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PREPAYMENT RISK AND LOWER INCOME MORTGAGE BORROWERS

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Wayne R. Archer, David Ling, and Gary McGill

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Abstract

This paper examines the differential home mortgage termination experience of "affordable housing" households in the United States from 1985 to 1995. Using five two-year panels of data from the American Housing Survey, we test for differential mortgage termination behavior by households with income at or below approximately 80 percent of median for the household's metropolitan area. Mortgage termination rates of "affordable housing" households are compared to those of other homeowners, and differentials in factors influencing the termination rate are examined. In a separate set of logistic regressions we redefine the test group to include only those low-to-moderate-income households that are first-time homeowners.

Results from the estimation of a series of logistic regressions suggest that the propensity for mortgage prepayment by low-to-moderate income households is little distinguished from higher income households. In particular, low-to-moderate income households are no less responsive to interest rate changes than higher income households. None of these results change when the analysis focuses on the prepayment behavior of only lower income first-time homebuyers.

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I. Introduction

Over the 1990s the U.S. housing finance system increased its attention to issues of affordable housing. The GSEs, notably Freddie Mac and Fannie Mae, introduced multiple special lending programs targeted to first-time homebuyers and to households with income below 80 percent of area median. At the same time, regulators for the related issue of "redlining" have carefully scrutinized banks and other depository institutions seeking merger authorization.

When loans are targeted to "affordable housing" needs, it is common to ask whether they engender differential default risk, and extensive investigation of this issue has occurred.[1] It has been less common to ask whether "affordable housing" loans incur differential prepayment risk. This is despite the fact that the residual default risk premium on home loans originated to GSE or FHA standards may be much smaller than the companion prepayment risk premium.[2] Further, although default risk appears to have been managed and mitigated very significantly by credit scoring, automated underwriting systems, and perhaps by better housing market information, the more systematic risk of prepayment actually may have increased due to greater homeowner financial awareness and lowered costs of refinancing.

Because the prepayment risk premium is a significant and intractable cost of home mortgage lending, it is valuable to ask whether that premium should differ for loans directed to affordable housing needs. Investigators have found that exercise of the prepayment option is dampened by income and collateral constraints (Archer, Ling, and McGill 1996; LaCour-Little 1999). In addition, exercise of the prepayment option may be less likely by households that are less financially endowed or less financially sophisticated. Thus, there is some reason to believe that prepayment risk may be lower for loans to affordable housing borrowers, especially those that are first-time homeowners. If so, investor recognition of this advantage should facilitate

[1] For evidence concerning GSE research on home mortgage default prediction, see, for example, Freddie Mac (1996) and HUD's 1996 study on mortgage foreclosures (U.S. Department of Housing and Urban Development 1996).

[2] See Hilliard, Kau and Slawson (1988) for simulated comparisons of default and prepayment premia. Also, note that the relative size of default and prepayment premia is suggested by their relative frequency of occurrence. While home mortgage foreclosure rates seldom have exceeded 0.35 percent of outstanding loans (Mortgage Bankers Association 2000), refinancings have accounted for an average of 38 percent of new loans during the 1990s, and have exceeded 50 percent in three different years (Mortgage Market Trends 1999:Table A2). Researchers recognize that heterogeneity among subpopulations of borrowers must be addressed in determining default and prepayment premia (e.g., Deng and Quigley 2000).

greater willingness to acquire portfolios of affordable housing loans and encourage more competitive pricing.[3]

This paper examines the differential home mortgage termination experience of "affordable housing" households in the United States from 1985 to 1995. Using five two-year panels of data from the American Housing Survey (AHS), we test for differential mortgage termination behavior by households with income at or below approximately 80 percent of median for the household's metropolitan area. Mortgage termination rates of "affordable housing" households are compared to those of other homeowners, and differentials in factors influencing the termination rate are examined. In a separate set of logistic regressions we redefine the test group to include only those low-to-moderate-income households that are first-time homeowners.

This study offers three important departures from the existing literature. First, it is the first effort known to examine differential termination behavior for affordable housing mortgage loans. Second, it relies on a database that is thought to be the most representative of American housing experience that exists, and third, it spans an important time of mortgage termination behavior that has not yet been broadly examined—the early 1990s.

In Section 2 we set out the logical framework of our analysis and review related studies. Section 3 describes the data and the empirical method used to test the model's predictions. Results and interpretations appear in Section 4, and the last section offers some concluding remarks.

II. Logical Foundations And Related Work

A General Framework for Mortgage Terminations

This study focuses on the termination of fixed-rate residential mortgages and proceeds from the following general framework (Archer, Ling, and McGill 1997). The probability of mortgage termination for all reasons at time t, λ_{Tt}, may be stated as

$$\lambda_{Tt} = \lambda_{Dt} + (1- \lambda_{Dt})\lambda_{M.NDt} + (1- \lambda_{Dt})(1 - \lambda_{M.NDt})\lambda_{P.NDMt} \qquad (1)$$

where λ_{Dt} is the probability of default at time t,

[3] Nothaft and Perry (1996) have found evidence that varying risk premia are present in conforming fixed-rate loans. Conversations by the authors with Freddie Mac staff indicate that both default risk and differential prepayment propensity are accounted for in the pricing of loans purchased.

$\lambda_{M.NDt}$ is the probability of moving and terminating, but not defaulting, at time t,

and

$\lambda_{P.NDMt}$ is the probability of terminating (prepaying) the mortgage, conditional upon not defaulting or moving.

Note that equation (1) is consistent with a hierarchy of choices. The borrower can terminate and neither default nor move. Choosing this "package" of options is referred to as refinancing. A second package of options available to the borrower is to move and, therefore, prepay, but not default. Default is the third available package and involves both moving and prepaying. The total probability of terminating is equal to the sum of these three interdependent probabilities.

The probability of defaulting, λ_{Dt}, can be stated in general terms as

$$\lambda_{Dt} = \lambda_{Dt}(\mathbf{x}_t,\mathbf{s}_t,\mathbf{T}_{\mathrm{DMt}},C_t) \tag{2}$$

where: $\mathbf{x}_t$ is a vector of household and property characteristics,

$\mathbf{s}_t$ is a vector of household shocks such as divorce, loss of employment, etc.,

$\mathbf{T}_{\mathrm{DMt}}$ is a vector of transactions costs due to defaulting and, therefore, moving,

and

C_t is the value of the option to prepay an in-the-money call or to preserve the mortgage if interest rates have risen since origination.

The probability of moving, conditional on not defaulting, $\lambda_{M.NDt}$, can be stated as

$$\lambda_{M.NDt} = \lambda_{M.NDt}(\mathbf{x}_t, \mathbf{y}_t,\mathbf{T}_{\mathrm{Mt}},C_t) \tag{3}$$

where $\mathbf{x}_t$ and C_t are as defined above, $\mathbf{y}_t$ is a vector of income opportunities related to potential moves, and $\mathbf{T}_{\mathrm{Mt}}$ is a vector of transactions costs due to moving. Finally, the probability of prepayment conditional on not defaulting or moving, $\lambda_{P.NDMt}$, can be stated as

$$\lambda_{P.NDMt} = \lambda_{P.NDMt}(C_t, \mathbf{x}_t), \tag{4}$$

where $\mathbf{x}_t$ and C_t are as defined above. In general terms,

$$C_t = C(\mathbf{x}_t,\mathrm{PVIS}_t,\mathbf{P},\boldsymbol{\lambda}_{\mathrm{M.NDt}},\boldsymbol{\lambda}_{\mathrm{Dt}}) \tag{5}$$

where: $\mathbf{x}_t$ is the same as above,

$PVIS_t$ is the present value of the interest savings from a refinancing at time *t*,

P is a vector of parameters governing interest rate movements,

$\boldsymbol{\lambda}_{M.NDt}$ is the vector of pure move probabilities from time *t* to the end of the mortgage term, and

$\boldsymbol{\lambda}_{Dt}$ is a corresponding vector of default probabilities.

Note that $\boldsymbol{\lambda}_{Dt}$ and $\boldsymbol{\lambda}_{M.NDt}$ are interdependent with C_t. That is, the value of the interest rate call option is partially determined by current and future move probabilities, while these latter probabilities are simultaneously affected by the value of the call option. Because of this interdependency, $\boldsymbol{\lambda}_{Dt}$, $\boldsymbol{\lambda}_{M.NDt}$, and C_t cannot be separately estimated; estimation inherently involves simultaneous equations. To avoid this simultaneity problem, we use the present value of interest savings (PVIS), and other exogenous variables, to proxy for the influence of C_t. This allows us to estimate the probability of terminating for any reason with a single reduced form equation. The remainder of this section discusses the three components of residential mortgage termination probabilities: interest rate driven calls (refinancings), moves, and defaults.

The Probability of Refinance

One option continuously available to mortgage borrowers is to simply refinance—and neither default nor move. Endogenous or "rational" prepayment models "predict" that borrowers with similar contract terms will react similarly to changes in market interest rates. However, many borrowers fail to exercise well-into-the-money call options, while others prepay when the call option is out-of-the-money. Archer et al. (1996) provide evidence that the refinancing behavior of households that are income or collateral constrained differs markedly from unconstrained households. A borrower considering refinancing must first qualify for a new mortgage. Current qualification standards are such that a fall in household income or the value of the home used as collateral may make qualification for a new loan difficult. In fact, Archer et al. (1996) conclude that household demographic characteristics are only important to the extent that they predict whether a household will be income or collateral constrained. In any case, interest rate influences on prepayment are conditioned upon non-interest rate factors, including the household's propensity to move.

Several previous studies have used individual loan data to analyze mortgage terminations. These studies generally have found that borrower income and housing equity are significant determinants of mortgage terminations. However, the data employed in these studies typically are measured as of the mortgage origination date rather than the termination date. Post-origination income and property values for individual observations are either proxied for by using their values at origination or estimated with aggregate adjustments. For example, the house value at origination may be inflated by the average amount of appreciation that has occurred in the surrounding market (usually metropolitan) area.[4] The measurement of post-origination income and equity in these studies is therefore hindered by data that are insufficient to capture the idiosyncratic nature of borrower incomes and house prices.[5] In contrast to the data sources of these earlier studies, the AHS data used here offer a more comprehensive set of households, more household-level detail, and actual post-origination data. Hence, the AHS data offer an exceptional opportunity to study the effects of micro-influences, including household income, on termination probabilities.

Relocation

The second "package" of options includes relocation. The probability of relocating (equation 3) depends on household and property characteristics, $\mathbf{x}_t$, income opportunities, $\mathbf{y}_t$, transaction costs of moving, $\mathbf{T}_{Mt}$, and the value of preserving any below market mortgage debt, C_t. By selling the home and relocating, the borrower is jointly deciding to move and refinance in that moving generally precipitates the termination of the mortgage. Thus, the advantages of relocating may be enhanced or diminished by simultaneously extinguishing an existing loan. For this reason, many of the same factors that determine the probability of a "pure" interest rate driven refinancing also exert influence on relocation decisions. From the extensive literature investigating household mobility, Archer et al. (1997) review and discuss variables that potentially impact mortgage termination decisions. What emerges from their analysis is that the household-level factors affecting mobility are far from simple. Rather, they appear to have considerable interaction, such as with life cycle, education, income, and employment longevity. Further, there does not appear to be any one data source that has supported a joint analysis of all

[4] See, for example, Foster and Van Order (1985), Quigley and Van Order (1990), Cunningham and Capone (1990), Capone and Cunningham (1992), Caplin, Freeman, and Tracy (1993), and Peristiani et al. (1996).
[5] A notable recent exception is LaCour-Little (1999).

the factors that have been identified. Moreover, until Quigley's (1987) work, little had been done to incorporate financial or investment portfolio considerations into the empirical analysis of mobility. In fact, the association between investment return (appreciation) and mobility is theoretically ambiguous (Kiel 1994). In short, a comprehensive, integrated theory of household mobility does not exist. Unfortunately, this creates an uncertain foundation for specifying the functional form of equation (3). Further, to the extent that the equation has been improperly specified, the error is likely to affect the estimation of $\lambda_{P.NDMt}(C_t, \boldsymbol{x}_t)$ and $\lambda_{Dt}(\boldsymbol{x}_t, \boldsymbol{s}_t, \boldsymbol{T}_{DMt}, C_t)$. In this case, it is likely to be unproductive to attempt to estimate the three equations separately and to sort out the separate effect of common variables. This leads us to rely on a reduced form model for this study.

The Probability of Default

A third package of options available to mortgage borrowers is default. Note that the decision to default is executed simultaneously with the decision to both move and prepay. For this reason, the advantages of default may be enhanced and/or diminished by the simultaneous decisions to move and prepay. However, the extensive literature investigating borrower default suggests prominent roles for two factors: cash flow deficiency (high payment burden) and "negative equity." In addition, recent attention has focused on the role of transactions costs as a barrier to default even when equity is negative, and upon the importance of "trigger events" or "shocks" such as unemployment, divorce, and death (Vandell 1995l; Deng, Quigley, and Van Order 2000). Although the theory of default behavior is perhaps more integrated than mobility theory, it still is very incomplete.

III. Method

Data and Periods

The analysis employs data from the 1985, 1987, 1989, 1991, 1993, and 1995 AHSs conducted by the U.S. Bureau of the Census (U.S. Department of Commerce 1985–1995). The AHS, conducted biennially, contains extensive micro-level data on household and property characteristics, including number, age, and marital status of occupants, income type and level, tenure status, original and current home values, home acquisition date, property tax payments, geographic location, etc. The AHS also includes detailed mortgage information for owners,

including the number and amount of mortgages, mortgage interest rates and payments, origination dates, and original and remaining loan terms.

Information on the construction of our five samples is provided in Figure 1. Consider the 1985–1987 sample. There were 27,490 useable owner households in the 1987 AHS. These households were first matched by unit control numbers with the 1985 sample of owner households. This matching procedure yielded 20,596 owner households. Of these 20,596 observations, 9,946 did not have a mortgage in 1985. Households headed by persons over age 65 (354 observations) and households with mortgages older than 15 years (689 observations) were excluded. An additional 4,513 were excluded because they had other than a fixed-rate primary mortgage, very small mortgage balances (less than 10 percent of house value), or lacked information necessary to determine whether the primary mortgage was terminated (in the case of non-movers). The final 1985–1987 sample contains 5,054 households. The four remaining samples were created in the same manner and contain 5,089, 4,955, 5,378, and 4,633 households, respectively. Figure 1 summarizes the sample construction information. Selective summary statistics are presented in Figure 2.

Figure 1: Sample Construction

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Useable owner-occupied households in window end year	27,490	27,975	28,091	29,925	28,182
Less households not in base year or end year	(6,894)	(6,868)	(6,854)	(8,262)	(6,567)
Total owner-occupied households in AHS matched by control number	20,596	21,107	21,237	21,663	21,615
Less:					
Households with no mortgage	(9,946)	(10,391)	(10,420)	(10,105)	(9,854)
Households headed by person > age 65	(354)	(293)	(365)	(367)	(360)
Mortgage older than 15 years	(689)	(673)	(748)	(865)	(919)
Excluded for other reasons[a]	(4,553)	(4,661)	(4,749)	(4,948)	(5,849)
Sample used in analysis	5,054	5,089	4,955	5,378	4,633

[a] Households had other than a fixed-rate primary mortgage, very small mortgage balances (less than 10 percent of house value), or lacked information necessary to determine whether the primary mortgage was terminated (in the case of non-movers).

Source: U.S. Department of Commerce, Bureau of the Census. *American Housing Survey 1985, 1987, 1989, 1991, 1993, 1995* and authors' tabulations.

Figure 2: Sample Descriptive Statistics

Panel A: 1985-87 Data Window

		Non-Low Income			Low-Income			Low-Income First-Time Owner		
		Mortgage Age Groups			Mortgage Age Groups			Mortgage Age Groups		
		0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years
Total households		1,122	1,384	459	818	885	386	434	459	226
Households that terminated mortgages	%	56	35	25	52	35	33	53	33	36
Current fair market value of residence ($000s)	median	79.50	80.00	80.00	46.50	55.00	55.00	45.00	48.00	50.00
	mean	86.75	88.84	90.76	50.43	62.04	62.81	46.06	55.13	58.16
	SD	41.87	43.45	42.85	32.01	36.76	37.10	28.78	34.26	34.76
Number of years mortgage outstanding	median	2.00	7.00	13.00	2.00	7.00	13.00	1.50	7.00	13.00
	mean	1.73	7.21	12.75	1.65	7.26	12.81	1.59	7.33	12.85
	SD	1.38	1.57	1.34	1.34	1.59	1.43	1.31	1.60	1.43
Present value of interest savings from prepayment[a]	median	10.00	0.58	-1.01	4.31	0.32	-0.49	4.59	0.28	-0.43
(PVIS) ($000s)	mean	11.42	2.23	-1.08	6.20	1.38	-0.49	6.46	1.25	-0.32
	SD	9.90	5.75	2.36	7.31	4.06	2.95	7.23	3.94	3.12
Mortgage call options in-the-money[b]	%	91	59	17	89	60	31	92	59	34
Book land-to-value ratio (LTV)	median	0.71	0.45	0.25	0.71	0.47	0.27	0.75	0.50	0.27
	mean	0.69	0.46	0.28	0.69	0.48	0.30	0.72	0.50	0.30
	SD	0.21	0.19	0.16	0.25	0.22	0.18	0.25	0.23	0.17
Annual payment-to-income ratio (PAYINC)	median	0.14	0.09	0.06	0.18	0.16	0.12	0.18	0.15	0.11
	mean	0.14	0.10	0.07	0.35	0.27	0.23	0.22	0.21	0.24
	SD	0.07	0.05	0.05	3.14	0.55	0.47	0.28	0.32	0.58
More than one mortgage (yes =1) (SECMORT)	%	8	13	18	7	12	13	6	10	15
First-time homeowner (yes=1) (FIRSTTIME)	%	39	39	50	53	52	59	100	100	100
Potential wasted interest as % of residence FMV	median	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02
(TAX)[c]	mean	0.00	0.00	0.00	0.05	0.03	0.03	0.06	0.04	0.03
	SD	0.01	0.01	0.01	0.10	0.07	0.04	0.10	0.09	0.04
Total income (INC)	median	43.00	45.00	45.00	21.00	21.00	20.00	21.55	21.00	20.00
	mean	48.48	50.53	49.66	19.99	19.42	18.45	20.39	19.86	18.69
	SD	19.03	19.82	17.74	7.57	8.44	8.36	7.45	7.92	8.31
Two wage earner (yes=1) (JOINTINC)	%	67	68	67	37	30	31	41	34	31
Age of household head (AGE)	median	35.00	39.00	44.00	33.00	38.00	45.00	30.00	35.00	42.50
	mean	36.19	41.01	45.80	35.99	41.23	46.54	31.65	37.49	43.94
	SD	8.44	8.36	7.77	10.76	9.91	9.13	8.52	8.48	8.35
Head with 2 or more years of college (yes=1)	%									
(COLLEGE)		60	59	57	35	32	24	37	32	21
Family size (FAMSIZE)	median	3.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00
	mean	3.10	3.46	3.57	2.80	3.25	3.24	2.68	3.35	3.50
	SD	1.29	1.31	1.41	1.44	1.58	1.49	1.42	1.59	1.48
African-American head (yes=1) (BLACK)	%	5	5	6	7	8	13	10	11	19
Hispanic head (yes=1) (HISP)	%	3	4	4	4	6	6	5	7	9
Rural location[d] (yes=1) (RURAL)	%	7	7	6	18	11	13	13	9	13

Figure 2 (continued): Sample Descriptive Statistics

Panel B: 1987-89 Data Window

		Non-Low Income			Low-Income			Low-Income First-Time Owner		
		Mortgage Age Groups			Mortgage Age Groups			Mortgage Age Groups		
		0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years
Total households		1,646	1,091	569	900	568	315	472	295	182
Households that terminated mortgages	%	32	33	26	37	37	32	38	38	31
Current fair market value of residence	median	90.00	85.00	80.00	55.00	52.50	55.00	50.00	47.00	50.00
($000s)	mean	102.04	97.17	96.71	60.75	63.46	66.68	56.08	55.66	59.50
	SD	49.82	50.53	52.08	40.50	42.77	42.59	37.73	38.97	40.38
Number of years mortgage outstanding	median	2.00	8.00	12.00	1.00	8.00	12.00	1.00	8.00	12.00
	mean	1.73	7.73	12.67	1.66	7.83	12.77	1.67	7.82	12.78
	SD	1.32	1.65	1.42	1.34	1.62	1.53	1.36	1.61	1.51
Present value of interest savings from	median	0.32	-0.36	-1.66	0.29	0.00	-1.06	0.36	0.06	-0.80
prepayment[a] (PVIS) ($000s)	mean	0.48	0.17	-1.72	0.60	0.21	-1.14	0.52	0.60	-0.93
	SD	6.07	4.29	2.02	4.37	3.68	2.21	4.09	3.79	1.95
Mortgage call options in-the-money[b]	%	55	44	13	64	51	25	67	56	26
Book loan-to-value ratio (LTV)	median	0.72	0.49	0.30	0.74	0.51	0.32	0.80	0.52	0.32
	mean	0.69	0.50	0.33	0.72	0.53	0.36	0.75	0.54	0.36
	SD	0.22	0.22	0.19	0.26	0.25	0.22	0.25	0.25	0.23
Annual payment-to-income ratio	median	0.16	0.10	0.07	0.21	0.18	0.14	0.21	0.16	0.13
(PAYINC)	mean	0.16	0.11	0.08	0.35	0.37	0.27	0.31	0.41	0.24
	SD	0.07	0.06	0.05	0.97	2.21	0.49	0.59	3.02	0.46
More than one mortgage (yes =1)										
(SECMORT)	%	5	16	18	4	12	13	3	10	12
First-time homeowner (yes=1)										
(FIRSTTIME)	%	39	41	48	52	52	58	100	100	100
Potential wasted interest as % of	median	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.04	0.04
residence FMV (TAX)[c]	mean	0.01	0.01	0.01	0.07	0.06	0.05	0.07	0.07	0.05
	SD	0.02	0.02	0.01	0.13	0.11	0.06	0.13	0.11	0.06
Total income (INC)	median	47.00	47.00	47.30	21.50	21.00	20.00	22.10	20.40	20.00
	mean	53.47	54.78	54.35	20.58	19.86	18.78	21.35	19.94	18.78
	SD	22.54	25.09	22.76	7.99	8.49	8.92	7.57	8.19	8.47
Two wage earner (yes=1) (JOINTINC)	%	69	67	70	31	31	29	33	34	31
Age of household head r (AGE)	median	35.00	40.00	44.00	34.00	40.00	45.00	29.00	36.00	42.00
	mean	36.68	41.43	45.61	36.47	41.95	46.79	31.62	37.78	43.35
	SD	8.40	8.30	7.24	10.97	9.96	9.37	8.27	8.30	8.29
Head with 2 or more years of college	%									
(yes=1) (COLLEGE)		62	61	59	36	32	32	36	30	32
Family size (FAMSIZE)	median	3.00	4.00	4.00	3.00	3.00	3.00	2.00	4.00	3.00
	mean	3.06	3.37	3.45	2.70	3.14	3.05	2.57	3.38	3.35
	SD	1.26	1.35	1.44	1.47	1.60	1.49	1.45	1.63	1.52
African-American head (yes=1)	%									
(BLACK)		5	5	6	7	12	13	8	17	17
Hispanic head (yes=1) (HISP)	%	4	4	4	5	5	6	6	6	9
Rural location[d] (yes=1) (RURAL)	%	7	8	7	16	17	12	14	14	12

Figure 2 (Continued): Sample Descriptive Statistics

Panel C: 1989-91 Data Window

		Non-Low Income			Low-Income			Low-Income First-Time Owner		
		Mortgage Age Groups			Mortgage Age Groups			Mortgage Age Groups		
		0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years
Total households		1,778	955	629	849	435	309	459	216	174
Households that terminated mortgages	%	25	39	24	31	39	25	29	35	26
Current fair market value of residence ($000s)	median	95.00	90.00	90.00	55.00	55.00	65.00	52.00	53.00	54.50
	mean	115.68	106.43	109.41	66.70	70.48	81.60	63.39	66.52	71.17
	SD	65.00	61.60	65.75	48.57	52.89	59.17	46.81	51.22	53.53
Number of years mortgage outstanding	median	2.00	7.00	13.00	2.00	7.00	12.00	2.00	7.00	12.00
	mean	2.00	7.38	12.69	1.76	7.51	12.50	1.72	7.32	12.43
	SD	1.32	1.86	1.34	1.37	1.94	1.33	1.35	1.93	1.27
Present value of interest savings from prepayment[a] (PVIS) ($000s)	median	3.19	2.16	-0.38	1.62	1.16	0.01	1.50	1.51	0.02
	mean	3.78	3.59	-0.34	2.38	2.48	-0.02	2.27	2.69	0.34
	SD	6.01	5.35	2.15	4.16	4.24	2.51	4.39	4.40	2.45
Mortgage call options in-the-money[b]	%	80	84	40	83	80	53	82	81	57
Book loan-to-value ratio (LTV)	median	0.71	0.53	0.32	0.72	0.51	0.36	0.75	0.56	0.36
	mean	0.69	0.54	0.35	0.70	0.54	0.39	0.73	0.57	0.40
	SD	0.21	0.24	0.19	0.24	0.28	0.24	0.23	0.27	0.25
Annual payment-to-income ratio (PAYINC)	median	0.15	0.11	0.07	0.21	0.18	0.15	0.22	0.17	0.14
	mean	0.16	0.11	0.08	0.36	0.61	0.40	0.30	0.29	0.40
	SD	0.07	0.06	0.05	1.26	6.21	1.07	0.59	0.54	1.08
More than one mortgage (yes =1) (SECMORT)	%	9	16	27	3	12	13	3	11	14
First-time homeowner (yes=1) (FIRSTTIME)	%	39	43	44	54	50	56	100	100	100
Potential wasted interest as % of residence fair market value (TAX)[c]	median	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06	0.06
	mean	0.02	0.02	0.02	0.10	0.11	0.07	0.11	0.10	0.08
	SD	0.04	0.05	0.03	0.16	0.27	0.07	0.17	0.15	0.09
Total income (INC)	median	50.00	52.00	52.00	22.10	22.00	21.00	22.92	23.00	21.55
	mean	57.44	58.88	58.45	20.81	19.73	19.44	21.42	20.84	19.15
	SD	25.15	25.98	24.73	8.19	8.86	9.35	7.97	8.36	9.72
Two wage earner (yes=1) (JOINTINC)	%	68	69	69	30	28	25	30	29	25
Age of household head (AGE)	median	36.00	41.00	44.00	34.00	40.00	46.00	31.00	36.00	43.00
	mean	37.18	41.64	45.43	37.22	42.04	47.44	32.89	37.57	44.44
	SD	8.54	8.24	7.22	10.65	9.84	9.69	8.30	8.24	9.02
Head with 2 or more years of college (yes=1) (COLLEGE)	%	62	59	58	35	31	32	34	34	23
Family size (FAMSIZE)	median	3.00	3.00	4.00	3.00	3.00	3.00	2.00	3.00	3.00
	mean	3.06	3.29	3.51	2.75	2.91	2.83	2.69	3.03	3.00
	SD	1.32	1.35	1.40	1.50	1.59	1.44	1.52	1.59	1.52
African-American head (yes=1) (BLACK)	%	4	6	5	8	10	12	11	15	16
Hispanic head (yes=1) (HISP)	%	4	5	3	8	6	4	9	7	5
Rural location[d] (yes=1) (RURAL)	%	6	8	8	14	18	14	12	15	16

Figure 2 (Continued): Sample Descriptive Statistics

Panel D: 1991-93 Data Window

		Non-Low Income			Low-Income			Low-Income First-Time Owner		
		Mortgage Age Groups			Mortgage Age Groups			Mortgage Age Groups		
		0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years
Total households		1,925	1,162	700	808	443	340	443	222	181
Households that terminated mortgages	%	51	59	43	42	50	39	38	45	39
Current fair market value of residence ($000s)	median	100.00	100.00	90.00	58.00	60.00	66.50	55.00	55.00	60.00
	mean	117.79	116.58	111.03	68.27	74.16	79.73	63.67	69.12	73.07
	SD	63.16	65.04	65.35	45.67	51.55	53.66	41.03	48.41	51.23
Number of years mortgage outstanding	median	2.00	6.00	13.00	2.00	6.00	13.00	2.00	6.00	13.00
	mean	2.00	6.68	12.93	1.94	6.76	13.00	1.95	6.68	13.07
	SD	1.38	1.66	1.38	1.36	1.66	1.33	1.37	1.63	1.31
Present value of interest savings from prepayment[a] (PVIS) ($000s)	median	17.03	11.02	4.10	8.88	6.83	3.32	8.86	7.18	2.64
	mean	19.45	13.05	5.94	11.01	9.11	4.26	10.92	9.35	3.81
	SD	13.06	9.69	5.92	9.80	8.55	4.37	9.52	8.21	4.54
Mortgage call options in-the-money[b]	%	100	99	97	99	99	97	99	99	96
Book loan-to-value ratio (LTV)	median	0.75	0.57	0.38	0.74	0.57	0.38	0.78	0.61	0.41
	mean	0.73	0.57	0.41	0.72	0.58	0.40	0.75	0.62	0.42
	SD	0.20	0.23	0.22	0.24	0.28	0.23	0.23	0.28	0.24
Annual payment-to-income ratio (PAYINC)	median	0.14	0.10	0.07	0.19	0.16	0.14	0.19	0.16	0.13
	mean	0.14	0.11	0.08	0.49	0.30	0.23	0.58	0.25	0.24
	SD	0.07	0.06	0.06	4.94	0.56	0.26	6.60	0.40	0.30
More than one mortgage (yes =1) (SECMORT)	%	8	18	28	5	13	17	3	14	17
First-time homeowner (yes=1) (FIRSTTIME)	%	41	41	44	55	50	53	100	100	100
Potential wasted interest as % of residence fair market value (TAX)[c]	median	0.00	0.00	0.01	0.06	0.06	0.05	0.07	0.07	0.06
	mean	0.02	0.02	0.02	0.10	0.10	0.08	0.11	0.11	0.09
	SD	0.04	0.05	0.05	0.14	0.17	0.11	0.15	0.17	0.13
Total income (INC)	median	52.30	55.85	54.00	23.45	24.00	21.80	23.00	24.90	22.26
	mean	60.51	63.29	60.47	21.57	21.61	20.02	21.67	22.45	19.82
	SD	26.63	28.58	26.58	8.34	8.87	9.53	8.03	8.02	10.07
Two wage earner (yes=1) (JOINTINC)	%	67	68	70	33	29	24	33	32	22
Age of household head (AGE)	median	35.00	40.00	44.00	34.50	40.00	46.00	31.00	36.00	43.00
	mean	37.18	41.20	45.58	37.36	42.27	47.02	33.21	37.66	44.62
	SD	8.58	8.13	7.55	10.80	10.02	8.81	8.87	8.41	8.58
Head with 2 or more years of college (yes=1) (COLLEGE)	%	63	61	58	37	35	30	37	36	28
Family size (FAMSIZE)	median	3.00	3.00	3.00	2.00	3.00	2.50	2.00	3.00	3.00
	mean	3.05	3.26	3.28	2.69	2.86	2.78	2.60	3.03	2.92
	SD	1.31	1.34	1.37	1.52	1.52	1.47	1.53	1.62	1.55
African-American head (yes=1) (BLACK)	%	5	5	6	7	9	12	10	11	17
Hispanic head (yes=1) (HISP)	%	4	3	4	8	7	5	9	11	7
Rural location[d] (yes=1) (RURAL)	%	8	7	9	14	19	15	11	18	15

Figure 2 (Continued): Sample Descriptive Statistics

Panel E: 1993-95 Data Window

		Non-Low Income			Low-Income			Low-Income First-Time Owner		
		Mortgage Age Groups			Mortgage Age Groups			Mortgage Age Groups		
		0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years	0-5 years	5-10 years	11-15 years
Total households		1,633	1,168	457	715	453	207	403	237	105
Households that terminated mortgages	%	36	48	46	40	44	49	39	41	51
Current fair market value of residence ($000s)	median	103.00	100.00	92.00	60.00	60.00	75.00	55.00	55.00	70.00
	mean	117.37	120.11	109.89	74.54	75.97	82.71	66.49	65.05	87.32
	SD	59.54	65.19	57.95	53.90	54.91	48.30	46.12	40.89	57.66
Number of years mortgage outstanding	median	2.00	7.00	14.00	2.00	7.00	13.00	2.00	7.00	14.00
	mean	1.98	7.00	13.37	1.92	6.92	13.19	1.89	6.86	13.37
	SD	1.35	1.63	1.39	1.36	1.64	1.36	1.37	1.61	1.38
Present value of interest savings from prepayment[a] (PVIS) ($000s)	median	9.43	7.53	4.46	6.19	6.71	4.74	6.04	6.90	4.43
	mean	11.51	10.28	6.62	8.32	8.48	6.47	8.09	8.32	5.87
	SD	10.23	10.30	7.75	9.04	8.37	6.15	8.21	7.73	5.66
Mortgage call options in-the-money[b]	%	96	96	97	97	98	100	97	98	99
Book loan-to-value ratio (LTV)	median	0.77	0.61	0.43	0.76	0.63	0.46	0.81	0.65	0.45
	mean	0.75	0.60	0.45	0.73	0.61	0.47	0.76	0.63	0.45
	SD	0.19	0.23	0.22	0.24	0.26	0.24	0.24	0.25	0.24
Annual payment-to-income ratio (PAYINC)	median	0.13	0.10	0.07	0.20	0.17	0.17	0.20	0.16	0.17
	mean	0.14	0.11	0.08	0.48	0.98	0.56	0.36	0.36	0.81
	SD	0.06	0.06	0.06	2.32	12.30	2.99	0.90	1.09	4.17
More than one mortgage (yes =1) (SECMORT)	%	4	13	18	3	10	15	2	11	14
First-time homeowner (yes=1) (FIRSTTIME)	%	41	40	42	56	52	51	100	100	100
Potential wasted interest as % of residence fair market value (TAX)[c]	median	0.00	0.00	0.00	0.06	0.07	0.05	0.07	0.07	0.05
	mean	0.02	0.02	0.02	0.11	0.10	0.08	0.13	0.09	0.07
	SD	0.04	0.04	0.07	0.19	0.13	0.09	0.22	0.09	0.07
Total income (INC)	median	55.00	58.43	56.50	23.52	24.90	21.00	23.50	25.00	22.50
	mean	62.29	66.60	64.82	21.38	22.00	20.28	21.35	22.22	20.74
	SD	26.41	30.74	29.15	8.95	9.41	10.24	8.94	9.52	10.35
Two wage earner (yes=1) (JOINTINC)	%	69	65	71	27	25	30	29	25	31
Age of household head (AGE)	median	36.00	40.00	45.00	35.00	40.00	45.00	32.00	36.00	43.00
	mean	37.52	41.46	45.95	37.73	41.71	47.23	34.28	38.15	45.42
	SD	8.52	8.00	7.15	10.39	9.69	8.81	9.31	8.25	8.56
Head with 2 or more years of college (yes=1) COLLEGE)	%	63	60	60	35	35	33	33	33	30
Family size (FAMSIZE)	median	3.00	3.00	3.00	2.00	3.00	3.00	3.00	3.00	3.00
	mean	3.03	3.32	3.19	2.75	2.79	2.91	2.74	2.75	3.07
	SD	1.33	1.43	1.38	1.58	1.45	1.53	1.62	1.41	1.68
African-American head (yes=1) (BLACK)	%	4	6	5	7	10	14	9	16	18
Hispanic head (yes=1) (HISP)	%	5	4	4	10	8	7	12	9	9
Rural location[d] (yes=1) (RURAL)	%	8	9	9	14	17	14	13	16	10

[a] The present value of interest savings from prepayment is the market value of first mortgage debt less the book value of first mortgage debt. Market value of first mortgage debt is the present value of the remaining payments discounted over the remaining loan period using Freddie Mac's monthly commitment rate on 30-year fixed-rate mortgages (the lowest rate for the period between the two AHS surveys is used for each window).

[b] If the market value minus the book value of the primary mortgage is greater than zero, then the call option is “in the money”.

[c] Potential “wasted” interest as a percentage of house value is used as a proxy for the mean weighted-average tax rate at which mortgage interest is deducted. Potential wasted interest represents the maximum amount of mortgage interest that will produce no tax savings due to the difference between the household's standard deduction and other itemized personal deductions, including property taxes. The potential wasted interest dollar amount is scaled by the fair market value of the residence.

[d] Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985-95 samples are included in the logistic regression models but not reported here.

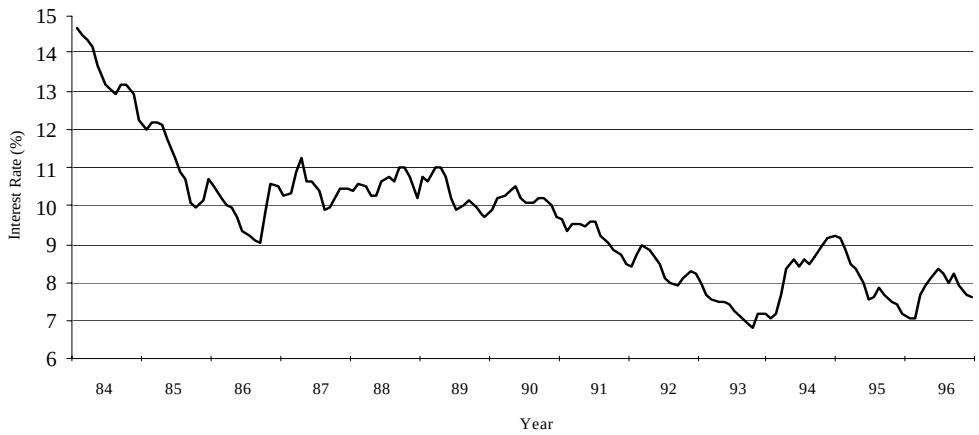
Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File. Reported values are either raw percentages or sample medians, means, and standard deviations.

All explanatory variables used in the analysis are measured at the beginning of each two-year window. The dependent variable—whether or not the household terminated its primary mortgage—is based on a comparison of its mortgage characteristics, including date obtained, type of mortgage, etc., at the beginning and end of each two-year window. [6]

This paper, in part, examines the variation in mortgage termination across households in response to changes in mortgage interest rates. Therefore it is important that the study include periods during which a significant number of households might consider the exercise of their call options, and, if possible, one or more in which they would not. Figure 3 displays Freddie Mac's monthly commitment rate on 30-year fixed-rate mortgages from January of 1984 to December 1996. The AHS is conducted during the last four months of the survey year. Mortgage interest rates averaged 12.19 percent in September of 1985, the beginning of the 1985–1987 window, after steadily declining from a record high of 18.45 percent in October of 1981. Rates continued to fall during the 1985–1987 window, reaching a low of 9.04 percent in March of 1987. The 1987–1989 window complements the previous period because rates, though volatile, had little trend during that period, ranging from 9.88 to 11.05 percent. The 1989–1991 window rates ranged from 9.24 to 11.05 percent with generally falling rates over the period. The 1991–1993 window rates ranged from 7.11 to 9.01 percent in a declining rate environment. Finally, the 1993–1995 window rates ranged from 6.83 to 9.17 percent with a steep rise in the middle of the period.

[6] The AHS follows housing units rather than housing occupants. Accordingly, several criteria were used to identify households that moved and, therefore, terminated their fixed-rate mortgages. First, sample observations were considered movers if the AHS survey did not indicate that at least some of the same household members lived in the unit in both the beginning and ending window years. Observations also were classified as movers if respondents reported that a move had occurred within the year prior to the end of the two-year window. Second, to classify remaining households as non-movers, observations from each pair of years (1985–87, 1987–89, 1989–91, 1991–93, and 1993–95) were matched on several criteria to ensure that the sample unit contained the same household in both the beginning and ending window years. Several checks were conducted to compare household characteristics across the two sample years within each window for stability or expected change. For example, the age of the household head should increase by approximately two years between surveys. Observations that failed one or more of these checks were classified as movers with remaining observations classified as non-movers. The effects of default are present in the data of this study, but they are not distinguished explicitly. Rather, they are part of the total of terminations. This is unavoidable since the data do not permit identification of default terminations. However, to distinguish default cases would be unproductive in any case in a national sample of the size used here because the occurrence of default is so limited (see Footnote 2).

Figure 3: Residential Mortgage Interest Rates: 1984–1996



Source: Freddie Mac's monthly commitment rate on 30-year fixed-rate residential mortgages.

Logistic Regression Models

A series of logistic regression model are estimated where

$$\text{TERM}_i = \mathbf{b}\text{N}\mathbf{x}_i + \mu_i \,. \tag{6}$$

TERM_i is a binary variable indicating whether the i*th* household has terminated, for any reason, its primary mortgage. **b** is a row vector of coefficients, $\mathbf{x}_i$ is a vector of variables that explains the household's decision to terminate a mortgage, and μ_i is the random error term. The vector **x** contains mortgage-related variables, household characteristic variables, location variables, and interaction terms for each of these variables (see below). Our inclusion of variables is motivated by their demonstrated importance in prior theoretical and empirical studies of default, mobility, and refinancing behavior.

We first examine how low- to-moderate-income households differ from higher income households in their propensity to terminate fixed-rate mortgages. This is accomplished by creating a binary variable (LOWINC) that takes on a value of one if the household's total income is less than 80 percent of the median income of the MSA in which they reside and a value of zero

otherwise.[7] All of the explanatory variables are then interacted with LOWINC to examine the incremental intercept and slope effects of households being classified as low-to-moderate income. We also identify the portion of the sample that is both low-to-moderate income and a first-time homeowner (FIRSTLOW). In a separate set of logistic regressions, we interact all explanatory variables with FIRSTLOW.

Both the low-to-moderate income interaction regressions and the first-time homeowner interaction regressions are disaggregated by mortgage age. More specifically, we partition mortgages into three categories: those that were originated less than five years ago; those that have been outstanding for 5-10 years; and those outstanding for 11-15 years. Mortgages originated more than 15 years prior to the analysis period are dropped from the analysis.

Mortgage-Related Variables

The mortgage variables in $\mathbf{x}_i$ include the age of the mortgage in years, the present value of the interest savings from refinancing (PVIS), book loan-to-value ratio (LTV), and the prospective payment-to-income ratio (PAYINC). In the empirical model, PVIS (the intrinsic benefit of refinancing) is set equal to the market value less the book value of the primary mortgage debt. The book value of the existing primary mortgage is based on the household's actual mortgage interest rate, term, and original amortization period. The market value of the primary mortgage is calculated as the present value of the remaining mortgage payments, discounted using the lowest Freddie Mac monthly commitment rate on 30-year fixed-rate mortgages during the respective AHS window.[8] A household's mortgage prepayment option is considered “in-the-money” if PVIS exceeds zero. PVIS is negative for a household if market interest rates have risen since mortgage origination. This negative intrinsic benefit from refinancing may result in a “lock-in” effect, where to move or refinance results in a higher cost of fixed-rate mortgage debt. The magnitude of PVIS varies significantly among mortgage age groups and across sample windows.

[7] Median income for the MSA of the housing unit from the 1990 U.S. Census is scaled to the window year using the ratio of state-level median income in the window year to 1990 Census state-level median income.

[8] The discount rate used to estimate market values of mortgages was 9.04 percent for the 1985-87 window, 9.88 for the 1987-89 window, 9.24 for the 1989-91 window, 7.11 for the 1991-93 window and 6.83 percent for the 1993-95 window. Use of the lowest mortgage rate during each two-year period to calculate the present value of the remaining payments may overstate the intrinsic benefit from refinancing because many terminating households in our sample may have prepaid at a rate that is well above the lowest rate during the two-year interval. To the extent that our calculation of PVIS is upwardly biased, our estimated effect of PVIS on mortgage terminations is understated. The empirical model does not include proxies for the current mortgage interest rate (or interest rate process) because these factors do not vary cross-sectionally.

Book loan-to-value ratio (LTV) is the book value of total outstanding mortgage debt (primary, plus any other mortgages) divided by the current fair market value of the residence.[9] A binary variable indicates whether the household has more than one mortgage (SECMORT). The "prospective" payment-to-income ratio (PAYINC) is calculated by assuming the current book value of the primary mortgage is refinanced as a fixed-rate 30-year mortgage at the prevailing rate. The denominator of this ratio is the household's total income, including earned and investment income.[10] Because higher current loan-to-value ratios and payment-to-income ratios indicate greater collateral and liquidity constraints, LTV and PAYINC are expected to have a negative effect on the probability of an interest rate driven termination (Archer et al. 1996). However, if equity in the house is negative (LTV > 1), or the payment burden increases substantially, a default driven termination is more likely. Because default occurs much less frequently than an interest rate driven refinancing, the former effect is expected to dominate the latter. However, the net effect of these offsetting influences on termination must be determined empirically.

Household Characteristic Variables

A binary variable indicates whether the household is a first-time homeowner (FIRSTTIME). Potential "wasted" interest as a percentage of house value is used as a proxy for the mean weighted-average tax rate at which mortgage interest is deducted (TAX). Potential wasted interest represents the maximum amount of mortgage interest that will produce no tax savings due to the difference between the household's standard deduction and other itemized personal deductions, including property taxes (Ling and McGill 1992). The sign of potential wasted interest is reversed in the logistic regressions because higher wasted interest represents a lower weighted-average tax rate. TAX should be negatively related to the probability of termination because higher levels of TAX represent a lower after-tax cost of mortgage debt.

Giliberto and Thibodeau (1989) and Dickinson and Heuson (1993) find that increases in household income has a positive effect on interest-rate-driven terminations. However, the direction of the total household income variable (INC) in our specification is unclear because

[9] Market value estimates by households have been shown to be accurate on average (e.g., Goodman and Ittner 1992, Follain and Malpezzi 1981, Kain and Quigley 1972, Robins and West 1977, and Kiel and Zabel 1999). Kiel and Zabel found that the average U.S. owner overstates house value by 5.1 percent and that this error generally is uncorrelated with particular characteristics of the house, occupant, or neighborhood.

INC captures the influence of total household income after controlling for whether the household income could support a new mortgage (PAYINC). Consequently, INC could proxy for features such as the financial sophistication of the household or the cost of nonpecuniary transaction costs such as the opportunity cost of time involved in refinancing. INC also may be negatively related to termination probability from moving (see Krumm 1984).

The binary variable JOINTINC takes on a value of one if household income is produced by two wage earners. JOINTINC is related to total income and its influence on liquidity constraints because two wage earners within a household might improve credit worthiness. However, the existence of two wage earners may signal households with greater income constraints and a reduced option to generate additional income. From the mobility literature, JOINTINC, as a signal of a married household, may proxy for higher propensity to terminate. Again, both theory and prior empirical studies provide little guidance for predicting the sign of JOINTINC in our estimation.

Quigley (1987) found that the probability of termination is negatively related to the age of the household head (AGE) and positively related to family size (FAMSIZE). If AGE or FAMSIZE has an effect it should be as a proxy for life cycle differences across households. AGE may signal a decreased benefit of moving, hence lower propensity to terminate, though the empirical mobility literature reports contradictory evidence. FAMSIZE has been reported in the mobility literature to be associated with higher mobility, implying a positive coefficient in explaining termination (Gronberg and Reed 1992). A binary variable (COLLEGE) is created that indicates whether the household head attended two or more years of college. COLLEGE may proxy for characteristics such as financial sophistication and willingness to change. If so, COLLEGE should be positively related to termination probabilities (Quigley 1987). COLLEGE also should have a positive effect on termination through its positive effect on mobility, perhaps, again, due to greater economic sophistication (Gronberg and Reed 1992, Henderson and Ioannides 1989).

Binary variables indicating whether the household head is an African-American (BLACK) or Hispanic (HISP) are also included in the regression specification. The effects of

[10] This payment burden ratio is less than a lender's front-end ratio because property taxes and insurance are excluded from the numerator and investment income is included in the denominator.

race and ethnicity are indeterminate, except for some empirical indication from the mobility literature that non-whites are more mobile.

Shocks (sudden or unexpected changes) can be a factor in household mobility (Quigley and Weinberg 1977). These events could include divorce, unemployment, events that change household size or household income, or significant change in neighborhood (Boehm and Ihlanfeldt 1986). A limitation of the AHS data is that it cannot account for such events because the survey is based on housing units rather than households. Thus, it loses the household at the time of relocation, and is unable to record the change in household characteristics that would signal the precipitating event.

Location variables include a binary variable indicating whether the property is located in a rural area (RURAL), and 10 binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985–1995 samples. These location variables are included to control for variations across MSAs in house price inflation, income growth rates, and general demographic trends.

Variation across households in the cost of terminating a mortgage may also help explain cross-sectional differences in termination rates (Archer and Ling 1993, Stanton 1997). Besides direct financial transaction costs, any factor that creates resistance to the borrower who would prepay is, in effect, a transaction cost. A wide range of other barriers may have this effect, including lack of creditworthiness, lack of comfort with financial affairs, opportunity cost of the time required for finding and arranging new financing, and, perhaps, other "psychological" barriers. Transaction costs associated with refinancing are captured by LTV, representing a collateral constraint, PAYINC, representing a liquidity constraint, with SECMORT, FIRSTTIME, TAX, INC, JOINTINC, AGE, COLLEGE, FAMSIZE, BLACK, HISP, RURAL, and the PMSA indicator variables controlling for the heterogeneous nature of borrowers.

Figure 4: Logistic Regressions Explaining Termination of Primary Mortgage With Low-to-Moderate Income Interactions: Mortgage Age Less than Five Years[a]

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Intercept	2.634	1.831	1.668	2.847	4.239
	(0.042)	(0.094)	(0.146)	(0.006)	(0.000)
Mortgage-Related Variables:					
Number of years mortgage outstanding (MTGAGE)	0.117	0.229	0.067	0.120	0.287
	(0.017)	(0.000)	(0.141)	(0.002)	(0.000)
Present value of interest savings (PVIS)	6.4E-05	0.6E-05	1.8E-05	5.1E-05	1.4E-05
	(0.000)	(0.501)	(0.071)	(0.000)	(0.019)
Book loan-to-value ratio (LTV)	-3.376	-1.648	-1.597	-1.900	-1.421
	(0.019)	(0.115)	(0.178)	(0.152)	(0.283)
Book loan-to-value ratio squared (LTV^2)	1.503	1.390	0.948	-0.516	0.425
	(0.140)	(0.062)	(0.265)	(0.584)	(0.641)
Annual payment-to-income ratio (PAYINC)	-6.202	-9.953	-1.439	-6.100	-7.692
	(0.037)	(0.001)	(0.582)	(0.026)	(0.019)
Annual payment-to-income ratio squared ($PAYINC^2$)	4.775	22.320	2.206	4.421	14.334
	(0.448)	(0.001)	(0.689)	(0.483)	(0.089)
More than one mortgage (yes =1) (SECMORT)	0.609	0.155	0.344	0.108	-0.036
	(0.020)	(0.531)	(0.079)	(0.584)	(0.892)
Household Characteristic Variables:					
First-time homeowner (yes=1) (FIRSTTIME)	-0.038	-0.018	-0.143	-0.351	-0.434
	(0.806)	(0.896)	(0.303)	(0.003)	(0.001)
Potential wasted interest as % of residence fair market value (TAX)	-6.995	-5.598	-1.975	-0.932	-1.144
	(0.311)	(0.133)	(0.300)	(0.491)	(0.531)
Total Income (INC)	-0.004	0.003	0.004	-0.005	-0.003
	(0.387)	(0.289)	(0.207)	(0.052)	(0.271)
Two wage earner (yes=1) (JOINTINC)	0.149	-0.348	-0.230	-0.064	-0.219
	(0.293)	(0.005)	(0.068)	(0.572)	(0.082)
Age of household head (AGE)	-0.031	-0.090	-0.113	-0.051	-0.176
	(0.612)	(0.086)	(0.031)	(0.280)	(0.001)
Age of household head squared (AGE^2)	19.5E-05	0.001	0.001	32.4E-05	0.002
	(0.795)	(0.099)	(0.043)	(0.566)	(0.002)
Household head with 2 or more years of college (yes=1) (COLLEGE)	0.136	0.036	-0.013	0.500	0.259
	(0.320)	(0.766)	(0.915)	(0.000)	(0.028)
Family size (FAMSIZE)	-0.051	0.030	0.035	0.013	0.041
	(0.334)	(0.520)	(0.448)	(0.763)	(0.363)
African-American head (yes=1) (BLACK)	-0.685	0.326	0.475	-1.198	0.050
	(0.030)	(0.204)	(0.073)	(0.000)	(0.854)
Hispanic head (yes=1) (HISP)	-0.200	0.032	0.349	-0.079	-0.145
	(0.589)	(0.906)	(0.193)	(0.757)	(0.570)
Location Variables:					
Rural location (yes=1) (RURAL)	-0.008	0.195	0.168	0.272	-0.284
	(0.960)	(0.180)	(0.299)	(0.061)	(0.071)
Low-to-Moderate Income Interactions:					
Income < 80% PMSA median income (yes=1) (LOWINC)	-0.842	-0.262	1.600	-1.026	-0.476
	(0.621)	(0.865)	(0.349)	(0.514)	(0.787)

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
MTGAGE x LOWINC					
	0.013	-0.146	0.036	-0.069	-0.127
	(0.864)	(0.048)	(0.632)	(0.318)	(0.106)
PVIS x LOWINC					
	-2.0E-05	2.2E-05	3.0E-05	-0.8E-05	1.8E-05
	(0.261)	(0.278)	(0.179)	(0.481)	(0.134)
LTV x LOWINC					
	-1.387	-2.762	-3.260	-1.609	-5.477
	(0.471)	(0.068)	(0.063)	(0.405)	(0.007)
LTV^2 x LOWINC					
	0.551	1.348	1.712	2.213	3.371
	(0.684)	(0.211)	(0.174)	(0.107)	(0.016)
PAYINC x LOWINC					
	6.216	10.083	1.543	6.307	7.739
	(0.037)	(0.000)	(0.556)	(0.021)	(0.018)
$PAYINC^2$ x LOWINC					
	-4.774	-22.318	-2.211	-4.423	-14.338
	(0.448)	(0.001)	(0.688)	(0.483)	(0.089)
SECMORT x LOWINC					
	-0.840	-0.026	-0.266	0.441	0.223
	(0.039)	(0.954)	(0.617)	(0.261)	(0.694)
FIRSTTIME x LOWINC					
	0.045	0.084	-0.154	-0.021	0.267
	(0.845)	(0.700)	(0.508)	(0.922)	(0.245)
TAX x LOWINC					
	2.090	2.878	-2.055	-1.791	-2.874
	(0.766)	(0.450)	(0.314)	(0.243)	(0.152)
INC x LOWINC					
	0.008	-0.006	-0.007	0.015	-0.013
	(0.571)	(0.611)	(0.601)	(0.200)	(0.274)
JOINTINC x LOWINC					
	-0.269	0.259	-0.259	0.093	0.072
	(0.231)	(0.222)	(0.268)	(0.664)	(0.767)
AGE x LOWINC					
	0.033	0.045	-0.014	-0.015	0.086
	(0.678)	(0.532)	(0.857)	(0.831)	(0.276)
AGE^2 x LOWINC					
	-44.0E-05	-56.0E-05	17.1E-05	37.9E-05	-91.0E-05
	(0.655)	(0.517)	(0.853)	(0.656)	(0.332)
COLLEGE x LOWINC					
	-0.274	-0.178	-0.040	-0.712	-0.090
	(0.202)	(0.373)	(0.850)	(0.000)	(0.678)
FAMSIZE x LOWINC					
	0.053	-0.005	-0.036	-0.040	-0.039
	(0.510)	(0.948)	(0.632)	(0.573)	(0.597)
BLACK x LOWINC					
	0.161	-0.078	0.108	0.913	-0.616
	(0.711)	(0.839)	(0.782)	(0.029)	(0.165)
HISPANIC x LOWINC					
	0.622	0.308	-0.485	-0.017	-0.104
	(0.234)	(0.458)	(0.235)	(0.965)	(0.794)
Number of observations	1,940	2,546	2,627	2,733	2,348
-2 Log-Likelihood statistic	2470.634	3090.045	2905.846	3416.553	2872.250
(p-value of Chi-squared statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Within-sample classification rate	60.0	67.1	74.3	61.4	63.7
Paired rank correlation ('c' statistic)	0.683	0.647	0.637	0.701	0.682

[a] Reported values are parameter estimates from Logistic Regressions with *p*-values of Wald chi-Square statistics in parentheses. See Figure 2 and the text for variable definitions. Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985-95 samples are included in the logistic regression models as location control variables but these results are not reported here. Tables including these variables are available from the authors on request.

Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 and National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File.

Figure 5: Logistic Regressions Explaining Termination of Primary Mortgage With Low-to-Moderate Income Interactions: Mortgage Age Five to 10 Years[a]

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Intercept	4.096	5.050	1.732	3.483	3.675
	(0.007)	(0.003)	(0.327)	(0.035)	(0.021)
Mortgage-Related Variables:					
Number of years mortgage outstanding (MTGAGE)	-0.045	-0.140	-0.111	0.159	0.077
	(0.349)	(0.002)	(0.006)	(0.000)	(0.051)
Present value of interest savings (PVIS)	12.9E-05	0.9E-05	5.5E-05	4.0E-05	2.9E-05
	(0.000)	(0.588)	(0.000)	(0.000)	(0.000)
Book loan-to-value ratio (LTV)	-2.180	-2.959	-0.786	-1.362	-1.197
	(0.108)	(0.011)	(0.512)	(0.264)	(0.274)
Book loan-to-value ratio squared (LTV^2)	1.459	2.357	-0.199	-0.143	0.247
	(0.245)	(0.014)	(0.837)	(0.880)	(0.763)
Annual payment-to-income ratio (PAYINC)	-19.528	-2.436	-10.113	-3.864	-5.738
	(0.000)	(0.531)	(0.012)	(0.304)	(0.081)
Annual payment-to-income ratio squared ($PAYINC^2$)	46.681	2.343	25.775	10.661	9.148
	(0.001)	(0.839)	(0.029)	(0.297)	(0.298)
More than one mortgage (yes =1) (SECMORT)	0.585	-0.004	-0.035	0.108	0.014
	(0.006)	(0.986)	(0.871)	(0.569)	(0.943)
Household Characteristic Variables:					
First-time homeowner (yes=1) (FIRSTTIME)	0.031	-0.157	-0.009	-0.075	-0.226
	(0.834)	(0.319)	(0.958)	(0.622)	(0.126)
Potential wasted interest as % of residence fair market value (TAX)	-1.983	-7.495	-3.474	-2.097	-3.563
	(0.843)	(0.084)	(0.084)	(0.239)	(0.067)
Total income (INC)	-0.010	0.005	0.005	0.003	0.005
	(0.008)	(0.150)	(0.143)	(0.301)	(0.079)
Two wage earner (yes=1) (JOINTINC)	-0.057	-0.216	-0.126	-0.085	-0.068
	(0.669)	(0.153)	(0.421)	(0.559)	(0.616)
Age of household head (AGE)	-0.102	-0.150	-0.024	-0.164	-0.148
	(0.140)	(0.046)	(0.761)	(0.024)	(0.040)
Age of household head squared (AGE^2)	98.1E-05	0.002	15.2E-05	0.002	0.001
	(0.210)	(0.070)	(0.865)	(0.041)	(0.081)
Household head with 2 or more years of college (yes=1) (COLLEGE)	0.162	-0.059	0.141	0.375	0.119
	(0.217)	(0.683)	(0.352)	(0.006)	(0.363)
Family size (FAMSIZE)	0.018	-0.080	-0.005	-0.040	-0.050
	(0.724)	(0.145)	(0.933)	(0.444)	(0.289)
African-American head (yes=1) (BLACK)	-0.009	0.083	-0.375	-0.711	-0.174
	(0.976)	(0.793)	(0.259)	(0.022)	(0.529)
Hispanic head (yes=1) (HISP)	0.248	0.266	0.072	-1.733	-0.158
	(0.407)	(0.445)	(0.830)	(0.000)	(0.616)
Location Variables:					
Rural location (yes=1) (RURAL)	-0.094	0.143	0.306	0.292	-0.153
	(0.589)	(0.428)	(0.104)	(0.124)	(0.377)
Low-to-Moderate Income Interactions:					
Income < 80% PMSA median income (yes=1) (LOWINC)	-2.831	-1.338	-0.762	1.462	1.493
	(0.196)	(0.599)	(0.788)	(0.592)	(0.568)

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
MTGAGE x LOWINC	-0.065	-0.176	68.3E-05	-0.058	0.006
	(0.377)	(0.032)	(0.993)	(0.453)	(0.931)
PVIS x LOWINC	0.4E-05	7.9E-05	0.2E-05	-0.1E-05	-1.0E-05
	(0.871)	(0.022)	(0.943)	(0.972)	(0.444)
LTV x LOWINC	-1.168	-0.311	-1.848	-3.178	-1.575
	(0.509)	(0.860)	(0.318)	(0.090)	(0.372)
LTV^2 x LOWINC	-0.481	-0.986	1.447	2.599	1.095
	(0.765)	(0.495)	(0.326)	(0.066)	(0.402)
PAYINC x LOWINC	20.186	2.126	9.691	3.671	5.500
	(0.000)	(0.588)	(0.017)	(0.334)	(0.096)
$PAYINC^2$ x LOWINC	-46.798	-2.342	-25.773	-10.634	-9.145
	(0.001)	(0.840)	(0.029)	(0.298)	(0.299)
SECMORT x LOWINC	-0.362	-0.294	-0.382	0.211	-0.139
	(0.266)	(0.448)	(0.386)	(0.567)	(0.720)
FIRSTTIME x LOWINC	-0.352	0.318	-0.208	-0.347	-0.107
	(0.120)	(0.243)	(0.486)	(0.222)	(0.698)
TAX x LOWINC	-10.178	4.975	-0.209	-0.872	1.371
	(0.324)	(0.267)	(0.929)	(0.675)	(0.537)
INC x LOWINC	0.024	-0.039	-0.018	-0.020	-0.023
	(0.123)	(0.025)	(0.284)	(0.242)	(0.123)
JOINTINC x LOWINC	-0.025	0.167	0.081	-0.009	0.353
	(0.911)	(0.540)	(0.787)	(0.976)	(0.213)
AGE x LOWINC	0.095	0.150	0.035	-0.068	-0.053
	(0.342)	(0.188)	(0.788)	(0.568)	(0.649)
AGE^2 x LOWINC	-0.001	-0.001	-26.0E-05	99.0E-05	57.4E-05
	(0.329)	(0.256)	(0.853)	(0.452)	(0.656)
COLLEGE x LOWINC	-0.420	-0.026	-0.227	0.416	-0.128
	(0.055)	(0.920)	(0.431)	(0.122)	(0.615)
FAMSIZE x LOWINC	-0.020	0.027	0.072	0.186	0.070
	(0.787)	(0.754)	(0.448)	(0.044)	(0.446)
BLACK x LOWINC	-0.041	-0.054	-0.603	0.089	0.248
	(0.921)	(0.900)	(0.264)	(0.857)	(0.587)
HISPANIC x LOWINC	-0.628	-0.816	0.261	1.982	0.584
	(0.172)	(0.154)	(0.637)	(0.001)	(0.237)
Number of observations	2,269	1,659	1,390	1,605	1,621
-2 Log-Likelihood statistic	2654.643	1988.540	1731.936	2014.221	2137.069
(p-value of Chi-squared statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Within-sample classification rate	68.6	66.7	62.1	62.7	56.6
Paired rank correlation ('c' statistic)	0.696	0.668	0.660	0.686	0.642

[a] Reported values are parameter estimates from Logistic Regressions with *p*-values of Wald chi-square statistics in parentheses. See Figure 2 and the text for variable definitions. Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985–1995 samples are included in the logistic regression models as location control variables but these results are not reported here. Figures including these variables are available from the authors on request.

Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File.

Figure 6: Logistic Regressions Explaining Termination of Primary Mortgage With Low-to-Moderate Income Interactions: Mortgage Age 11-15 Years[a]

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Intercept	1.007	1.709	-1.942	4.063	7.817
	(0.788)	(0.656)	(0.609)	(0.199)	(0.054)
Mortgage-Related Variables:					
Number of years mortgage outstanding (MTGAGE)	-0.002	0.210	0.033	-0.268	-0.169
	(0.981)	(0.007)	(0.675)	(0.000)	(0.023)
Present value of interest savings (PVIS)	27.2E-05	19.2E-05	19.6E-05	7.0E-05	4.5E-05
	(0.000)	(0.001)	(0.000)	(0.000)	(0.008)
Book loan-to-value ratio (LTV)	4.340	-0.760	-2.282	-2.356	-3.335
	(0.111)	(0.679)	(0.221)	(0.090)	(0.060)
Book loan-to-value ratio squared (LTV^2)	-0.935	1.674	2.456	1.635	1.704
	(0.753)	(0.345)	(0.192)	(0.179)	(0.254)
Annual payment-to-income ratio (PAYINC)	-18.861	1.142	-11.778	-8.021	-1.226
	(0.035)	(0.874)	(0.050)	(0.140)	(0.846)
Annual payment-to-income ratio squared ($PAYINC^2$)	42.041	15.108	32.519	23.566	6.876
	(0.146)	(0.564)	(0.050)	(0.172)	(0.736)
More than one mortgage (yes =1) (SECMORT)	0.554	-0.687	-0.235	0.365	0.714
	(0.167)	(0.043)	(0.440)	(0.111)	(0.016)
Household Characteristic Variables:					
First-time homeowner (yes=1) (FIRSTTIME)	0.399	-0.187	-0.223	-0.044	-0.339
	(0.146)	(0.417)	(0.329)	(0.820)	(0.141)
Potential wasted interest as % of residence fair market value (TAX)	-1.817	-11.961	-1.874	-0.916	-4.629
	(0.940)	(0.193)	(0.618)	(0.653)	(0.138)
Total income (INC)	0.008	0.016	-0.001	0.003	0.003
	(0.310)	(0.004)	(0.816)	(0.446)	(0.566)
Two wage earner (yes=1) (JOINTINC)	0.190	0.125	-0.392	-0.142	0.017
	(0.494)	(0.599)	(0.091)	(0.464)	(0.947)
Age of household head (AGE)	-0.092	-0.213	0.047	-0.002	-0.229
	(0.571)	(0.194)	(0.765)	(0.990)	(0.161)
Age of household head squared (AGE^2)	0.001	0.002	-40.0E-05	-18.0E-05	0.002
	(0.554)	(0.275)	(0.806)	(0.895)	(0.179)
Household head with 2 or more years of college (yes=1) (COLLEGE)	-0.030	-0.006	-0.054	0.082	0.632
	(0.908)	(0.978)	(0.797)	(0.640)	(0.005)
Family size (FAMSIZE)	-0.252	-0.158	0.148	0.007	0.011
	(0.018)	(0.060)	(0.072)	(0.914)	(0.898)
African-American head (yes=1) (BLACK)	-0.501	0.325	1.249	-0.438	0.280
	(0.341)	(0.436)	(0.004)	(0.232)	(0.574)
Hispanic head (yes=1) (HISP)	0.422	0.606	-0.052	-0.207	-0.503
	(0.480)	(0.248)	(0.938)	(0.650)	(0.368)
Location Variables:					
Rural lcation (yes=1) (RURAL)	0.411	0.141	0.146	0.019	0.080
	(0.158)	(0.617)	(0.593)	(0.934)	(0.785)
Low-to-Moderate Income Interactions:					
Income < 80% PMSA median income (yes=1) (LOWINC)	6.965	1.666	2.107	-2.604	-5.807
	(0.191)	(0.757)	(0.707)	(0.590)	(0.370)

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
MTGAGE x LOWINC					
	-0.025	-0.319	0.138	0.247	0.065
	(0.853)	(0.009)	(0.320)	(0.039)	(0.663)
PVIS x LOWINC					
	13.6E-05	29.5E-05	3.4E-05	2.6E-05	1.9E-05
	(0.213)	(0.017)	(0.682)	(0.535)	(0.610)
LTV x LOWINC					
	-7.775	-0.439	-0.726	-2.072	0.029
	(0.025)	(0.859)	(0.789)	(0.339)	(0.992)
LTV^2 x LOWINC					
	2.746	-1.040	-1.925	-0.387	-1.860
	(0.478)	(0.650)	(0.471)	(0.849)	(0.467)
PAYINC x LOWINC					
	19.578	-1.061	13.414	8.851	1.257
	(0.030)	(0.884)	(0.032)	(0.127)	(0.842)
$PAYINC^2$ x LOWINC					
	-42.503	-15.047	-33.428	-24.476	-6.874
	(0.142)	(0.566)	(0.044)	(0.158)	(0.736)
SECMORT x LOWINC					
	-0.075	0.120	-0.342	0.472	-0.275
	(0.894)	(0.834)	(0.590)	(0.269)	(0.629)
FIRSTTIME x LOWINC					
	-0.358	-0.301	0.026	0.301	0.538
	(0.372)	(0.446)	(0.950)	(0.358)	(0.181)
TAX x LOWINC					
	-13.490	6.109	-5.338	-2.951	-3.862
	(0.588)	(0.532)	(0.266)	(0.292)	(0.354)
INC x LOWINC					
	-0.013	-0.003	-0.024	-0.005	0.003
	(0.650)	(0.926)	(0.393)	(0.813)	(0.863)
JOINTINC x LOWINC					
	0.074	-0.569	0.770	-0.059	0.196
	(0.855)	(0.171)	(0.088)	(0.872)	(0.675)
AGE x LOWINC					
	-0.253	0.131	-0.097	-0.040	0.304
	(0.263)	(0.563)	(0.672)	(0.842)	(0.243)
AGE^2 x LOWINC					
	0.003	-0.001	64.4E-05	65.9E-05	-0.004
	(0.274)	(0.638)	(0.787)	(0.748)	(0.185)
COLLEGE x LOWINC					
	-0.493	-0.475	-0.434	-0.111	-1.251
	(0.234)	(0.226)	(0.298)	(0.730)	(0.003)
FAMSIZE x LOWINC					
	0.208	0.195	-0.418	-0.105	-0.271
	(0.156)	(0.165)	(0.007)	(0.377)	(0.074)
BLACK x LOWINC					
	1.114	-0.462	-1.164	0.098	-1.375
	(0.089)	(0.424)	(0.074)	(0.855)	(0.050)
HISPANIC x LOWINC					
	0.669	-0.283	-0.365	0.062	-0.054
	(0.383)	(0.709)	(0.732)	(0.931)	(0.949)
Number of observations	845	884	938	1,040	664
-2 Log-Likelihood statistic	827.345	936.325	923.543	1310.623	834.232
(p-value of Chi-squared statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Within-sample classification rate	73.8	72.3	76.7	60.6	56.5
Paired rank correlation ('c' statistic)	0.776	0.716	0.708	0.690	0.698

[a] Reported values are parameter estimates from Logistic Regressions with *p*-values of Wald chi-square statistics in parentheses. See Figure 2 and the text for variable definitions. Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985–-1995 samples are included in the logistic regression models as location control variables but these results are not reported here. Figures including these variables are available from the authors on request.

Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File.

Figure 7: Logistic Regressions Explaining Termination of Primary Mortgage With Low-to-Moderate Income and First-Time Owner Interactions: Mortgage Age Less than Five Years[a]

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Intercept	2.534	1.729	1.239	2.036	3.132
	(0.039)	(0.087)	(0.247)	(0.042)	(0.005)
Mortgage-Related Variables:					
Number of years mortgage outstanding (MTGAGE)	0.116	0.225	0.059	0.103	0.269
	(0.018)	(0.000)	(0.188)	(0.006)	(0.000)
Present value of interest savings (PVIS)	6.5E-05	0.7E-05	1.7E-05	5.2E-05	1.4E-05
	(0.000)	(0.433)	(0.077)	(0.000)	(0.020)
Book loan-to-value ratio (LTV)	-3.349	-1.667	-1.608	-2.043	-1.382
	(0.020)	(0.110)	(0.175)	(0.124)	(0.297)
Book loan-to-value ratio squared (LTV^2)	1.470	1.389	0.939	-0.507	0.278
	(0.149)	(0.061)	(0.269)	(0.592)	(0.760)
Annual payment-to-income ratio (PAYINC)	-6.296	-10.015	-1.369	-5.792	-7.159
	(0.035)	(0.001)	(0.599)	(0.033)	(0.028)
Annual payment-to-income ratio squared ($PAYINC^2$)	5.049	22.438	2.013	3.567	13.416
	(0.423)	(0.001)	(0.713)	(0.567)	(0.109)
More than one mortgage (yes =1) (SECMORT)	0.627	0.169	0.353	0.143	0.020
	(0.017)	(0.497)	(0.071)	(0.466)	(0.941)
Household Characteristic Variables:					
Potential wasted interest as % of residence fair market value (TAX)	-7.272	-5.775	-2.003	-0.976	-1.336
	(0.293)	(0.126)	(0.294)	(0.475)	(0.465)
Total income (INC)	-0.004	0.003	0.004	-0.005	-0.002
	(0.405)	(0.311)	(0.170)	(0.087)	(0.528)
Two wage earner (yes=1) (JOINTINC)	0.144	-0.349	-0.243	-0.080	-0.247
	(0.311)	(0.005)	(0.053)	(0.476)	(0.048)
Age of household head (AGE)	-0.027	-0.083	-0.098	-0.023	-0.142
	(0.651)	(0.098)	(0.052)	(0.616)	(0.005)
Age of household head squared (AGE^2)	15.2E-05	96.9E-05	0.001	8.6E-05	0.002
	(0.836)	(0.117)	(0.067)	(0.878)	(0.008)
Household head with 2 or more years of college (yes=1) (COLLEGE)	0.134	0.033	-0.011	0.495	0.231
	(0.328)	(0.783)	(0.928)	(0.000)	(0.049)
Family size (FAMSIZE)	-0.048	0.028	0.043	0.033	0.066
	(0.355)	(0.545)	(0.347)	(0.425)	(0.136)
African-American head (yes=1) (BLACK)	-0.692	0.361	0.447	-1.215	-0.009
	(0.028)	(0.160)	(0.090)	(0.000)	(0.973)
Hispanic head (yes=1) (HISP)	-0.190	0.051	0.329	-0.103	-0.196
	(0.609)	(0.849)	(0.221)	(0.687)	(0.439)
Location Variables:					
Rural location (yes=1) (RURAL)	-0.100	0.128	0.224	0.215	-0.365
	(0.634)	(0.465)	(0.236)	(0.200)	(0.041)
Low-to-Moderate Income/First-time Owner Interactions:					
Income < 80% PMSA median income and first-time owner (yes=1) (FIRSTLOW)	1.765	1.699	3.739	-0.803	3.143
	(0.406)	(0.375)	(0.079)	(0.672)	(0.146)

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
MTGAGE x FIRSTLOW					
	-0.009	-0.110	0.157	-0.032	-0.109
	(0.931)	(0.249)	(0.123)	(0.727)	(0.282)
PVIS x FIRSTLOW					
	-3.0E-05	2.7E-05	5.4E-05	-0.5E-05	5.4E-05
	(0.127)	(0.374)	(0.089)	(0.719)	(0.004)
LTV x FIRSTLOW					
	-6.352	-4.540	-3.194	-1.241	-8.829
	(0.020)	(0.025)	(0.184)	(0.620)	(0.001)
LTV^2 x FIRSTLOW					
	3.286	2.352	1.935	2.118	5.004
	(0.067)	(0.090)	(0.261)	(0.235)	(0.004)
PAYINC x FIRSTLOW					
	6.940	9.341	-0.014	6.267	6.965
	(0.031)	(0.002)	(0.996)	(0.023)	(0.034)
$PAYINC^2$ x FIRSTLOW					
	-5.154	-21.793	-1.694	-3.571	-13.410
	(0.414)	(0.001)	(0.758)	(0.567)	(0.110)
SECMORT x FIRSTLOW					
	-1.297	-0.121	0.438	1.137	-0.367
	(0.017)	(0.858)	(0.499)	(0.057)	(0.698)
TAX x FIRSTLOW					
	-2.712	3.416	-1.238	-3.916	-2.485
	(0.714)	(0.384)	(0.570)	(0.032)	(0.241)
INC x FIRSTLOW					
	0.067	0.004	-0.029	0.055	-0.023
	(0.015)	(0.825)	(0.175)	(0.004)	(0.209)
JOINTINC x FIRSTLOW					
	-0.378	0.288	-0.042	-0.324	0.356
	(0.195)	(0.291)	(0.893)	(0.258)	(0.247)
AGE x FIRSTLOW					
	-0.070	-0.042	-0.125	-0.092	-0.031
	(0.497)	(0.667)	(0.217)	(0.336)	(0.757)
AGE^2 x FIRSTLOW					
	73.7E-05	71.7E-05	0.002	0.001	37.7E-05
	(0.576)	(0.566)	(0.212)	(0.279)	(0.760)
COLLEGE x FIRSTLOW					
	0.113	-0.277	0.162	-0.898	0.163
	(0.683)	(0.283)	(0.565)	(0.001)	(0.576)
FAMSIZE x FIRSTLOW					
	0.028	0.048	-0.047	-0.084	0.025
	(0.782)	(0.593)	(0.629)	(0.357)	(0.789)
BLACK x FIRSTLOW					
	0.273	-0.743	0.223	0.724	-0.265
	(0.588)	(0.120)	(0.613)	(0.134)	(0.606)
HISPANIC x FIRSTLOW					
	0.432	0.033	-0.443	-0.371	0.415
	(0.488)	(0.949)	(0.407)	(0.457)	(0.373)
Number of observations	1,556	2,118	2,237	2,368	2,036
-2 Log-Likelihood statistic	1936.272	2532.327	2439.103	2920.147	2467.967
(p-value of Chi-squared statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Within-sample classification rate	60.7	67.1	75.0	63.0	64.1
Paired rank correlation ('c' statistic)	0.701	0.655	0.628	0.713	0.684

[a] Reported values are parameter estimates from Logistic Regressions with *p*-values of Wald chi-square statistics in parentheses. See Figure 2 and the text for variable definitions. Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985–1995 samples are included in the logistic regression models as location control variables but these results are not reported here. Figures including these variables are available from the authors on request.

Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File.

Figure 8: Logistic Regressions Explaining Termination of Primary Mortgage With Low-to-Moderate Income and First-time Owner Interactions: Mortgage Age Five to 10 Years[a]

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Intercept	4.160	4.499	1.684	3.332	2.842
	(0.004)	(0.005)	(0.316)	(0.035)	(0.060)
Mortgage-Related Variables:					
Number of years mortgage outstanding (MTGAGE)	-0.046	-0.143	-0.111	0.157	0.070
	(0.325)	(0.002)	(0.005)	(0.000)	(0.073)
Present value of interest savings (PVIS)	12.8E-05	0.9E-05	5.5E-05	4.0E-05	2.9E-05
	(0.000)	(0.602)	(0.000)	(0.000)	(0.000)
Book loan-to-value ratio (LTV)	-2.047	-3.074	-0.829	-1.357	-1.312
	(0.131)	(0.008)	(0.491)	(0.266)	(0.230)
Book loan-to-value ratio squared (LTV^2)	1.358	2.436	-0.186	-0.158	0.288
	(0.280)	(0.012)	(0.848)	(0.868)	(0.725)
Annual payment-to-income ratio (PAYINC)	-19.784	-2.423	-9.987	-3.590	-5.315
	(0.000)	(0.534)	(0.014)	(0.339)	(0.105)
Annual payment-to-income ratio squared ($PAYINC^2$)	47.170	2.664	25.451	10.167	8.318
	(0.001)	(0.818)	(0.030)	(0.320)	(0.345)
More than one mortgage (yes =1) (SECMORT)	0.572	-0.021	-0.041	0.102	0.007
	(0.007)	(0.920)	(0.848)	(0.591)	(0.970)
Household Characteristic Variables:					
Potential wasted interest as % of residence fair market value (TAX)	-2.596	-7.573	-3.610	-1.983	-4.011
	(0.795)	(0.081)	(0.073)	(0.267)	(0.044)
Total income (INC)	-0.010	0.005	0.005	0.004	0.005
	(0.007)	(0.124)	(0.133)	(0.284)	(0.041)
Two wage earner (yes=1) (JOINTINC)	-0.053	-0.222	-0.126	-0.083	-0.087
	(0.691)	(0.141)	(0.420)	(0.566)	(0.517)
Age of household head (AGE)	-0.104	-0.130	-0.021	-0.161	-0.120
	(0.122)	(0.075)	(0.784)	(0.023)	(0.088)
Age of household head squared (AGE^2)	99.4E-05	0.001	11.9E-05	0.002	0.001
	(0.194)	(0.104)	(0.892)	(0.039)	(0.142)
Household head with 2 or more years of college (yes=1) (COLLEGE)	0.160	-0.070	0.135	0.375	0.116
	(0.223)	(0.626)	(0.372)	(0.006)	(0.377)
Family size (FAMSIZE)	0.018	-0.071	-0.006	-0.038	-0.040
	(0.719)	(0.195)	(0.915)	(0.460)	(0.384)
African-American head (yes=1) (BLACK)	97.1E-05	0.072	-0.386	-0.725	-0.212
	(0.997)	(0.820)	(0.245)	(0.019)	(0.442)
Hispanic head (yes=1) (HISP)	0.237	0.251	0.080	-1.745	-0.173
	(0.430)	(0.473)	(0.811)	(0.000)	(0.585)
Location Variables:					
Rural location (yes=1) (RURAL)	-0.231	0.103	0.195	0.497	-0.222
	(0.265)	(0.624)	(0.384)	(0.026)	(0.258)
Low-to-Moderate Income/First-time Owner Interactions:					
Income < 80% PMSA median income and first-time owner (yes=1) (FIRSTLOW)	-1.403	-3.008	3.363	4.160	2.098
	(0.592)	(0.334)	(0.346)	(0.242)	(0.543)
MTGAGE x FIRSTLOW	-0.160	-0.204	-0.071	-0.089	-0.030
	(0.094)	(0.056)	(0.497)	(0.422)	(0.774)

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
PVIS x FIRSTLOW	1.2E-05	9.9E-05	-3.0E-05	-3.0E-05	1.0E-05
	(0.746)	(0.029)	(0.498)	(0.204)	(0.704)
LTV x FIRSTLOW	-4.339	1.662	-2.646	-5.427	-1.445
	(0.048)	(0.473)	(0.344)	(0.042)	(0.554)
LTV^2 x FIRSTLOW	1.542	-2.790	1.229	4.611	1.366
	(0.434)	(0.148)	(0.579)	(0.018)	(0.436)
PAYINC x FIRSTLOW	20.527	2.025	9.033	2.152	3.021
	(0.000)	(0.607)	(0.033)	(0.607)	(0.469)
$PAYINC^2$ x FIRSTLOW	-47.361	-2.660	-25.407	-9.456	-8.332
	(0.001)	(0.818)	(0.031)	(0.356)	(0.351)
SECMORT x FIRSTLOW	-0.328	0.146	0.164	0.536	0.841
	(0.473)	(0.777)	(0.794)	(0.271)	(0.085)
TAX x FIRSTLOW	-7.835	3.815	-1.304	0.694	1.355
	(0.455)	(0.415)	(0.666)	(0.744)	(0.678)
INC x FIRSTLOW	0.010	-0.048	-0.024	-0.029	-0.071
	(0.668)	(0.035)	(0.440)	(0.340)	(0.021)
JOINTINC x FIRSTLOW	0.228	0.339	0.032	0.234	0.491
	(0.429)	(0.329)	(0.940)	(0.547)	(0.198)
AGE x FIRSTLOW	0.090	0.257	-0.139	-0.199	-0.067
	(0.473)	(0.080)	(0.424)	(0.236)	(0.684)
AGE^2 x FIRSTLOW	-0.001	-0.003	0.002	0.003	96.4E-05
	(0.486)	(0.095)	(0.379)	(0.162)	(0.619)
COLLEGE x FIRSTLOW	-0.118	-0.208	-0.021	1.162	0.365
	(0.683)	(0.538)	(0.958)	(0.004)	(0.292)
FAMSIZE x FIRSTLOW	-0.017	-0.021	0.181	0.297	0.213
	(0.859)	(0.843)	(0.151)	(0.013)	(0.118)
BLACK x FIRSTLOW	0.344	-0.174	-0.738	0.431	-0.035
	(0.456)	(0.723)	(0.254)	(0.487)	(0.946)
HISPANIC x FIRSTLOW	-0.634	-0.432	0.275	1.564	-0.058
	(0.257)	(0.521)	(0.695)	(0.020)	(0.927)
Number of observations	1,843	1,386	1,171	1,384	1,405
-2 Log-Likelihood statistic	2118.906	1670.058	1445.093	1714.498	1846.257
(p-value of chi-squared statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Within-sample classification rate	70.1	66.2	62.9	62.9	56.6
Paired rank correlation ('c' statistic)	0.700	0.654	0.667	0.696	0.639

[a] Reported values are parameter estimates from Logistic Regressions with *p*-values of Wald chi-square statistics in parentheses. See Figure 2 and the text for variable definitions. Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985-95 samples are included in the logistic regression models as location control variables but these results are not reported here. Figures including these variables are available from the authors on request.

Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File.

Figure 9: Logistic Regressions Explaining Termination of Primary Mortgage With Low-to-Moderate Income and First-time Owner Interactions: Mortgage Age 11-15 Years[a]

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
Intercept	2.360	0.941	-2.708	3.992	6.015
	(0.527)	(0.805)	(0.468)	(0.189)	(0.126)
Mortgage-Related Variables:					
Number of years mortgage outstanding (MTGAGE)	0.010	0.209	0.015	-0.273	-0.170
	(0.916)	(0.007)	(0.847)	(0.000)	(0.022)
Present value of interest savings (PVIS)	27.4E-05	19.1E-05	19.3E-05	7.1E-05	4.5E-05
	(0.000)	(0.001)	(0.000)	(0.000)	(0.009)
Book loan-to-value ratio (LTV)	4.708	-0.829	-2.261	-2.438	-3.194
	(0.085)	(0.651)	(0.229)	(0.080)	(0.070)
Book loan-to-value ratio squared (LTV^2)	-1.398	1.744	2.522	1.715	1.616
	(0.636)	(0.323)	(0.184)	(0.159)	(0.279)
Annual payment-to-income ratio (PAYINC)	-18.623	1.842	-11.949	-8.411	-2.491
	(0.040)	(0.798)	(0.049)	(0.126)	(0.694)
Annual payment-to-income ratio squared ($PAYINC^2$)	41.346	13.919	33.011	24.757	11.096
	(0.160)	(0.594)	(0.048)	(0.157)	(0.591)
More than one mortgage (yes =1) (SECMORT)	0.496	-0.714	-0.230	0.373	0.698
	(0.219)	(0.036)	(0.451)	(0.104)	(0.019)
Household Characteristic Variables:					
Potential wasted interest as % of residence fair market value (TAX)	-3.706	-11.550	-1.655	-0.956	-4.494
	(0.874)	(0.206)	(0.659)	(0.639)	(0.148)
Total income (INC)	0.010	0.017	-0.001	0.003	0.003
	(0.221)	(0.002)	(0.832)	(0.500)	(0.584)
Two wage earner (yes=1) (JOINTINC)	0.181	0.133	-0.380	-0.149	0.052
	(0.516)	(0.572)	(0.101)	(0.444)	(0.838)
Age of household head (AGE)	-0.143	-0.190	0.078	0.001	-0.167
	(0.382)	(0.245)	(0.616)	(0.991)	(0.297)
Age of household head squared (AGE^2)	0.001	0.002	-64.0E-05	-19.0E-05	0.002
	(0.410)	(0.326)	(0.691)	(0.889)	(0.302)
Household head with 2 or more years of college (yes=1) (COLLEGE)	-0.046	-0.027	-0.049	0.080	0.622
	(0.860)	(0.900)	(0.817)	(0.647)	(0.006)
Family size (FAMSIZE)	-0.262	-0.151	0.153	0.011	0.024
	(0.015)	(0.071)	(0.062)	(0.874)	(0.787)
African-American head (yes=1) (BLACK)	-0.394	0.311	1.188	-0.460	0.234
	(0.454)	(0.451)	(0.006)	(0.207)	(0.635)
Hispanic head (yes=1) (HISP)	0.499	0.530	-0.106	-0.184	-0.525
	(0.412)	(0.313)	(0.872)	(0.685)	(0.349)
Location Variables:					
Rural location (yes=1) (RURAL)	0.568	0.047	0.139	0.098	-0.120
	(0.104)	(0.884)	(0.648)	(0.699)	(0.720)
Low-to-Moderate Income/First-time Owner Interactions:					
Income < 80% PMSA median income and first-time owner (yes=1) (FIRSTLOW)	11.869	4.676	1.966	2.744	1.424
	(0.090)	(0.458)	(0.775)	(0.623)	(0.863)
MTGAGE x FIRSTLOW	-0.110	-0.357	0.059	0.270	0.013
	(0.515)	(0.024)	(0.756)	(0.080)	(0.949)

	Two-Year Data Windows				
	1985-87	1987-89	1989-91	1991-93	1993-95
PVIS x FIRSTLOW	56.2E-05	35.8E-05	0.8E-05	0.3E-05	-0.7E-05
	(0.003)	(0.096)	(0.933)	(0.951)	(0.896)
LTV x FIRSTLOW	-6.603	-1.029	-1.832	-1.709	-0.625
	(0.146)	(0.725)	(0.557)	(0.527)	(0.862)
LTV^2 x FIRSTLOW	1.426	-0.912	-1.356	-1.095	-0.465
	(0.795)	(0.739)	(0.642)	(0.670)	(0.886)
PAYINC x FIRSTLOW	17.854	-2.653	15.051	12.135	2.330
	(0.052)	(0.755)	(0.027)	(0.053)	(0.713)
$PAYINC^2$ x FIRSTLOW	-41.462	-15.289	-35.582	-28.450	-11.090
	(0.158)	(0.562)	(0.034)	(0.108)	(0.591)
SECMORT x FIRSTLOW	0.072	0.539	-0.275	0.277	-0.431
	(0.914)	(0.503)	(0.723)	(0.625)	(0.573)
TAX x FIRSTLOW	-6.487	5.869	-5.992	-1.857	1.605
	(0.792)	(0.578)	(0.252)	(0.499)	(0.759)
INC x FIRSTLOW	-0.037	-0.008	-0.056	-0.028	-0.039
	(0.363)	(0.859)	(0.159)	(0.348)	(0.193)
JOINTINC x FIRSTLOW	0.124	-0.742	0.769	0.010	0.878
	(0.806)	(0.133)	(0.185)	(0.984)	(0.194)
AGE x FIRSTLOW	-0.456	0.030	-0.032	-0.255	0.110
	(0.134)	(0.914)	(0.914)	(0.279)	(0.739)
AGE^2 x FIRSTLOW	0.005	-9.0E-05	4.8E-05	0.003	-0.002
	(0.104)	(0.975)	(0.988)	(0.241)	(0.647)
COLLEGE x FIRSTLOW	-0.529	-0.889	-0.111	-0.253	-1.499
	(0.348)	(0.082)	(0.853)	(0.551)	(0.008)
FAMSIZE x FIRSTLOW	0.275	0.285	-0.370	-0.098	-0.367
	(0.126)	(0.088)	(0.050)	(0.486)	(0.056)
BLACK x FIRSTLOW	1.106	-0.314	-1.635	-0.304	-0.908
	(0.116)	(0.632)	(0.036)	(0.631)	(0.266)
HISPANIC x FIRSTLOW	0.479	-0.538	-0.768	0.251	-0.944
	(0.580)	(0.521)	(0.565)	(0.753)	(0.380)
Number of observations	685	751	803	881	562
-2 Log-Likelihood statistic	634.039	788.432	793.526	1104.434	716.747
(p-value of chi-squared statistic)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Within-sample classification rate	74.9	71.9	75.8	60.6	55.0
Paired rank correlation ('c' statistic)	0.801	0.709	0.705	0.701	0.687

[a] Reported values are parameter estimates from Logistic Regressions with *p*-values of Wald chi-square statistics in parentheses. See Figure 2 and the text for variable definitions. Ten binary variables indicating whether the home is located in one of the top 10 most represented PMSAs in the combined 1985–1995 samples are included in the logistic regression models as location control variables but these results are not reported here. Figures including these variables are available from the authors on request.

Source: Authors' tabulations and estimates from the American Housing Survey, 1985, 1987, 1989, 1991, 1993, and 1995 National Files supplemented with non-housing expense estimates based on data from Internal Revenue Service Individual Tax Model File.

IV. Empirical Results

Figures 4 through 9 contain logistic regressions, with parameter estimates, *p*-values of the associated Wald chi-square statistics (in parentheses), and measures of goodness-of-fit, including two model classification rates. The first group of figures (4 through 6) report results from estimating equation (6) with the sample partitioned by income level alone. Included is a complete set of low-to-moderate-income interaction variables. Figure 4 contains the results for mortgages less than five years old. Figures 5 and 6 contain the corresponding results for mortgages 5-10 and 11-15 years old, respectively. In Figures 7 through 9, the control group is again all non-low-to-moderate-income households. However, the test group consists of households that are both low-to-moderate-income households and first-time homeowners.

Results for the 1985–1987 window are reported in the first column of each figure, followed by the results for the remaining four windows. The -2 lLog Likelihood statistics are significant for all models, indicating that the independent variables provide explanatory power, and the classification rates are superior to a naive model based on every household being classified as a non-terminator. The base case (non-low-to-moderate income) coefficients are discussed first, followed by an analysis of the low-to-moderate income interactions in Figures 4 through 6. The results for the more restrictive test group, low-to-moderate income and first-time homeowners, are then discussed.

Results for the Higher Income Control Group

The coefficient on mortgage age for the 0-5 mortgage age group (Figure 4) is generally positive and significant. Thus, even within the 0-5 age group, mortgages that have been outstanding longer are more likely to be terminated. The coefficients on PVIS in Figure 4 are positive and strongly significant in all but the 1987–1989 window. This indicates that larger interest savings from refinancing have a direct and positive effect on the termination probabilities of higher income households and is consistent with option-based explanations of mortgage prepayments. The coefficient on book LTV is consistently negative, suggesting that increased collateral constraints reduce the probability of termination for higher income households, as would be expected given the empirical findings of Archer et al. (1996) and Hurst and Stafford (1996). However, this result is statistically significant only in the 1985–1987 window. A potential

explanation is that higher income households generally use less mortgage debt than low-to-moderate income households. Thus, they are less likely to find themselves collaterally constrained if house values decline subsequent to origination. The estimated coefficients on LTV^2 are generally insignificant, suggesting that the effects of collateral constraints are not highly nonlinear.

Except for the 1989–1991 window, the coefficients on PAYINC are negative and statistically significant. This is not surprising because households considering an interest-rate driven prepayment are likely to find loan qualification more difficult as the prospective payment burden increases. The estimated coefficients on $PAYINC^2$ suggest the effects of payment constraints are not highly nonlinear. Taken together, the results for the underwriting variables suggest higher income borrowers are more likely to be liquidity/income constrained than to be constrained by the value of their housing collateral.

For mortgages that have been outstanding 5-10 years (Figure 5), the effects of mortgage age are much less clear than for less seasoned mortgages. In two windows the estimated coefficient is negative and significant; in two subsequent windows the coefficient is positive and significant. Similar to the results for less seasoned mortgages, termination rates for mortgages 5-10 years of age are positively and significantly related to PVIS, generally unaffected by contemporaneous LTVs, and negatively related to contemporaneous payment burdens.

Mortgages 11-15 years of age display some variations in termination rates within this age category. Most importantly, PVIS continues to have a positive and highly significant effect on termination rates. Thus, we find no evidence among higher income households that borrowers are less likely to respond to attractive prepayment opportunities as their mortgage age increases. The coefficients on both LTV and PAYINC are negative and significant in two of five windows for these more seasoned mortgages. Finally, there is limited evidence in Figures 4 through 6 that the existence of a second mortgage is associated with higher first mortgage termination probabilities among higher income households, all else equal.

Turning to the household characteristic variables, we find that first-time homeowners who obtained their first mortgage less than five years ago are somewhat less frequent terminators that non first-time owners. For more seasoned mortgages (Figures 5 and 6), the first-time owners shift variable is not significant. The coefficient on TAX is generally negative and marginally

significant as expected; the probability of termination decreases as TAX increases because higher levels of TAX represent lower after-tax costs of mortgage debt.

There is no evidence in Figures 4 through 6 that the termination behavior of higher income households is affected by the level of household income, after controlling for the effect of PAYINC. This is not consistent with the notion that higher income proxies for increased financial sophistication and awareness, which, in turn, produces larger responses to in-the-money refinancing options. There is limited evidence in Figures 4 through 6 that, if household income is produced by two wage earners, the probability of termination is decreased. This is clearly not consistent with the hypothesis that, for a given level of income, two wage earners within a household improves creditworthiness. It also is not consistent with evidence from the mobility literature that married households are more mobile, all else equal. This result is consistent with the notion that households with two income earners may be relatively more income constrained.

The negative and statistically significant coefficients on AGE in Figures 4 and 5 indicate that the probability of termination decreases with age. However, the positive coefficient on AGE^2 suggests the effect of age is nonlinear. An explanation consistent with this result is that households generally become less mobile as the head ages, hence, the lower probability of termination. However, as the head approaches retirement age, and any children have left the house (and not returned), the probability of a downsizing or relocation move may increase. In addition, older households are more likely to have accumulated enough wealth to allow them to simply pay off the remaining balance on their mortgage loan.

The coefficient on COLLEGE is consistently positive, and occasionally significant. This result provides some support for Quigley's (1987) contention that COLLEGE should be positively related to termination probability. The signs and magnitudes of the coefficients on FAMSIZE provide no clear picture of the effect of family size on terminations. This contrasts with the mobility literature where greater household size has been found to increase the likelihood of relocating. Similarly, the coefficients on BLACK and HISP provide no clear evidence that the termination behavior of these two groups can be distinguished from observationally equivalent non-Black or Hispanic households. In sum, many of the household level variables are significant and thus increase the explanatory power of the termination model compared with a model with mortgage and option characteristics only.

Location indicator variables for the 10 PSMAs that contribute the largest number of observations to our analysis were also included in the estimations in an attempt to control for differences in past market conditions, including average house price appreciation. These location variables also may proxy for cross-sectional differences in expectations about future price appreciation. Although the coefficients on these location dummies are occasionally significant, no clear geographic pattern emerges. Thus, to conserve space, these estimates are not reported.[11]

Low-to-Moderate Income Interactions

We now examine the incremental intercept and slope effects for households having total income less that 80 percent of area median. The intercept shift variable (LOWINC) is strikingly insignificant in all five windows and for all three mortgage age groups. Thus, there appears to be no difference in the baseline rate at which low-to-moderate income households terminate their fixed-rate mortgages. The PVIS interaction variable captures the extent to which low-to-moderate income households differ from higher income households in their responsiveness to interest rate changes. Recall that for higher income households the coefficient on PVIS is positive and highly significant. Interestingly, the results reported in Figures 4 through 6 provide no clear evidence that lower income households are differentially sensitive to attractive refinancing opportunities. In particular, low-to-moderate income households are clearly not *less* responsive than higher income households to interest rate changes. Said differently, these results provide no evidence that the price "charged" by lenders for the embedded call option should be different for lower income borrowers.

The LTV interaction variable captures the extent to which the current (not original) leverage ratio affects the termination probabilities of low-to-moderate income households differently than higher income households. In Figure 4, the estimated coefficient on this interaction variable is negative in all five windows and statistically significant in three windows. This result suggests that larger amounts of mortgage debt (relative to house value) slow the terminations of low-to-moderate income households significantly more than higher income terminations. This may reflect the fact that low-to-moderate income households generally have less accumulated wealth and therefore must (debt) finance a larger percentage of the initial

[11] The 10 PMSAs that contribute the largest number of usable observations are Chicago, Detroit, Los Angeles, Philadelphia, Washington, D.C., Minneapolis-St. Paul, New York Metro, Nassau and Suffolk County, Houston, and Phoenix. These coefficient estimates are available from the authors upon request.

purchase price. However, if the market value of their home declines after purchase, they may not be able to qualify for a replacement mortgage as large as the outstanding balance on the existing loan. Thus, even if interest rates have fallen since origination, the borrower may not choose to prepay because doing so may require the borrower to invest additional equity capital in the housing asset. Said differently, such a household is more likely to become constrained by the value of their mortgage collateral than borrowers who obtain lower LTVs at origination. The LTV^2 interaction term is largely insignificant.

The coefficient on PAYINC for higher income households was negative and highly significant, as discussed above. The coefficients on the PAYINC interaction variable are positive and generally significant. In fact, the magnitude of the interaction coefficient effectively offsets the negative high-income coefficient in each of the five sample periods. This indicates the termination behavior of low-to-moderate income households is *not* responsive to changes in prospective payment burdens, all else equal. This insensitivity to changes in the payment burden is somewhat surprising. Most have posited that low-to-moderate income households are *more* adversely affected by increases in the prospective payment burden on a new mortgage because these households generally have less wealth available to them to increase their equity downpayment. However, this result may simply reflect that the lower income test group is already significantly income constrained. Thus, further increases in the prospective payment burden have no significant effects.

Examination of Figures 4 through 6 reveals that the coefficients on the remaining interaction variables are strikingly insignificant. Thus, the influence of household characteristics and location variables does not appear to differ across the two income subsamples. This finding is important as a further indication that the prepayment behavior of lower income, first-time homebuyers is little different from that of other homeowners except for the influence of collateral and income constraints.

To examine the sensitivity of our results to the definition of low-to-moderate income, we conducted preliminary tests setting LOWINC equal to one if household income was less than 60 percent of the MSA median and produced a logistic regression for each of the five sample periods. Although not reproduced here, the results were little different from the initial specification that classified as low-to-moderate income all households with less than 80 percent of the median income in the MSA. In particular, the intercept shift variable is still insignificant in

four of the five windows. Once again, the estimated coefficients on the PVIS interaction variable indicate that low-to-moderate income households were clearly no less responsive to changes in mortgages interest rates.

Low-to-Moderate Income and First-Time Homeowner Interactions

The interaction variables in Figures 4 through 6 capture the incremental intercept and slope effects for households having total income less that 80 percent of area median. A household's status as a first-time homeowner is not separately considered. However, numerous housing policies focus on a subset of our low-to-moderate-income test group, i.e., those households that are both lower income *and* non-homeowners. We now examine how the termination behavior of this smaller subset of households varies from the non-low income control group. More specifically, in our second set of regressions, the control group remains the same as in Figures 4 though 6; that is, all households with income above 80 percent of the area median. However, we create a new dummy variable, FIRSTLOW, that takes on a value of one if the household has income below 80 percent of the area median *and* the household head is a first-time owner. These results are reported in Figures 7 through 9.

The estimated coefficients on FIRSTLOW in Figure 7 are positive, but statistically significant (at the 0.079 level) only in the 1989–1991 window. Largely insignificant results are also found for more seasoned mortgages (Figures 8 and 9). Thus, relative to the control group, there appears to be little difference in the baseline rate at which lower income, first-time owner households terminate their fixed-rate mortgages.

Recall that the results reported in Figures 4 through 6 contain no clear evidence that lower income households are more sensitive to attractive refinancing opportunities than the control group. Interestingly, the results in Figure 7 provide limited evidence that lower income, first-time owners are actually *more* sensitive than the control group to in-the-money call options because the PVIS-FIRSTLOW interaction variable is positive and statistically significant in both the 1989–1991 and 1993–1995 windows. Certainly, these results do not support the contention that the price charged by lenders for the embedded prepayment option should be different, i.e. lower, for lower income, first-time owners.

In Figure 4, the estimated coefficient on the LTV-LOWINC interaction variable is negative in all five windows and statistically significant in three windows. Similarly, the LTV-FIRSTLOW interaction coefficient is negative and significant in three of the five windows for

the 0-5 mortgage age group (Figure 7) and negative and significant in two of the three windows for mortgages that have been seasoned five to 10 years. Although negative, the LTV-FIRSTLOW interaction coefficient is not significant in the most seasoned (11-15 years) mortgage age group. In sum, these results suggest that larger amounts of mortgage debt (relative to house value) do slow the terminations of lower income, first-time owners more than the control group.

The coefficients on the PAYINC-LOWINC interaction variable in Figures 4 through 6 are positive and generally significant. These results carry over to the PAYINC-FIRSTLOW interaction results contained in Figures 7 through 9. Again, the magnitude of the PAYINC-FIRSTLOW interaction coefficients effectively offsets the negative control group high-income coefficients. This indicates that the termination behavior of the test group is generally *not* responsive to changes in prospective payment burdens, all else equal.

Examination of Figures 7 through 9 reveals that the coefficients on the remaining interaction variables are largely insignificant. Thus, we again conclude that the influence of household characteristics and location variables on the termination behavior of the test group largely do not vary from their effects on the control group.

V. Summary

This study examines mortgage termination behavior at the household level with a focus on the effects of household income and first-time home purchase. Results from the estimation of a series of logistic regressions suggest that the propensity for mortgage prepayment by low-to-moderate income households is little distinguished from higher income households. In particular, low-to-moderate income households are no less responsive to interest rate changes than higher income households. In fact, they appear to be slightly more responsive. The fact that lower income households exhibit lower prepayment rates appears to be attributable to the effect of constraints. Specifically, the slope coefficients on the two underwriting variables, LTV and PAYINC, are significantly different for low-to-moderate income households. High current LTVs do not appear to impede the terminations of higher income households. However, high LTVs do significantly slow low-to-moderate income terminations. On the other hand, it would seem contradictory that higher prospective payment burdens significantly slow higher income terminations, but have little effect on the mortgage terminations of lower income households.

This contradiction may be explainable, however, by the fact that the lower income groups are, by definition, universally income-constrained. None of these results change when the analysis focuses on the prepayment behavior of only lower income first-time homebuyers.

Finally, the low-to-moderate income interaction coefficients on the household characteristic and location interaction variables are remarkably insignificant. Thus, although numerous demographic and locational variables are shown to significantly affect termination behavior, their effects on low-to-moderate income households cannot be distinguished from their effects on higher income households. This result contributes further to the impression that differences in prepayment behavior between non-low income and lower income households are attributable largely to differences in income and collateral constraints.

The study further partitioned households by age of mortgage. This partitioning reveals little difference in results. The primary findings of strong interest rate sensitivity and the influence of collateral and income constraints remains consistent across mortgages from zero to five years old, mortgages five to 10 years old and mortgages 11 to 15 years old. Further, the general absence of influence on prepayment by other household characteristics is confirmed for all three mortgage age groups.

There are several reasons to believe that the findings of this study are credible: First, the estimated equations have a high degree of statistical significance across five separate panels of data that cover a 10-year period. Further, the estimated coefficients show a strong pattern of consistency across the five separate two-year time intervals of data. Finally, the individual coefficients have a large measure of economic plausibility. In light of this credibility, it is significant that we find little indication that low-to-moderate income households have lower prepayment propensity than other home borrowers. This result has significant implications for the pricing of fixed-rate mortgages at both origination and in the secondary market.

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