analyze government loan policies. Some might object to the property of these models (as well as all other models of credit rationing) that (ex ante) observationally equivalent borrowers are not treated the same in equilibrium, e.g., some minority applicants will receive loans, while other seemingly identical applicants will not. Because of this property, lenders will not be able to (ex post) rationalize particular loan denials on the basis of individual default risk factors observable at the time of the loan application. However, this is what advocates of antidiscrimination policy often allege and is thus a desirable consequence in a model seeking to answer the questions posed in our introduction.

1 unit of consumption if the loan is approved (with known probability π) to buy a home costing 1. With probability P_i, she receives income y sufficient to repay this loan, a fact known to the lender, and is entitled to keep the house (worth v). With probability $1 - P_i$, she receives no income to repay this loan, and thus must default. So the expected utility of a type i applicant applying for a type j loan is

$$\begin{aligned} U_{ij} &= \pi_j P_i(v + y - R_j) + (1 - \pi_j)(P_i y + \beta_i) \\ &= \pi_j P_i(v - R_j) + (1 - \pi_j)\beta_i + P_i y \quad i, j = H, L. \end{aligned} \tag{1}$$

Because application is voluntary, a separating equilibrium must satisfy the self-selection constraints

$$U_{ii} \geq U_{ij}, \quad i, j = H, L \quad i \neq j, \tag{2}$$

which ensure that borrowers of both types voluntarily agree to the loan terms they receive in a separating equilibrium.

3.2.1. *Parametric restrictions.* It is reasonable to assume that the marginal utility of the loan approval rate is positive, i.e., that among lenders posting the same loan terms, applicants prefer the one offering the best chance of obtaining a loan. To find a simple parametric restriction ensuring this, differentiate (1) to find $\partial U_{ii}/\partial \pi_i = P_i(v - R_i) - \beta_i$. This is positive when v is sufficiently large to ensure that the following condition is satisfied:

$$v - R_i > \frac{\beta_i}{P_i} \qquad i = H, L. \tag{3}$$

To preserve the possibility that a separating equilibrium will exist, needed later to explain some of the empirical evidence, we follow Cooper (1984) and many others in assuming the single crossing condition. This condition requires that the slope of a high-risk applicant's indifference curve in the (R, π) plane is less than that of a low-risk applicant, evaluated at the same combination of approval rate and loan cost, i.e.,

$$\frac{d\pi_H}{dR_H} < \frac{d\pi_L}{dR_L}, \tag{4}$$

at the intersection of any pair of their respective indifference curves. At an intersection, then, high-risk borrowers are more willing to accept higher loan payments in return for a better chance of obtaining a loan.

Condition (4) is guaranteed by the following parametric restriction[12]:

$$\frac{\beta_H}{P_H} < \frac{\beta_L}{P_L}. \tag{5}$$

By definition of applicant type, $P_H < P_L$. Assumption (5) will then be satisfied (so that (4) will also hold) when β_H is sufficiently smaller than β_L. Because β represents the utility obtained from alternative housing arrangements in the event that a loan application is denied, assumption (5) will be satisfied when the consequences of loan rejection harm high-risk borrowers sufficiently more. This is not implausible. For example, the existing housing of high-risk applicants might be worse than that of low-risk applicants in ways not easily observed by lenders, perhaps because high-risk applicants lack the resources and skills needed for noncosmetic maintenance. A consequence of loan rejection would likely be a continuation of applicants' current housing—an outcome that is then relatively worse for high-risk applicants.[13]

Additional parametric restrictions are required to produce an equilibrium matching the empirical evidence. Let λ denote the fraction of minorities in the applicant population. Let θ^b denote the lenders' belief about the fraction of high risks among the minority applicants (in the intermediate risk class), while θ^w denotes their belief about the fraction of high risks among the white applicants. Then $\theta \equiv \lambda\theta^b + (1 - \lambda)\theta^w$ is the perceived fraction of high risks in the risk class. We also need to assume that θ^b is sufficiently larger than θ^w and that θ is sufficiently small. The first assumption is that lenders believe that minority applicants in the risk class have a higher fraction of (unobservably) high risks than white applicants. This matches Yinger's (1994) definition of statistical discrimination. The second assumption will be satisfied whenever there is a suitably small fraction of (unobservably) high risks than in the risk class overall. Because $\theta \equiv \lambda\theta^b + (1 + \lambda)\theta^w$, the two assumptions are jointly sustainable when θ^w and/or the applicant population's fraction of minorities (λ) are not too large.

3.3. *A Pooling Equilibrium without Discrimination*

While all lenders know that the overall fraction of (unobservably) high-risk applicants in the intermediate risk class is small, we assume, in this section, that lenders do not use the above information about differential

[12] Formally, along an indifference curve for type i compute $d\pi_i/dR_i = -\partial U_{ii}/\partial R_i/\partial U_{ii}/\partial \pi_i = \pi_i P_i/(P_i(v - R_i) - \beta_i)$. Evaluating at a common $\pi_H = \pi_L$ and $R_H = R_L$ shows that (5) is sufficient to ensure (4). Figure 1, explained in detail in the following section, depicts the indifference curves.

[13] Note that this refers to housing conditions that are observable only by the existing resident/loan applicant. A referee raised the possibility that housing conditions observable by lenders might be used as a screening variable. If so, this would further mitigate the adverse selection problem.

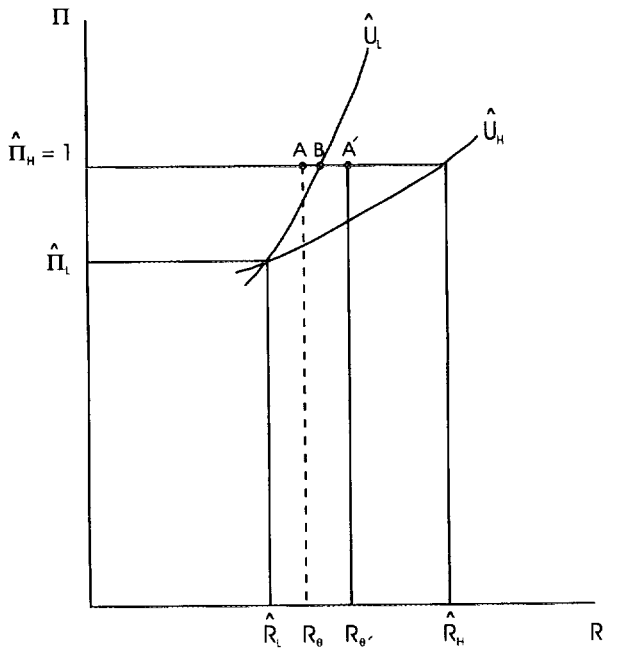

FIG. 1. Nondiscriminatory pooling equilibrium is point A. There is no credit rationing, and all applicants receive loans at a loan cost R_θ.

minority/white high-risk fractions in formulating loan policies. That is, in this section we assume that lenders do not statistically discriminate between whites and minorities in the process of deciding what loan terms to offer. A graphical analysis simplifies description of the equilibrium. In Fig. 1, indifference curves for high and low-risk applicants are denoted $\hat{U}_H$ and $\hat{U}_L$, respectively. Borrowers prefer lower loan costs, and parametric restriction (3) guarantees that v is sufficiently large to ensure that borrowers prefer higher loan approval rates in this range of R, so the indifference curves of both applicant types slope upward and utility increases to the northwest. Parametric assumption (5) ensures that the single crossing condition (4) holds.

If the Wilson equilibrium were separating (as we will soon see, the equilibrium in Fig. 1 is not separating), the competitive, zero expected excess profit condition would require that

$$P_i R_i - 1 = 0, \quad i = H, L. \tag{6}$$

That is, we assume that the lending market is competitive enough so that

the probability of repayment times the scheduled repayment, less the unit cost of loans, is forced to zero. Implicit in (6) are the usual claims that antitrust regulation and entry possibilities are effective in eliminating excess profit. Furthermore, for simplicity we are excluding expected revenues from foreclosures.[14] This is justified if foreclosure costs imposed by legal restrictions, and relatively small probabilities of default, combine to make the expected revenue from foreclosure insignificant relative to the expected revenue from loan repayment.[15] Thus, in a separating equilibrium, conditions (6) determine the equilibrium loan costs $\hat{R}_L$ and $\hat{R}_H$, respectively, which differ only because of default risk. Conditions (6) are depicted by the vertical lines in Fig. 1 through those two loan costs. Because the loan acceptance rate does not affect lenders' expected profit per loan made, the Wilson equilibrium's requirement that applicant expected utility be maximized subject to the zero expected profit constraint will result in all high-risk applications being approved, i.e., $\hat{\pi}_H = 1$. Furthermore, in Fig. 1, high-risk borrowers would be indifferent between receiving $(\hat{R}_H, 1)$ or $(\hat{R}_L, \hat{\pi}_L)$, while low-risk borrowers would prefer the latter to the former, thus verifying that the self-selection constraints (2) are also satisfied.

It would thus appear that this pair of loan combinations are the equilibrium, but this isn't so. To see this, suppose that all lenders offer only one combination of loan cost and approval rate. The probability that a loan will be repaid is then the applicant population-weighted average of the high- and low-risk repayment probabilities. Competition again would require zero expected excess profit-per-loan, i.e.,

$$(\theta P_H + (1 - \theta)P_L)R_\theta - 1 = 0. \tag{7}$$

In Fig. 1, (7) is illustrated by the vertical line through R_θ. Remembering that the difference between high- and low-risk borrowers is that $P_H < P_L$, it is easy to see that R_θ solving (7) is smaller when the fraction θ of high risks in the risk class is smaller. In Fig. 1, θ is small enough to make the loan combination labelled A lie to the left of the loan combination labelled B, which is the point where the indifference curve $\hat{U}_L$ through $(\hat{R}_L, \hat{\pi}_L)$ intersects the horizontal line through $\hat{\pi}_H = 1$. The figure clearly shows that high-risk applicants prefer the combination A to $(\hat{R}_H, 1)$, and low-risk

[14] Independent work by Calomiris *et al.* (1994) also excluded expected revenues from foreclosures.

[15] We could have included a term representing the (relatively small) expected revenues from foreclosure, but this would not change our conclusions. In fact, any model of credit rationing induced by adverse selection must limit the role of mortgage and/or other forms of collateral. As shown in Besanko and Thakor (1987), the existence of unlimited collateral could be used to make all loans riskless, and even lesser collateral could be used as a sorting device in place of the loan approval rate.

applicants also prefer A to $(\hat{R}_L, \hat{\pi}_L)$. The competitively determined, pooled loan combination A is thus Pareto superior to this pair of combinations and is the nondiscriminatory Wilson equilibrium under the maintained parametric restriction that θ is small enough to make loan combination A lie to the left of combination B.

Note from Fig. 1 that, under these conditions, there is no credit rationing. All loan applications are accepted, and all borrowers—whether white or minority, whether high- or low-risk—pay a single, competitively determined loan cost. Alternatively, if θ were sufficiently large, e.g., θ' corresponding to $R_{\theta'}$ in Fig. 1, then high-risk applicants would not prefer $(\hat{R}_H, 1)$ to A', but low-risk applicants would prefer $(\hat{R}_L, \hat{\pi}_L)$ to A'. Those two separate combinations would then be a separating equilibrium.

3.4. *An Equilibrium with Discrimination*

In the absence of effective antidiscrimination policies, a lender may offer different loan combinations based on beliefs about the separate fractions of high risks among the white and minority applicants in the risk class. We now derive the equilibrium resulting when lenders do act on the belief that the fraction of (unobservably) high risks among the minority applicants is sufficiently higher than the fraction of (unobservably) high risks among the white applicants (i.e., $\theta^b > \theta^w$). It will turn out that when lenders statistically discriminate in the way, under our parametric assumptions it is plausible that whites will be pooled in equilibrium while minorities will be separated. As such, minority applicants will not be treated the same as white applicants in equilibrium. In this discriminatory equilibrium, some of the most (unobservably) creditworthy minority applicants are denied loans that equally (unobservably) creditworthy white applicants receive. Because this did not occur in the pooling equilibrium of Section 3.3, we may attribute this outcome to statistical discrimination.

To see why white applicants will still be pooled, recall that the fraction of high risks is sufficiently small to sustain the pooling equilibrium in the absence of discrimination (Section 3.3). Under our assumption that lenders believe that $\theta^b > \theta^w$, $\theta \equiv \lambda\theta^b + (1 - \lambda)\theta^w > \theta^w$. So θ^w is also sufficiently small to ensure that white applicants will be pooled when lenders discriminate. Thus, under discrimination, all white applicants will still receive a common loan combination. However, it will be a different combination than they received in the absence of discrimination.

Figure 2 illustrates this phenomenon. The vertical line through R_θ^w is the zero expected excess profit constraint for loans made to the pool of white applicants. Because $\theta^w < \theta$, substitution of θ^w into (7) shows that R_θ^w solving (7) (with θ^w substituted for θ) is less than R_θ derived in Section 3.3, so that the point C in Fig. 2 still lies to the left of B. Using the same reasoning as

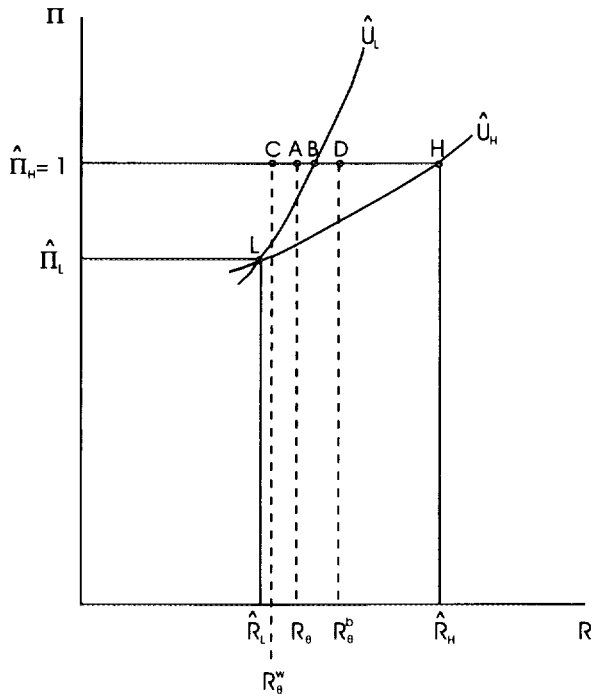

FIG. 2. Discriminatory equilibrium is point C for white applicants, while low-risk minority applicants select point L, and high-risk minority applicants select point H.

before, both high- and low-risk white applicants will now select the loan combination C. That is, all white applicants in the intermediate risk class have their loan applications accepted, obtaining a common loan cost R^w_θ, which is lower than the loan cost R_θ that they obtained in Section 3.3. Because lenders perceive that there is even a smaller fraction of white applicants who are high risk than there is in the total applicant population in this risk class, it still does not pay to separate high-risk white applicants from low-risk ones. But because lenders believe that whites have lower default risk on average, unfettered competition does force them to lower the cost of loans made to whites.

To see why minority applicants will be separated, note that the assumption that θ^b is sufficiently greater than θ^w implies that R^b_θ exceeds R_θ, where R^b_θ solves (7) with θ^b substituted for θ. As illustrated in Fig. 2, θ^b is large enough to place the point D (which corresponds to the possible pooling of high- and low-risk minorities) to the right of point B. Because of this, low-risk minority applicants prefer the combination L to the combination D. The latter thus cannot be an equilibrium. That is, minority applicants

will not be pooled in equilibrium. Instead, low-risk minority applicants will select L, while high-risk minority applicants will accept the combination H in Fig. 2. That is, minority applicants will be separated by risk type in this equilibrium.[16]

3.5. *Discussion*

The analyses in Sections 3.3 and 3.4 are consistent with some of the evidence arising in debates about antidiscrimination policy. First, the pooling equilibrium in Section 3.3 is consistent with claims that in the absence of discrimination, minority applicants would be treated the same as white applicants, and that no applicants with reasonable credit scores would be denied loans. This is true even though there is an adverse selection problem, i.e., credit-scoring methods are not perfect. Second, Section 3.4 showed that discrimination still results in all high-risk minority applicants receiving loans, but the loans will cost those borrowers more than before, i.e., $\hat{R}_H > R_\theta$. Furthermore, the high-risk minority borrowers' loans cost more than equally high-risk white borrowers' loans, i.e., $\hat{R}_H > R_\theta^W$. Third, even though the low-risk minority applicants who do get their loans approved will pay a lower loan cost $\hat{R}_L < R_\theta$, only a fraction $\hat{\pi}_L$ of their applications are accepted. To compute this fraction, note from Fig. 2 that $\hat{U}_{HH} = \hat{U}_{HL}$. Substituting (6) and $\hat{\pi}_H = 1$ into (1) results in a linear equation with the solution

$$\hat{\pi}_L = \frac{v - 1/P_H - \beta_H/P_H}{v - 1/P_L - \beta_H/P_H} \equiv \frac{v - \hat{R}_H - \beta_H/P_H}{v - \hat{R}_L - \beta_H/P_H}, \tag{8}$$

which is between 0 and 1 under the maintained assumption that v is sufficiently large to satisfy (3). Because Fig. 2 shows that low-risk minority applicants prefer the Section 3.3 equilibrium (A in Fig. 2) to their discriminatory equilibrium combination L, even the most (unobservably) creditworthy minority applicants suffer the effects of discrimination. A fraction of minority applicants will have their loans denied, despite the facts that those denied are actually among the most (unobservably) creditworthy of all applicants and that all equally creditworthy white applicants receive loans. That is, discrimination (rather than adverse selection *per se*) causes the loan approval rate for minority applicants to be lower than the rate for whites in the same (observable) risk class, consistent with evidence cited in Section 2.2.

Finally, discrimination increases the measured default rate among minority borrowers, consistent with the evidence in Section 2.4. To see this,

[16] This equilibrium corresponds to case B in the insurance model of Hoy (1982).

note that in Section 3.3, no one is denied credit. So in the absence of discrimination, the default rate among minority borrowers is just the minority applicant population-weighted average of high-risk and low-risk default rates. That is, the minority default rate is $\theta^b(1 - P_H) + (1 - \theta^b)(1 - P_L)$. Similarly, the white default rate is $\theta^w(1 - P_H) + (1 - \theta^w)(1 - P_L)$. Using the assumption that $\theta^b > \theta^w$ and the definition of high risk (i.e., $(1 - P_H) > (1 - P_L)$), the minority default rate can be shown to exceed the white default rate in the absence of discrimination. In the presence of discrimination, though, Section 3.4 shows that a fraction of low-risk minority applicants will be denied loans and no high-risk minority applicants will be denied loans. Because of this, in the discriminatory equilibrium the fraction of high risks among minority *borrowers* is higher than the fraction of high risks among minority *applicants*. By inducing this credit rationing, discrimination causes an increase in the minority default rate, further deepening the gap between white and minority default rates.

It should be emphasized that particular parametric restrictions were employed to obtain equilibrium results that are consistent with the evidence of interest here. To summarize, we showed that the overall fraction of high risks θ must be small enough so that whites and minorities are pooled together in the absence of discrimination and that θ^b must be sufficiently larger than θ^w in order for minority applicants to be separated by risk in the presence of discrimination. Because none of the three other possible cases identified by Hoy (1982) (i.e., pooling to pooling, separating to pooling, or separating to separating) are consistent with the evidence, it is notable that the parametric restrictions are not implausable.

Furthermore, these parametric restrictions deliver other equilibrium results which may be of interest to empirical researchers. Figure 2 shows that the presence of discrimination results in more dispersion of interest rates among minorities than among whites. In addition, Fig. 2 demonstrates that minority applicants should be rejected more frequently for low interest rate loans than for high interest rate loans. It would be interesting to gather race-specific interest rate data in order to test these discriminatory equilibrium predictions.

4. ANALYSIS OF ANTIDISCRIMINATION POLICIES

4.1. *Antidiscrimination Regulation*

Federal government agencies are charged with enforcing fair lending statutes, including the Equal Credit Opportunity Act and provisions of the Fair Housing Act. A recent joint policy statement (U.S. Department of Housing and Urban Development, 1994, p. 516) clarifies the intent of this

enforcement; "Discrimination in lending on the basis of race or other prohibited factors is destructive, morally repugnant, and against the law ... the Agencies will not tolerate lending discrimination in any form." Suppose the Agencies could replace the discriminatory, separating equilibrium of Fig. 2 with the nondiscriminatory, pooling equilibrium of Fig. 1. Even if such administrative policies were costless, the resulting market equilibrium would not be Pareto improving, because white borrowers would have higher cost loans.

But even if Congress chose to make this tradeoff, it is apt to be costly to administer. Statistical discrimination is illegal and it seems unethical for individual applicants of different races to be treated differently just because the frequency of default differs by race. Nevertheless, the elimination of statistical discrimination will be neither easy nor costless. Lenders might search for legal, nonracial instrumental variables that proxy for the information contained in the applicant's race and use those to legally "justify" their decisions. Despite the current costly documentation process and on-site examinations employed by the federal agencies, their proposal of new enforcement rules indicates that they believe that still greater vigilance is needed.

Our analysis suggests that statistical discrimination may be limited to those markets where our parameter restrictions apply. In addition, (8) shows that the problem will be greater in markets where P_H is much smaller than P_L. These findings may be useful in allocating resources dedicated to fair-lending enforcement.

4.2. *Subsidized Lending*

The Community Development Banking Act of 1994 creates the government-owned Community Development Financial Institutions Fund (CDFIF) to provide money and technical assistance to lenders serving either low- or moderate-income areas or disadvantaged minority populations. While the law provides broad guidelines governing allocations, the CDFIF is in the process of formulating more precise criteria.

CDFIF may choose to target such subsidies at those with the least access to private credit. Suppose that funds are used to help make loans to those whose applications were previously denied in the private sector. In our model's discriminatory equilibrium, these assisted loans have the surprising effect of reducing the volume of private loans made to others. To see this, suppose that the subsidized community development lenders grant loans costing R_α to a fraction α of the applicants who have had their loan applications denied by private lenders. Ex ante, the existence of this loan program alters all applicants' expected utility, which becomes

$$U_{ij} = \pi_j P_i(v - R_j) + (1 - \pi_j)P_i\alpha(v - R_\alpha) + (1 - \pi_j)(1 - \alpha)\beta_i + P_i y. \quad (9)$$

The second term in (9) is the contribution to expected utility from receiving a community development loan after private credit has been denied. The third term is the contribution associated with the consequences of having both private and community development loans denied. The fourth term is the applicant's expected gross income, which is earned regardless of what happens to her loan application(s). Indifference curves derived from (1) will thus be changed when community development lenders approve a positive fraction α of community development loan applications.

For a type i applicant, the marginal expected utility of the community development loan probability α is $(1 - \pi_i)(P_i(v - R_\alpha) - \beta_i)$. As previously assumed for private loans, it is reasonable to assume parametric restrictions ensuring that this marginal utility is positive, i.e., we assume that

$$v - R_\alpha > \frac{\beta_i}{P_i}, i = H, L. \tag{10}$$

Again, this may be ensured by assuming that v is sufficiently large. Using (9), set $U_{HH} = U_{HL}$ to solve for the new fraction of approved private loans to low-risk minorities, denoted $\hat{\pi}_L^\alpha$,

$$\hat{\pi}_L^\alpha = \frac{(v - \hat{R}_H) - \alpha((v - R_\alpha) - \beta_H/P_H) - \beta_H/P_H}{(v - \hat{R}_L) - \alpha((v - R_\alpha) - \beta_H/P_H) - \beta_H/p_H}. \tag{11}$$

There is no loan program when $\alpha = 0$, in which case (11) gives the same result as (8). When $\alpha > 0$, use (11) to compute

$$1 - \hat{\pi}_L^\alpha = \frac{\hat{R}_H - \hat{R}_L}{(v - \hat{R}_L) - \alpha((v - R_\alpha) - \beta_H/P_H) - \beta_H/P_H}. \tag{12}$$

Using (12) and (10), compute $\partial \hat{\pi}_L^\alpha / \partial \alpha < 0$. Thus, while community development loans will be made to a fraction of the (unobservably) low-risk minority applicants who were denied private loans, their presence will "crowd out" a fraction of private loans that would otherwise have been made to other low-risk minority applicants. This is an unavoidable effect of government-assisted lending targeted to those who would otherwise be denied credit.

Recall from Section 3.2 that parametric restriction (5) ensured that high-risk applicants' indifference curves were less steep than low-risk applicants; i.e., high-risk applicants were more willing to accept worse private loan terms in return for a better chance of obtaining a private loan. The presence of community development loans makes high-risk applicants less willing to make that trade-off (i.e., indifference curves become steeper), because

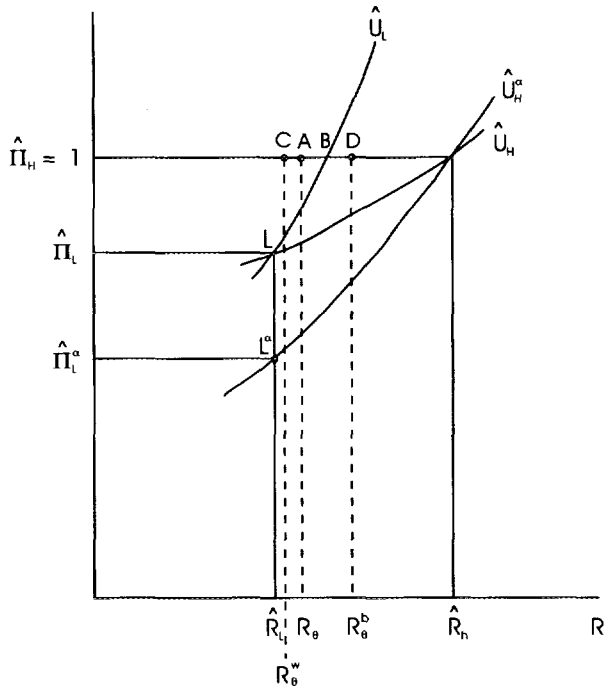

FIG. 3. The possibility of government-assisted community development loans for those denied private credit steepens the indifference curves. This reduces the fraction of private sector loans made to low-risk minority applicants.

the consequences of private loan rejection will not be as severe when the chance of a desirable community development loan exists. As such, the market can induce self-selection only by approving an even smaller fraction of private loan applications costing $\hat{R}_L$. The process is depicted in Fig. 3.

The crowding out effect may be severe enough to actually decrease aggregate lending (community development plus private) to low-risk minority borrowers. In the absence of community development loans, the fraction of low-risk minority applicants receiving loans is given by (8). In the presence of community development loans, the fraction receiving loans is the fraction receiving private loans (11) plus the fraction receiving community development loans $\alpha(1 - \hat{\pi}_L^a)$. In the appendix to Smith and Stutzer (1989), it is shown that this aggregate is less than (8) if and only if the government loan rate $R_\alpha < R_L$. That is, if community development loans are made at a lower interest rate to low-risk minority borrowers than the competitive private sector interest rate for low-risk minority borrowers (in which case community development loans lose money), then crowding out is severe enough to cause private lending to low-risk minorities to fall by more than

the volume of community development loans. However, the appendix to Smith and Stutzer (1989) also shows that in this case, the below-market interest rate raises the ex ante expected utility of low-risk minority applicants above what it would be in the absence of community development loans (i.e., the equilibrium value of U_{LL} in (9) is higher than in (1)). In summary, there is an unavoidable tradeoff between the ex ante welfare of low-risk minority applicants, on the one hand, and both the dollar decreases in total loan volume and the dollar losses of community development lenders, on the other hand.[17]

5. CONCLUSIONS

The empirical evidence on racial differences in loan approval and default rates can be explained by a simple model with counterintuitive implications for government antidiscrimination policies. In this model, profit maximizing lenders are presumed to use credit analysis methods based on individual default risk factors that are observable when loans are applied for. However, it is assumed that these credit analysis methods cannot exactly determine the default probability of loan applicants deemed to be of intermediate creditworthiness. This creates a problem of adverse selection, which alone will not explain the evidence on loan approval and default rates. Under suitable parametric restrictions, we show that when lenders statistically discriminate, i.e., they act on the belief that the fraction of (unobservably) high risks among minorities of intermediate creditworthiness exceeds that of whites in this risk class, a fraction of the (unobservably) low-risk minority applicants in this risk class will have their applications denied. Because it is the relatively low-risk minority applicants who are denied credit, the default rate among minority borrowers (i.e., approved applicants) will rise. Both of these model predictions are consistent with empirical evidence, which has documented higher rates of both rejected loan applications and loan defaults among some minority groups.

However, in this model, policies intended to alleviate these consequences have some surprising side effects. Any successful effort to prevent private lenders from using race (or geographic location, sex, age group, etc.) to

[17] The separating equilibrium for minority applicants is identical to the nondiscriminatory equilibrium analyzed in Smith and Stutzer (1989), so its appendix can be used to prove the existence of this tradeoff. The concordance of the notation here with the notation in their appendix is as follows: our v is their y, our $\hat{\pi}_L^a$ is their π_L^D, our R_a is their R_g. Furthermore, our Eq. (1) replaces their (2), and our (9) replaces their (10). Readers attempting to replicate the appendix's proof will note that the additive term P_{HY} in our (1) and (9) cancels out, leaving the appendix's derivation valid, and that the first line on p. 193 should read "while π_L^D solves $U_{HH}^D = U_{HL}^D$, or from (10)."

help estimate default probabilities does help races (locations, sex, age groups) with high average default risk. But it also has the side effect of harming loan applicants from groups with lower average risk. Government-assisted community development lending could be used to provide loans to some group members who were unjustly denied private credit, but this has the surprising side effect of crowding out some private loans, which would otherwise have been made to other members of the same groups. As a result, the only way to increase the ex ante expected utility of a typical low-risk applicant from a targeted group is to offer community development loans on terms that earn subnormal profits. However, if this is done, the volume of private loans falls by more than the volume of community development loans. There would thus be no possibility of societal benefits associated with an increased stock of owner-occupied housing.

The existence of these side effects underscores the importance of performing policy analysis in the context of economic models which are consistent with the empirical evidence of racial differences in loan approval and default rates.

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