Statistical Evidence of Mortgage Redlining? A Cautionary Tale

*Fred J. Phillips-Patrick**
*Clifford V. Rossi**

***Abstract*. Statistical analyses of mortgage redlining at the neighborhood level have fueled the debate over the existence of racial redlining in mortgage lending, both "proving" and "disproving" that redlining exists, depending upon the type of model used. In this paper, we compare results of different statistical models using data for the Washington, DC metropolitan area to determine their usefulness in providing statistical evidence on this issue. After demonstrating the sensitivity of single-equation models to specification error, we estimate a simultaneous equations model of mortgage credit flows. This model makes it possible to analyze differences in the supply and demand for mortgage credit by the racial composition of the community. We conclude that most, if not all, statistical evidence of racial redlining based on aggregate loan data is at best inconclusive, and more likely, misleading.**

Introduction

Lending patterns in mortgage markets have been the focal point of many recent policy debates. Observed disparities in these patterns have led to such federal regulations as the Community Reinvestment Act of 1977 (CRA), and the Home Mortgage Disclosure Act (HMDA). Statistical analysis, in particular, has fueled the debate over the existence of racial redlining in mortgage lending, both "proving" and "disproving" that racial redlining exists, depending on which analysis is used. In this paper, we analyze the major approaches that have been used in the analysis of racial redlining to determine their usefulness in providing statistical evidence on this issue.

So far, the evidence of redlining in neighborhoods has been confined to single-equation, reduced-form models of mortgage credit flows (Holmes and Horvitz, 1994; Perle, Lynch and Horner, 1993). We show that these models, similar to those used in virtually all previous research, are unable to attribute neighborhood characteristics to demand or supply. To highlight the weakness of single-equation models, we first estimate several single-equation models of mortgage credit flows in the Washington, DC metropolitan area, each increasing in statistical sophistication. As we move from model to model, using the same data, we show that the statistical evidence that appears in one model then disappears in a subsequent model. Such reversals are due to model specification errors that arise from not taking into account the countervailing effects of differences in supply and demand.

To correct for this, we estimate a simultaneous equation model and, for the first time, are able to analyze differences in the supply of and demand for mortgatge credit by the racial make-up of a community. We find results that are consistent with racial redlining

*Office of Thrift Supervision, 1700 G Street, NW, Washington, DC 20552.
Date Revised—June 1995; Accepted—July 1995.

by lenders. However, these results are also consistent with differences in creditworthiness that others have found in individual loan-level analyses.

We find the statistical evidence on racial redlining to be extremely sensitive to the way the analysis is performed, and its reliability entirely dependent on the completeness of the data used. We conclude that most, if not all, statistical evidence of racial redlining based on aggregate loan data is at best inconclusive and more likely, misleading. There seems to be an unusually large gap between what is claimed about the statistical evidence on racial redlining and what can be justified by the actual analyses.

Testing for Redlining Based on Mortgage Flows

Racial redlining, according to the law, is defined as the refusal by a lender to offer credit to a particular community based on the racial make-up of the neighborhood. Courts have determined that racial redlining violates the Fair Housing Act. In an economic context, Becker (1971) defines discrimination as the situation wherein firms or individuals are willing to forego profitable opportunities to satisfy their "taste for discrimination." Under the Becker paradigm, redlining would occur if firms avoided making profitable loans to applicants from minority neigborhoods. For Becker, discrimination must have a demonstrable economic cost.

Models of mortgage credit flows attempt to measure differences in mortgage originations among neighborhoods. Most of these aggregate-level models are built upon the notion that the number of loans originated in a neighborhood, usually at the census tract level, can be explained by various proxies for demand and supply. A negative and statistically significant relation between percent minority in the neighborhood and the number of mortgages originated is often seen as "proof" of racial discrimination (Holmes and Horvitz, 1994). This result is interpreted as showing that as the percentage minority in a neighborhood increases, the ratio of originations to salable properties falls. For example, in a statistical analysis of mortgage lending patterns in Boston over 1982–1987, Bradbury, Case and Dunham (1989) report regression results that include a statistically significant negative impact from the percentage black in the neighborhood. In other words, they find that significantly fewer mortgage loans were originated in black neighborhoods than in white neighborhoods, even after controlling for some economic and other non-racial factors. Whether this type of finding constitutes evidence of racial redlining is the subject of much debate.

Perle, Lynch and Horner (1993) claim that aggregate level analyses of mortgage credit flows cannot identify redlining due to problems associated with model structure and specification, data limitations, and overaggregation. To demonstrate these problems, the authors estimate single-equation models of varying complexity for the Detroit metropolitan statistical area (MSA). The results associated with the racial composition variable are not robust across specifications. Specific to the problem of single-equation estimation, the authors lament that "one cannot attribute lower lending levels in minority areas to supply or demand effects. Simply put, reduced-form estimation cannot adequately discern supply-related redlining."

More recently, Holmes and Horvitz estimated a census tract-level model of mortgage credit flows for the Houston MSA. Their model included a number of independent variables intended to proxy for demand-side effects which might otherwise be correlated with race and hence, give a misleading indication that redlining occurs. The major contribution they made was the addition of variables reflecting risk underlying mortgage loans in an area such as the foreclosure rate on government-insured mortgages, and the change in home prices. The authors find that in estimating the model without the risk variables, the percent black variable was negative and statistically significant. However, upon estimation of the model with the risk factors included, the racial composition variable was no longer significant. Although the inclusion of these proxies for risk represents a useful extension to mortgage credit flow studies, it still suffers from a misspecification problem. We address that deficiency by providing a formal justification for adopting a simultaneous equations approach to estimating mortgage credit flows and empirical results from single-equation models and a simultaneous system of demand and supply for mortgage credit.

The Case for Simultaneity

To date, efforts to analyze mortgage credit flows at the neighborhood level have done so using single-equation reduced-form models. These models can be generalized as follows;

$$S_L \frac{ORIG}{UNITS} = \alpha_0 + \alpha_1 RACE + \sum_{i=1}^{N} \alpha_i X_i + \sum_{j=1}^{M} \alpha_j Zj + e_{L,} \tag{1}$$

where S_L is the supply of mortgage credit to neighborhood *L, ORIG* is the number of loan originations in a census tract, *UNITS* is the number of residential properties in the neighborhood, *RACE* is a variable indicating the racial composition of the neighborhood, *X* are variables affecting supply, and *Z* are variables affecting demand. In this model, demand is assumed to be exogenously determined. Holmes and Horvitz used this approach in modeling redlining in Houston. However, the assumption that demand is exogenous oversimplifies the nature of the mortgage market. Rachlis and Yezer (1993), for example, conceptualize the mortgage lending decision in a four-equation simultaneous framework. Rachlis and Yezer claim that separate equations should be estimated for choosing a lender, applying for a mortgage, endorsement of the loan, and finally loan default. The authors in this case do not empirically estimate this model due to the lack of data.

Maddala and Trost (1982) actually estimated a simultaneous model of mortgage credit on a loan-level basis in Columbia, South Carolina. Their model related demand and supply to a set of explanatory variables, including applicant race, and the interest rate on the loan. They argued that estimating models of loan rejection rates obfuscates the relationship of explanatory factors to supply or demand. As a result, such models cannot distinguish whether differences in lending patterns across neighborhoods are supply or demand-related. Single-equation models such as (1) suffer from this problem. By estimating equation (1) without estimating simultaneously an equation for the demand for mortgage credit, the model results in inconsistent and biased estimates of the parameters. To see this, assume that the actual model of mortgage credit flows take the following form:

$$D_R = \frac{APPS}{UNITS} = \beta_0 + \beta_R RACE + \beta_Z Z + \beta_S S_m + u_{R,} \tag{2a}$$

$$S_m = \frac{ORIG}{UNITS} = \alpha_0 + \alpha_R RACE + \alpha_X X + \alpha_D D_R + u_m, \tag{2b}$$

where D_R is the demand for mortgage credit in tract R as reflected by the ratio of loan applications ($APPS$) to $UNITS,$ and Z is a vector of non-racial variables explaining demand. In matrix form, we can reexpress the structural equations as follows:

$$q'\Psi + x'\theta = \mu', \tag{3}$$

where

$$q = \begin{bmatrix} S_t \\ D_t \end{bmatrix} x = \begin{bmatrix} 1 \\ X \\ Z \\ RACE \end{bmatrix} \mu = \begin{matrix} \mu_s \\ \mu_D \end{matrix}$$

$$\Psi = \begin{bmatrix} 1 & -\beta_S \\ -\alpha_D & 1 \end{bmatrix} \theta = \begin{bmatrix} -\alpha_0 & -\beta_0 \\ -\alpha_X & 0 \\ 0 & -\beta_Z \\ -\alpha_R & -\beta_R \end{bmatrix} E(\mu\mu') = \begin{bmatrix} \sigma_S{}^2 & \sigma_{SD} \\ \sigma_{DS} & \sigma_D{}^2 \end{bmatrix}$$

The reduced form of this two-equation model may be expressed as the following:

$$q' = x'\Delta + \xi, \tag{4}$$

where

$$\Delta = \theta\Psi^{-1} = \begin{bmatrix} \delta_{SO} & \delta_{DO} \\ \delta_{SX} & \delta_{DX} \\ \delta_{SZ} & \delta_{DZ} \\ \delta_{SR} & \delta_{DR} \end{bmatrix} \xi' = \mu'\theta^{-1}.$$

As Johnston (1984) shows, the OLS estimator for the model estimating supply becomes:

$$p\lim\theta = \theta + p\lim\left(\frac{1}{n}X'X\right)^{-1} p\lim\left(\frac{1}{n}X'\mu\right). \tag{5}$$

However, due to non-zero correlations between the disturbance term and explanatory factors in the model, the following condition holds:

$$p\lim\left(\frac{1}{n}X'\mu\right) \neq 0. \tag{6}$$

As a result, the estimates in the estimated supply of mortgages equation are biased. To explore these issues empirically, we first estimate a single-equation model of mortgage credit flows that is similar in construct to Holmes and Horvitz and then we estimate a simultaneous model of demand and supply. We are then able to examine the effect of race and non-racial factors attributed to demand and supply.

Modeling Mortgage Flows in Washington, DC

To illustrate the kinds of problems encountered in studies of mortgage credit flows, we present the results from our own statistical analysis that tests for mortgage redlining in the Washington, DC MSA. We estimate several versions of these models to show how easily differing results about redlining can be obtained. The base case model features a single-equation model that includes only a few key census tract variables—often the only ones used. We contrast the results from this model to a more complete single-equation version. Finally, we compare the results from a single-equation approach to those from a simultaneous equation model of mortgage loan demand and supply.

The dependent variable for the single-equation models is the ratio of originations to salable properties. This follows the convention of previous studies such as Holmes and Horvitz, and Perle, Lynch and Horner. We combine 1990 Census and 1992 HMDA data for the Washington, DC MSA. We confine our sample to mortgages for the purchase (not refinancing) of one- to four-family homes. We include both conventional and government (VA and FHA) loans, as our interest is in measuring all mortgage credit flows to the census tracts. Our final sample included 633 census tracts, representing 40, 419 loans and applications. A list of variable definitions is found in Exhibit 1.

The analysis features three different model specifications. Our first reduced-form model includes median income, median home price, and percent black residents as independent variables to explain the ratio of loan originations to total salable units in a census tract. The second reduced-form model extends the simple model by adding a number of variables characterizing the neighborhood, such as census tract loan-to-value ratio, unemployment rate and rental rate, among others. This approach follows Holmes and Horvitz's attempt to control for various demand-side factors that the simple model does not consider.

The third model features the simultaneous estimation of demand and supply of mortgage credit. While we retain the dependent variable for supply, we define demand slightly differently as in equation 2a. Defining demand in terms of a mortgage application rate is broadly consistent with Rachlis and Yezer's conceptual simultaneous framework for mortgage credit flows. Since the estimated form of this model represents the first

Exhibit 1
Variable Description

Variable	Definition
PBLK	Percent of residents in a census tract that are black
INCOME	Median neighborhood income ($000s)
*INCOME*2	*INCOME* squared
LTV	Tract median loan-to-value ratio
VACANCY	Tract vacancy rate
BOARD	Tract percentage of boarded-up property
UNEMP	Tract unemployment rate
RENTAL	Tract percentage of rental units
INMIG	Tract percentage in-migration 1989–90
AGE	Tract median age of residents
LOAN	Median tract loan amount ($000s)

appearance of such a model in the literature, a discussion of the exact specification is warranted.

The simultaneous model estimated takes the form:

$$S = \frac{ORIG}{UNITS} = \begin{array}{l} a_0 + a_1 PBLK + a_2 PRICE + a_3 INCOME \\ + a_4 INCOME2 + a_5 LTV + a_6 VACANCY \\ + a_7 BOARD + a_8 UNEMP + a_9 D \end{array} \tag{7a}$$

$$D = \frac{APPS}{UNITS} = \begin{array}{l} b_0 + b_1 PBLK + b_2 PRICE + b_3 INCOME \\ + b_4 INCOME2 + b_5 VACANCY + b_6 RENTAL \\ + b_7 BOARD + b_8 UNEMP + b_9 INMIG \\ + b_{10} AGE + b_{11} S. \end{array} \tag{7b}$$

In this configuration, we include the percent black variable in both the demand and supply equations. Holding constant all relevant factors, a negative coefficient on *PBLK* in the supply equation would be consistent with mortgage redlining. The sign on *PBLK* in the demand equation is uncertain. For instance, a positive coefficient may reflect increased lender outreach to meet CRA commitments. Information asymmetries may provide an alternative explanation for such a result. If minority borrowers are less able to assess the likelihood of obtaining a loan from a lender, they may apply more frequently. A negative coefficient associated with *PBLK* might be a sign that blacks are discouraged from applying for loans.

A number of other independent variables appear in both equations. Some of these reflect characteristics of prospective applicants such as median home price and income. Others reflect economic or physical condition of the neighborhood such as the unemployment rate, vacancy rate, and percent boarded-up property. The decision to apply for a loan is in part a function of the financial profile of the applicant. However, variables such as the vacancy rate and unemployment rate control for underlying strength of loan demand. For example, a high vacancy rate could reflect weak demand simply based on the limited availability of housing stock for purchase in the area.

These same variables could have a very different interpretation in the supply equation. For example, employment of prospective borrowers is a legitimate underwriting criterion as is borrower income and *LTV*. However, as indicated by Munnell, Browne, McEneaney, and Tootell (1992), redlining might also occur if factors reflecting neighborhood condition such as percent boarded-up property or vacancy rate are used in the underwriting process. The authors in that study first estimated models explaining loan rejection rates including neighborhood condition variables. Their model showed that higher vacancy rates and percent boarded-up property were associated with higher rejection rates, an effect that might indicate redlining based on neighborhood condition. However, when variables representing the economic characteristics of the loan applicants were included, the neighborhood effects were no longer significant, suggesting that lenders do not redline by neighborhood condition. We include such variables in the supply equation.

Several variables appear in one equation but not the other. Neighborhood *LTV* is one such variable. In this case it is used to gauge the ability to put up a downpayment for a mortgage by applicants in a neighborhood. The inclusion of the percent rental variable controls for cross-sectional variations in housing stock available for purchase. Neighborhoods with high percentages of rental units may have less demand for mortgages simply because there are fewer available units for sale. The in-migration variable is included on the demand side to reflect demographic changes that would tend to affect demand. Median age of the neighborhood is also hypothesized to be a demand factor.

For completeness, we close the structural model by including demand in the supply equation, and supply in the demand equation. According to the order condition, both equations are identified.

Mortgage Characteristics in Washington

Exhibit 2 shows far fewer institutions serve predominantly black neighborhoods than other areas, but it does not mean that firms avoid originating loans in black tracts. Also, loan application numbers are much lower in black neighborhoods, which could be supply or demand driven. There is, for example, ample difference in the characteristics of the neighborhoods. Vacancy rates, percent boarded-up properties, and unemployment rates are considerably higher in black areas. Black areas also experienced less in-migration between 1989 and 1990 than did other areas, a factor that might lower demand for loans in these areas relative to non-black census tracts. Loan acceptance rates are markedly lower in black neighborhoods. This result could reflect differences in the risk profiles of prospective borrowers residing in these areas. Alternatively, it could reflect redlining. Univariate statistics provide little information about this issue

Exhibit 2
Summary Statistics by Firm and Neighborhood

	Commercial Banks		Thrifts		Mortgage Companies	
Variable	Black Tracts	Non-Black Tracts	Black Tracts	Non-Black Tracts	Black Tracts	Non-Black Tracts
Number of firms	30	103	15	58	10	45
VACANCY (%)	8.69	5.50	6.63	5.19	6.87	5.35
INCOME ($)	37,160	63,664	41,287	65,577	43,919	58,767
LTV (%)	73.02	67.54	68.10	73.61	77.39	71.05
RENTAL (%)	44.68	25.67	38.19	25.17	31.88	29.12
BOARD (%)	1.76	.09	1.26	.11	1.22	.10
UNEMP (%)	7.88	2.74	6.66	2.63	6.11	2.84
INMIG (%)	17.53	21.08	16.97	20.12	16.57	23.41
Acceptance rate (%)	80.58	92.86	67.86	92.15	67.80	87.10
Average applications per firm (#)	20.6	218.37	8.93	267.21	17.7	343.04
LOAN ($)	73,737	144,036	70,392	161,052	82.773	136.328

Empirical Results

Single-Equation Results

The results from the reduced-form single-equation models are reported in Exhibit 3. The first two columns of Exhibit 3 show the results from the simple model. In our second specification of the simple model, we substituted an indicator variable on whether the census tract is predominantly black (more than 75%) for the percent black to test for differences between under-served areas and other neighborhoods. The results from this model are similar to the finding of the previous model, i.e., the ratio of originations to salable units in black neighborhoods is significantly lower than in non-black areas. The results from these two simple models, without further analysis, would lead to the conclusion that redlining exists in the Washington, DC area. However, this simplistic approach has several statistical problems.

This simple single reduced-form statistical model cannot separate out demand- versus supply-side reasons for mortgage flows, which may contribute to the finding of redlining. The model also omits important census tract information that could reflect demand-side effects. To remedy the latter deficiency, we add several census tract-level variables to the model, similar to those used in several of the studies described above. We include the following: median loan-to-value ratio (*LTV*),[1] which on the demand side might proxy for a borrower's relative ability to come up with a downpayment, and on the supply side proxy as a measure of risk, as *LTV* is a key indicator of mortgage performance in default studies; the unemployment rate and percent rentals, which might reflect demand for mortgages; and the percent of boarded-up housing and vacancy rate variables as possible controls on neighborhood condition (Campbell and Dietrich, 1983; Holloway,

Exhibit 3
Single-Equation Estimation†

Variable	(1)	(2)	(3)	(4)	(5)
Intercept	51.55*	35.50*	138.14*	137.16*	141.78*
No. of Salable properties	.131*	.133*			
Percent black	−.551*		−.011		.001
Median home price	.0001*	.0001*			
Median income	−.0013*	−.0011*	−8.443*	−8.322*	−9.214*
Black neighborhood		−45.47*		−2.427	
LTV			−.344*	−.339*	−.361*
VACANT			.417*	.419*	
AGE			.016	.034	
RENT			−.096*	−.094*	−.110*
BOARD			−.714**	−.662**	
UNEMP			−.758*	−.706*	−.676*
INMIG			.396*	.389*	.496*
Loan amount			−1.946	−2.427	−.604
Adjusted R^2	.49	.49	.37	.37	.36

†Dependent variable for columns 1 and 2=Total Originations
Dependent variable for columns 3, 4 & 5=Originations/Salable Units
*, **significant at the 1% and 5% levels, respectively

MacDonald and Straka, 1993). The results from this specification are found in columns 3–5 of Exhibit 3.

Many of the added explanatory variables in the expanded regression model are significant and have the anticipated sign. The *LTV* ratio is inversely associated with mortgage credit flows. The unemployment rate and percent rental variables are significant and have negative effects. We find that the percentage black and black neighborhood indicator variables are no longer statistically significant when we add census tract variables. This more complete specification follows similar models used by Holmes and Horvitz, and Perle, Lynch and Horner, and produces similar results.

As indicated earlier, separating demand and supply effects of some of the tract characteristics variables in a single-equation model is problematic, particularly as it relates to the interpretation of redlining. To deal with this, we reestimate the expanded model, this time excluding the vacancy rate and percent of boarded-up property factors that could have both supply and demand effects. The percent black variable did not become significant after the two variables were omitted.

A Simultaneous Equations Model of Mortgage Flows

Finally, we estimate a simultaneous equation model of mortgage demand and supply using two-stage least squares. The measure of demand is the ratio of mortgage applications to total salable units. Supply is defined, as before, as the ratio of originations to total salable units. By estimating separate models, we can examine the effects that variables may have on both demand and supply. The results from this estimation are found in Exhibit 4.

Exhibit 4
Simultaneous Model of Mortgage Origination in Washington, DC†

Variable	Demand	Supply
Intercept	−.1525**	−.2206**
Percent black	.0144*	−.0176*
Median home price	.0060	.0099
Median income	−.4745*	.1742**
Median income squared	.1481*	−.0665**
LTV		.0819
Vacancy rate	−.0072	−.0070
Percent rentals	−.0600*	
Percent boarded-up property	.0016	.0001
Unemployment rate	−.0124	.0193**
Percent in-migration 1989–90	.0673*	
Median age	.4711*	
Demand		1.0264*
Supply	.9986*	
System-wide R^2	.345	

†Demand=Applications/Salable Units
Supply=Originations/Salable Units
*, **significant at the 1% and 5% levels, respectively; N=633.

In the simultaneous equations model, we find on the demand side that as the percentage of black households in a neighborhood rises, the ratio of mortgage applications to salable units rises as well. This result could reflect, among other things, more aggressive marketing by lenders in minority areas or that minority applicants face greater uncertainty or arbitrariness in loan decisions and compensate by applying more frequently. By contrast, the results from the supply equation show that originations drop in neighborhoods as the percentage of black residents rises. This result could reflect redlining, or it could reflect an omitted variables problem (no creditworthiness data). Several authors have noted that omitting factors such as credit history may be correlated with the race variable and hence, yield biased estimates of the race coefficient (Horne, 1994; Schill and Wachter, 1993; Perle, Lynch and Horner, 1993). In either case, without additional information, we are unable to determine the cause of these findings.

Thus, whle the extended single-equation model found no significant effect from the percent black variable, the simultaneous equation model suggests that loan supply is negatively associated with racial composition. The result from the single-equation model may in fact reflect the offsetting effects of racial composition in the demand and supply equations. Hence, the results from a single-equation model are not reliable indicators of redlining or its absence. Yet even the simultaneous model does not provide definitive evidence of redlining, as those results may be caused primarily by differences in individual credit histories, as in the Munnell et al., Boston study.

Conclusion

Our statistical analysis of the Washington, DC MSA illustrates the hazards associated with using single-equation models of mortgage credit flows to examine racial redlining. A simple model can show the presence of redlining, while a more complete single-equation model that adds additional variables to correct some deficiencies does not. A further refinement—a simultaneous equations model with separate demand and supply equations—leads to another reversal by suggesting potential redlining practice. However, even this result requires further investigation using credit history information or default rates as additional explanatory variables.

A major drawback of all aggregate credit flow models is that they focus exclusively on the neighborhood and not the individual borrower and lender. Ultimately, it is the dynamics of the mortgage market and the participants, both borrower and lender, that determine lending outcomes.

The use of statistical models of mortgage credit flows to test for racial redlining is a worthwhile but risky endeavor. The danger comes from either concluding that racial redlining exists when it does not, or concluding that racial redlining does not exist when it does. To underscore this point, we showed that alternative specification of the underlying mortage market can lead to completely different conclusions about racial redlining. Our analysis shows how precarious the results derived from statistical models can be in showing the presence or absence of racial redlining. And the costs of misidentifying racial redlining are not inconsequential both to borrowers when we fail to find a bias when it exists, and to lenders when we find evidence of bias when it does not exist.

Note

[1]We calculated median *LTV* as the ratio of the median loan amount originated in a census tract to the census tract's median home price.

References

Becker, G. S., *The Economics of Discrimination,* Chicago: University of Chicago Press, second edition 1971.

Bradbury, K. L., K. E. Case and C. R. Dunham, Geographic Patterns of Mortgage Lending in Boston, 1982–87, *New England Economic Review,* 1989, 3–30.

Campbell, T. S. and J. K. Dietrich, The Determinants of Default on Insured Conventional Residential Mortage Loans, *Journal of Finance,* 1983, 38, 1569–81.

Holloway, T. M., G. D. MacDonald and J. W. Straka, Credit Scores, Early-Payment Mortgage Defaults, and Mortgage Loan Performance, paper presented at the 1993 mid-year AREUEA meetings, 1993.

Holmes, A. and P. Horvitz, Mortgage Redlining: Race, Risk, and Demand, *Journal of Finance,* 1994, 49, 81–99.

Horne, D. K., Evaluating the Role of Race in Mortgage Lending, *FDIC Banking Review,* Spring/Summer, 1994, 7, 1–15.

Johnston, J., *Econometric Methods,* New York: McGraw-Hill, second edition 1984.

Maddala, G. S. and R. P. Trost, On Measuring Discrimination in Loan Markets, *Housing Finance Review,* 1982, 245–68.

Munnell, A. H., L. E. Browne, J. McEneaney, and G. M. G. Tootell, Mortgage Lending in Boston: Interpreting HMDA Data, Working Paper 92–7, Federal Reserve Bank of Boston, 1992.

Perle, E. D., K. Lynch and J. Horner, Model Specification and Local Mortgage Market Behavior, *Journal of Housing Research,* 1993, 4, 225–43.

Rachlis, M. B. and A. M. J. Yezer, Serious Flaws in Statistical Tests for Discrimination in Mortgage Markets, *Journal of Housing Research,* 1993, 4, 315–36.

Schill, M. H. and S. M. Wachter, A Tale of Two Cities: Racial and Ethnic Geographic Disparities in Home Mortgage Lending in Boston and Philadelphia, *Journal of Housing Research,* 1993, 4, 245–76.

Yezer, A. M. J., R. Phillips and R. P. Trost, Bias in Estimates of Discrimination and Default in Mortgage Lending: The Effects of Simultaneity and Self-Selection, *Journal of Real Estate Finance and Economics,* 1994, 9, 197–215.

The authors thank Anthony Yezer and David Horne for helpful comments. The views expressed herein are those solely of the authors and do not necessarily reflect those of the Office of Thrift Supervision.