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Homeowner Mobility and Mortgage Interest Rates: New Evidence from the 1990s

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When interest rates vary, the value to a homeowner of a mortgage at a fixed interest rate varies as well. In particular, if mortgages are not fully assumable, then when interest rates increase, the value of a preexisting mortgage contract increases as well. Thus, homeowners have an incentive to postpone moving in response to other economic incentives. Similarly, when interest rates decrease, households that had previously postponed moving now have this disincentive removed. The only empirical evidence on the magnitude of this effect is based upon the period of unusual volatility and increasing interest rates in the late 1970s. This paper investigates the importance of these mortgage contracts upon mobility during a more typical environment, the early 1990s, when much lower interest rates declined further. Thus, it investigates the implications for mobility of a decline in the "lock in" effect of mortgage contracts. The paper uses the same data source and methodology that had been used previously to analyze the effects of high interest rates in 1979–1982 upon homeowner mobility.

Household mobility has important effects on the efficiency of the broader economy. For example, interregional household mobility provides a powerful mechanism for promoting labor market efficiency in the United States. Similarly, intraurban household mobility is the principal mechanism enforcing allocative efficiency in the local public sector.

The potential of household and worker mobility to alleviate interregional disparities and to enhance the efficiency of the local public sector is limited by information and transactions costs. The out-of-pocket costs of searching and moving are substantial (Weinberg, Friedman and Mayo 1981), and there is an extensive literature documenting the nonpecuniary costs of relocating (*e.g.*, Dynarski 1985).

About two-thirds of U.S. households are homeowners. For these households, the cost of mortgage finance is a large component of transactions costs, almost as large as brokerage fees incurred in purchase and sale. Homeowner mobility

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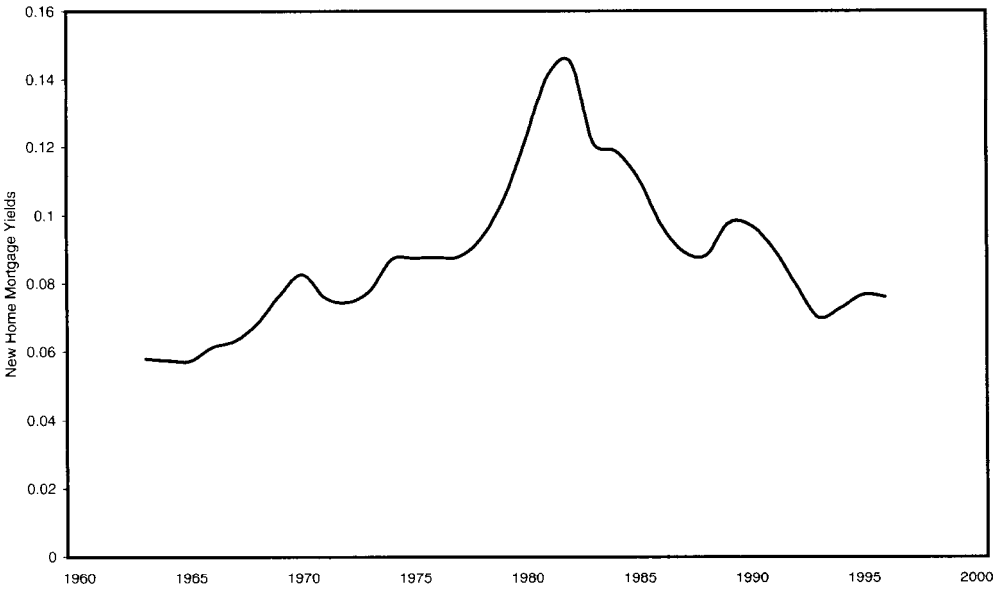
may require the payment of penalties under existing mortgage contracts, as well as application fees and up-front payments associated with new mortgages. Among these financial costs, those associated with interest rate variations are likely to be the largest. In periods of increasing interest rates, holders of fixed-rate nonassumable mortgages will have strong incentives to postpone residential moves that would require incurring new mortgage debt.

Some systematic evidence is available on the quantitative importance of the lock-in effect of favorable mortgage terms upon homeowner behavior. One study (Quigley 1987) relates variations in interest rates to the decisions of individual households to relocate for consumption or for labor market motives. In that study, variations in mortgage contract terms among homeowners—coupon rates, times to maturity, and monthly payments—were used to value homeowner mortgages during periods of high interest rates (1979, 1980, and 1981). The results revealed highly significant and large effects of variations in the terms of existing mortgage contracts upon the mobility of decisions of homeowners. Subsequently, Potepan (1989) presents a model focused on housing consumption in which homeowning households choose between moving to satisfy their consumption goals or investing in home renovations. His analysis suggests that the lock-in effect arising from the ownership of mortgages on favorable terms is important in influencing homeowners' choices between moving and investing in home improvements. During periods of high interest rates, homeowners are more likely to choose to renovate existing dwellings rather than to move to dwellings better suited to their changing housing demands.

Both of these studies analyze the effects of interest rate variations on homeowner behavior during an unusual period of high and volatile interest rates. Quigley's analysis is based upon the Panel Study of Income Dynamics (PSID) for the period 1979–1981; Potepan's analysis is based upon PSID data for 1979. By way of comparison, mortgage yields on new purchases increased by 67%, from 9 to 15 percentage points, during the 1977–1982 period that spans these empirical studies.

This paper provides new evidence on the effect of mortgage contract terms on homeowner mobility from a time period in which interest rates have varied within a more typical range. We analyze household behavior during the 1991–1992 period, using the same data source (the Panel Study on Income Dynamics) that was analyzed during the 1979–1981 period. The years 1991 and 1992 were chosen because this is the only period in which the requisite data were reported at the household level in the PSID sample survey. In contrast to the period analyzed previously, this was an era of falling interest rates. Mortgage yields on new purchases declined by almost 30%, from 10 to a little over 7 percentage points, during the 1990–1993 period that spans this analysis. Thus, any incentive

Figure 1 ■ The course of mortgage interest rates, 1963–1996.



Source: Federal Housing Finance Board.

to delay residential moves due to unfavorable mortgage terms declined during this period of analysis.

The focus of the empirical analysis is, as far as possible, on the "replication" of results. We use the same underlying data source analyzed in the 1979–1981 period, and we use the same logic to define the key behavioral variables. We also use the same statistical methods to make inferences. The principal differences in application arise from limitations in Quigley's original 1987 study, which should have been known at that time.[1]

Figure 1 reports the course of mortgage interest rates during the past three decades and highlights differences in the interest rate environment during the periods covered by these empirical analyses. The interest rate used is reported annually by Freddie Mac. It represents the national average yield on new fixed-rate mortgages during the calendar year.[2]

The next section sets out the basic model and the statistical methodology used to estimate it. The third section reports the statistical analysis and the results. The fourth section is a brief conclusion.

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[1] These embarrassments in the original research design—efficiency in estimation and asymmetry in behavioral response—are noted below.

[2] PSID data on mobility are reported annually, so nothing is gained by a more refined time series on interest rates.

The rich set of results may be summarized briefly. We find strong evidence that certain demographic factors and market conditions—changes in the head of household, an increase in family size, appreciation in house values—affect family mobility prospects. The evidence about the importance of mortgage contracts upon mobility is more ambiguous. In fact, in a simple proportional hazards framework, there is little evidence of a relationship in these more recent data.

However, when the model is extended to investigate nonproportional responses —that is, when the mobility response to changes in mortgage conditions is allowed to vary with the household's current length of tenure—a systematic pattern emerges. For households who have lived in their current dwellings for more than a decade, possession of a mortgage under favorable terms substantially reduces the probability of household mobility. However, these effects are small relative to demographic influences upon household mobility.

Mortgage Terms and Household Mobility

Households make labor market adjustments by changing jobs, often necessitating residential moves. Homeowning households make adjustments in housing consumption through renovations or by moving to accommodations which more closely reflect their incomes and tastes. Absent transactions costs, households would adjust to variations in labor market conditions or housing preferences immediately, changing dwellings in response to investment or consumption incentives.

The financial conditions underlying home mortgages may represent substantial transactions costs. Beyond prepayment penalties, households may incur losses whenever they hold mortgages whose coupon interest rates are higher than those charged for new mortgages of equivalent maturities. If mortgage contracts were assumable and if their financial terms were fully capitalized into house prices, then current homeowners could always realize the financial advantages of favorable mortgage terms upon selling the house. Neither of these conditions holds. Most mortgage contracts specify that they are not assumable by third parties, and empirical evidence suggests that, even if assumable, the favorable financial terms in mortgage contracts are only incompletely capitalized into the selling prices of houses.[3]

The financial advantage arising from ownership of a mortgage at contract interest rate i, when the interest rate charged on new first mortgages is r, depends

[3] Durning and Quigley (1985) present evidence of incomplete capitalization for the United States. Conflicting results are reported by Englund *et al.* (1998, 2000) for Sweden.

upon the monthly payment P for debt service and the term to maturity η. With fixed-rate, level-payment mortgages, the difference between the book and market value of the mortgage, PDV, for $i < r$) is

$$PDV(P, i, \eta, r) = \sum_{j=1}^{\eta} \frac{P}{(1+i)^j} - \sum_{j=1}^{\eta} \frac{P}{(1+r)^j} \tag{1}$$

$$PDV(P, i, \eta, r) = B - \sum_{j=1}^{\eta} \frac{P}{(1+r)^j}$$

$$= g[Y],$$

where B is the unpaid balance of the mortgage at time $j = 1$ and Y is a vector of contractual terms and interest rates, $Y(P, B, i, r, \eta)$.

Of course, the financial incentives summarized by the $g[\ ]$ function are not the only reason, or even the most important reason, why mobility rates vary across homeowners. Housing demand and residential mobility vary with a wide range of sociodemographic characteristics of households (see, *e.g.*, Quigley and Weinberg 1977, or Archer *et al.* 1996, 1997). Let the vector X represent that set of sociodemographic characteristics and let Y represent the vector of contractual and interest rate determinants (P, B, i, r, η).

Let T be a continuous random variable that measures the duration of household tenure, that is, the elapsed time since an individual household last moved. Define

$$F(t) = \text{prob}(T \geq t) \tag{2}$$

as the survivor function and

$$f(t) = \frac{-dF(t)}{dt} \tag{3}$$

as the probability density function of t.

The conditional hazard function, specifying the instantaneous probability of household move at $T = t$, conditional upon survival to time T is

$$h(t) = \frac{-d \ln F(t)}{dt} = \frac{f(t)}{F(t)}. \tag{4}$$

Now, assume that the hazard rate of mobility is separable and proportional:

$$h(t, x, y) = h_0(t)\pi(X, Y), \tag{5}$$

where h_0 is the baseline hazard, a function of duration alone. The factor π varies with the sociodemographic characteristics of households X and the contractual and interest rate terms Y.

Assume further that π is separable in the form

$$\pi(X, Y) = \exp(\beta_1 X + \beta_2 g[Y]), \tag{6}$$

where $\beta 1$ and β_2 are parameters.

More generally, it may be reasonable to presume that the importance of mortgage terms and interest rates is not independent of tenure time. For example, if households' attachment to neighborhoods increases over time (see Dynarski 1985), then the same increase in the transactions costs of moving may affect the mobility incentives of households (and their hazards of moving) quite differently depending upon length of tenure. The proportionality assumption can be tested in a straightforward manner, for example, by assuming

$$\pi(X, Y, t) = t^{\beta_3 g[Y]} \exp(\beta_1 X + \beta_2 g[Y]) \tag{7}$$

by testing the hypothesis that $\beta_3 = 0$.

Equations (5) and (6) define the Cox proportional hazard model (see Cox and Oakes 1985):

$$h(t, X, Y) = h_0(t) \exp(\beta_1 X + \beta_2 g[Y]). \tag{8}$$

Similarly, Equations (5) and (7) define the Cox nonproportional hazard model:

$$h(t, X, Y) = h_0(t) \exp(\beta_1 X + \beta_2 g[Y] + \beta_3 g[Y] \log t). \tag{9}$$

This specification was used previously to evaluate the effects of mortgage terms upon homeowner mobility using the PSID for 1979–1981. From the raw data, it was possible to compute the Y vector for about half of the homeowners surveyed in the PSID. In addition to the $g[Y]$ variable measuring the value of mortgage terms, the empirical analysis included controls for nine sociodemographic characteristics of households (X).

The results of this investigation are reproduced exactly in Table 1. Note that in each of the three samples, the coefficient β_2 is highly significant. β_2 is reported in the first line of Table 1. The significance of the coefficient β_3 is more ambiguous. Of the three replications, one is highly significant ($t = 2.3$), one is clearly insignificant ($t = 1.3$), and one is marginal ($t = 1.7$).

Table 1 ■ Hazard rate models of household mobility.

	Proportional			Nonproportional		
Variable	1979	1980	1981	1979	1980	1981
g[Y] (×10,000)	−0.572	−1.125	−0.582	−1.370	−0.910	−1.280
	(5.06)	(4.78)	(3.96)	(2.27)	(3.42)	(2.36)
g[Y]log t (×10,000)				−0.200	−0.550	−0.180
				(1.70)	(2.31)	(1.26)
Increase in family	0.402	0.558	0.841	0.342	0.577	0.831
size (number)	(2.53)	(2.46)	(3.47)	(2.26)	(2.60)	(3.44)
Decrease in family	0.046	0.064	0.034	0.108	0.061	0.339
size (number)	(0.45)	(0.25)	(2.65)	(1.90)	(0.23)	−(2.63)
Income of family	0.172	0.140	−0.069	0.027	0.134	0.786
(×100,000)	(0.36)	(5.15)	(0.13)	(0.53)	(5.56)	(0.14)
Age of family	−8.988	−7.508	−7.521	−0.093	−7.293	−7.453
head (×100)	(11.12)	(7.06)	(6.84)	(12.39)	(6.93)	(6.79)
Education of family	0.155	0.096	0.073	0.116	0.097	0.068
head (years)	(3.92)	(1.72)	(1.43)	(3.26)	(1.78)	(1.32)
Size of family	−0.101	0.040	0.075	−0.010	0.022	0.076
(number)	(1.51)	(0.41)	(0.81)	(0.18)	(0.22)	(0.81)
Black household	−0.319	0.328	−0.904	−0.319	0.231	−0.903
(1 = yes)	(1.10)	(0.38)	(2.01)	(1.31)	(0.22)	(2.00)
Other non-White	0.744	0.274	−0.526	0.955	3.806	−0.530
household (1 = yes)	(2.06)	(0.27)	(0.52)	(2.90)	(0.37)	(0.52)
Change in family		1.374	1.227		1.451	1.212
head (1 = yes)		(2.04)	(2.91)		(2.13)	(2.87)
Likelihood ratio	316.32	212.57	182.23	394.00	260.82	228.29
(chi-square)						
Observations	1768	1092	1142	1768	1092	1142
Number of moves	134	58	71	134	58	71

Note: Asymptotic t-ratios in parentheses.
Source: Quigley (1987, p. 639).

These results suggest that mortgage terms and interest rates significantly affect the propensity of homeowners to move in any year. The results provide no strong grounds for distinguishing between the proportional and nonproportional representation of interest rate effects.

With the advantage of a decade of hindsight, several aspects of these published results seem problematic. First, we may expect the effects of the present value of financial terms upon household mobility to be asymmetric. If the g function is positive, indicating that the present value of maintaining an existing mortgage is large relative to acquiring a new mortgage at current market conditions, households will have economic incentives to postpone or forego residential moves. However, if the g function is negative, households will have economic

incentives to refinance, not necessarily to move. This suggests that the coefficient β_2 associated with g in the hazard model should be negative when g is positive but could be zero when g is negative.

Indeed, if we observe that g is negative for some household, then we may wonder why it has chosen not to refinance an existing mortgage. For some households, the transactions costs may simply exceed the economic gains from refinance. However, we may observe that other households do not refinance because they cannot easily do so, for example, because their incomes or house values have declined. Those households who could no longer qualify for mortgages on their current properties may act quite rationally in maintaining their existing mortgage finance. In fact, for these reasons, we may expect some households to be less mobile when the value of g is negative.

Finally, the results presented in Table 1 are based upon observing household behavior during three one-year intervals in the estimation of the hazard of mobility. Quite clearly, a more efficient estimation strategy would have entailed observing each household during a single three-year interval in estimating the conditional hazard of household mobility.[4]

These problematic aspects of previous research can be addressed by extending the analysis, using the same data source but relying upon more recent observations on behavior.

New Results from the 1990s

As noted above, it is possible to extend this analysis to the years 1991 and 1992 by relying on the PSID survey for 1990–1992. During those three years, the PSID survey asked household respondents to report their remaining mortgage balances and the remaining term to maturity of their mortgages. The survey also asked households to indicate their gross monthly payments and the portion of payments reserved for insurance and property taxes.

Computation of the present value of homeowner mortgages was undertaken for 1990 and 1991 and was related to homeowner mobility during the subsequent years 1991 and 1992. Thus, the 1992 sample refers to moving behavior observed in 1992 based on household demographics in 1991 and the present value of the mortgage observed in that same year.

[4] Using a single three-year interval for each household brings all the sample information to bear in estimating each parameter and standard error, rather than only some subset of the information.

Despite the care taken in verifying data by PSID researchers, it was necessary to exclude a substantial fraction of the sample of homeowners from the statistical analysis. Homeowners were eliminated from the analysis sample based upon five general criteria.

First, households were eliminated if all raw data required to calculate the PDV in Equation (1) were not available for the previous year as well as the current year. A total of 346 households out of 4,871 homeowners in 1991 were eliminated, and 519 out of 5,079 households in 1992 were eliminated according to this criterion.

Second, households were eliminated if the homeowner was unable to provide its remaining mortgage principal, its monthly mortgage payment or its property tax bill. In many of these circumstances, the PSID staff supervising the survey made "imputations." Removal of these undocumented imputations reduced the analysis sample by 864 homeowners in 1991 and by 805 households in 1992.

Third, households were eliminated if their computed mortgage interest rates were unreasonable. The PSID survey did not ask homeowners directly for their mortgage interest rates. Interest rates were computed from the remaining mortgage balance and the remaining term, the gross monthly payments and the portion of that payment used to pay insurance or property taxes. Households were excluded from the analysis if their mortgage interest rate, so computed, lay outside the range of 2 to 20%. A total of 444 households were eliminated according to this criterion in 1991, and 441 households were eliminated in 1992.

Fourth, nonmoving households were eliminated if the interest rates computed for them during adjoining years differed by more than 10 percentage points. A total of 240 households were eliminated in 1991 according to this criterion. The sample in 1992 was reduced by 256 by applying this criterion.

Finally, households were eliminated if it was not possible to establish the year they had moved into their current dwelling. The length of tenure for each household was computed by linking longitudinal records for each household back to 1968, the first year of the survey. Each year, households were asked if they had moved in the previous year. Missing values to these responses sometimes resulted in ambiguities about households' tenure. A total of 240 households were eliminated from the 1991 sample, and 396 were eliminated from the 1992 sample through application of this criterion.

Altogether, the application of these criteria reduced the homeowner samples available for analysis by about half. The analysis sample for 1991 included 2,562 of the 4,871 homeowner households, about 53%. For 1992, the analysis sample

Table 2 ■ Homeowner sample sizes and exclusions in PSID, 1991–1992, and exclusions from analysis sample.

	1991 Sample	1992 Sample
Sample sizes		
Total number of homeowners	4,871	5,079
Total number of exclusions	2,309	2,417
Analysis sample	2,562	2,662
Type of exclusion		
Data unavailable for previous year	346	519
Imputation of mortgage principal, mortgage payment, or property taxes	864	805
Unreasonable interest rate computation for previous year	444	441
Nonmoving households with unreasonable changes in interest rate, or interest rate not computable	240	256
Years of tenure unknown	415	396
Total exclusions	2,309	2,417

Note: The sample for any year consists of contemporaneous demographic information and mortgage valuations as of the end of the previous year.

included 2,662 homeowners, about 53% of the sample of 5,079 homeowners in the PSID.[5]

Table 2 summarizes the reasons for excluding households from the samples for 1991 and 1992. We present hazard models based upon these data. The analysis sample consists of observations on all those households observed during the two-year period 1991–1992, on all those households observed in 1991 but not included in the sample in 1992 and on all those households observed in 1992 but not included in the sample in 1991.

[5] The fraction of homeowners eliminated because data were incomplete, missing, or inconsistent is quite comparable to the fraction eliminated in the earlier study using PSID data from 1979–1981. In particular, in both studies about 10–12% of homeowners were eliminated because the implied mortgage interest rate (computed from information on the gross monthly payment, the fraction of that payment used to pay insurance or property taxes, the remaining term of the mortgage, and the unpaid balance) was implausible. The large number of households eliminated due to inconsistent data leads one reviewer to question the accuracy of the imputations for the remaining households. At a minimum, these consistency checks suggest that there is substantial measurement error in the computed variable indicating the present value of the mortgage premium—suggesting that the statistical significance of its effects will be underestimated by conventional *t*-tests.

Table 3 ■ Mean values of variables for homeowners in PSID data and in analysis sample, 1991–1992.

Covariate	1991		1992	
	PSID Homeowners	Analysis Sample	PSID Homeowners	Analysis Sample
Mortgage premium (dollars)	−108	−568	−1,212	2,255
Remaining principal (dollars)	29,823	35,334	31,238	35,057
House value (dollars)	83,931	99,791	84,761	96,761
Premium/house value (percent)	−1.04	−0.93	−2.02	−2.75
Annual mortgage payment (dollars)	4,302	4,818	4,519	4,841
Remaining mortgage term (years)	11.98	11.91	11.89	11.55
Length of tenure at residence (years)	11.22	12.41	11.21	12.56
Increase in family size (number)	0.15	0.10	0.19	0.09
Decrease in family size (number)	0.12	0.10	0.12	0.11
Family income (dollars)	44,221	48,714	45,545	49,252
Age of head (years)	47.76	48.44	48.07	48.75
Education of head (years)[a]	11.92	12.70	12.09	12.58
Size of family (number)	3.07	2.93	3.05	2.95
House value appreciation (one year, in dollars)	7,377	9,216	3,826	4,587
Loan/value ratio (percent)	36.56	33.58	37.23	34.16
Payment/income (percent)	11.45	8.82	10.69	9.03
Black households (percent)	20.20	17.83	20.10	20.18
Other non-White households (percent)	5.81	1.49	6.40	1.72
Moving households (percent)	9.69	4.79	8.29	4.14
Number of observations	4,871	2,086	5,079	2,662

[a]Years of education is estimated from categories reported in 1991. Years of education is measured directly in 1992.

Table 3 summarizes the average differences in each year between the homeowner sample in the PSID and the subsample used for the statistical analysis. Households in the analysis sample have slightly higher incomes and educational levels than other homeowners in the PSID. They own more expensive houses and have somewhat higher outstanding mortgage balances. The average mortgage premium is negative (suggesting that, in the absence of prepayment fees or transactions costs, the average household would be better off refinancing its mortgage). The average premium is somewhat larger in absolute terms for the analysis samples than for homeowners in general, and it is a larger fraction of the average outstanding mortgage balance. It is about the same as a fraction of house values. The number is more negative in 1992 than 1991, presumably reflecting the decline in interest rates during the period.

There are some differences in demographic factors between the full sample of PSID homeowners and the subsample used for analysis. The fraction of Blacks and other non-White households is smaller in the analysis sample than in the full sample of PSID homeowners, and the length of tenure is slightly longer. More troubling is the fact that the mobility rate for the analysis sample is about half that of the full sample.[6]

Of course, the analysis sample includes a substantial fraction of households—about 40 percent—who have no mortgages at all. For those households, the mortgage premium is zero (and is unaffected by interest rates). Table 4 indicates the distribution of mortgage premia and shows a substantial mass point at zero.

Table 5 reports the results of a series of hazard models that include household demographics as well as the financial variables whose distribution is summarized in Table 4. These demographic variables are the same as those defined in Quigley's study using the PSID data from a decade earlier. The pattern of these coefficients is similar to that estimated from the earlier data reported in Table 1. However, the coefficients are much more precisely estimated. This is because all sample information (rather than a stratification) is used to estimate each coefficient. Increases in family size are significantly related to household mobility, but decreases in family size have no statistically significant impact. Younger households and those with more education are more likely to move in any given year. Neither the level of income nor the size of the family is significantly related to household mobility. There is some evidence that, holding other factors constant, Black homeowners are less likely to move than Whites.

Although the chi-squared statistic indicates that each of the models reported in Table 5 is highly significant, there is no credible evidence that mortgage financial terms affected household mobility during this period of declining interest rates. The coefficient on the mortgage premium in Models A through D is insignificantly different from zero.

Table 6 reports the results from an expanded set of variables hypothesized to affect household mobility. First, in Models E through H, we delete the four demographic variables which are clearly insignificant in the results reported in Table 5: decrease in family size, household income, family size, and the dummy variable signifying other non-White households. Second, following

[6] This difference may well reflect the inability of some of the respondents to distinguish between the terms of a current mortgage, recently signed, and a prior mortgage, recently terminated. Again, to the extent that this group includes households who moved (rather than those who refinanced), the importance of interest rates in conditioning residential mobility will be underestimated.

Table 4 ■ Distribution of mortgage premium.

Panel A: Premium in dollars

	1991		1992	
Premium	Frequency	Percent	Frequency	Percent
−$10,000	155	7.43	306	11.94
−$10,000 to −$5,000	144	6.91	244	9.52
−$5,000 to −$2,500	154	7.39	160	6.25
−$2,500 to −$1,000	112	5.37	148	5.78
−$1,000 to $0.01	96	4.60	93	3.63
$0	898	43.07	1,091	42.58
$0.01 to $1,000	107	5.13	100	3.90
$1,000 to $2,500	83	3.98	112	4.37
$2,500 to $5,000	111	5.32	111	4.33
$5,000 to $10,000	110	5.28	109	4.25
$10,000	115	5.52	88	3.43
Total observations	2,085	100.00	2,562	100.00

Panel B: Premium/value

	1991		1992	
Premium/value	Frequency	Percent	Frequency	Percent
−0.25	35	1.68	79	3.08
−0.25 to −0.10	153	7.34	272	10.62
−0.10 to −0.05	155	7.43	240	9.37
−0.05 to −0.0001	318	15.25	360	14.05
0	898	43.07	1,091	42.58
0.0001 to 0.05	292	14.00	321	12.53
0.05 to 0.10	115	5.52	105	4.10
0.10 to 0.25	100	4.80	78	3.04
−0.25	19	0.91	16	0.62
Total observations	2,085	100.00	2,562	100.00

Note: Mortgage premium is defined in Equation (1) as the *PDV* of the mortgage at the contract rate minus the *PDV* at the current rate for newly issued mortgages.

Keil (1994), we include a measure of the one-year house price appreciation experienced by each household. This is computed from the self-assessed house values reported for each homeowner. Third, following Wu (1997), we include measures of the current loan-to-value ratio for each household as well as its monthly housing payment-to-income ratio. Wu argues that these two variables are proxies that identify those constrained households who cannot refinance in response to interest rate declines.

Table 5 ■ Basic hazard models of household mobility.

Covariate	Model A	Model B	Model C	Model D
Mortgage premium ($\times 10^4$)	0.009			
	(1.52)			
Premium/house value		0.487		
		(1.52)		
Premium * dummy for positive ($\times 10^4$)			0.067	
			(0.59)	
Premium * dummy for negative ($\times 10^4$)			0.112	
			(1.22)	
(Premium/value) * (dummy for positive)				0.637
				(0.58)
(Premium/value) * (dummy for negative)				0.388
				(0.72)
Increase in family size (number)	0.662*	0.662*	0.661*	0.663*
	(9.80)	(9.81)	(9.76)	(9.85)
Decrease in family size (number)	0.097	0.094	0.095	0.095
	(0.62)	(0.60)	(0.61)	(0.61)
Family income (1,000s of dollars)	0.001	0.001	0.001	0.001
	(0.51)	(0.49)	(0.57)	(0.47)
Age of head (years)	−0.016*	−0.016*	−0.016*	−0.016*
	(2.24)	(2.23)	(2.26)	(2.18)
Education of head (years)	0.055**	0.054**	0.056**	0.054**
	(1.66)	(1.65)	(1.67)	(1.65)
Family size (number)	0.012	0.012	0.013	0.012
	(0.27)	(0.27)	(0.28)	(0.27)
Black household (1 = yes)	−0.366**	−0.364**	−0.365**	−0.366**
	(1.72)	(1.70)	(1.71)	(1.71)
Other non-White household (1 = yes)	0.081	0.078	0.086	0.072
	(0.19)	(0.19)	(0.20)	(0.17)
New family head (1 = yes)	1.330*	1.336*	1.331*	1.336*
	(6.53)	(6.57)	(6.54)	(6.59)
Chi-square	273.62	269.83	274.88	271.67

*Significant at the 5% level. **Significant at the 10% level.
Note: Asymptotic t-ratios in parentheses.

The chi-squared statistics reported in Table 6 are larger than for the previous models, reflecting the increased statistical significance of the results. There is strong evidence that household mobility decisions are related to increases in family size, the presence of a new head of household, and the age and the education of the head of household. Mobility is also sensitive to recent changes in housing values. If housing values increase substantially, households are more likely to move to rebalance their portfolios (Kiel 1994). If housing values decline substantially, households are more likely to postpone moving and

Table 6 ■ Expanded hazard models of household mobility.

	Model			
Covariate	E	F	G	H
Mortgage premium ($\times 10^4$)	0.084			
	(1.49)			
Premium/house value ($\times 10^4$)		0.391		
		(0.54)		
Premium * dummy for positive ($\times 10^4$)			0.065	
			(0.63)	
Premium * dummy for negative ($\times 10^4$)			0.105	
			(1.19)	
(Premium/Value) * (dummy for positive)				0.327
				(0.23)
(Premium/Value) * (dummy for negative)				0.430
				(0.35)
Increase in family size (number)	0.675*	0.674*	0.675*	0.674*
	(9.80)	(9.80)	(9.78)	(9.78)
Age of head (years)	−0.015**	−0.015**	−0.015**	−0.015**
	(1.91)	(1.87)	(1.90)	(1.87)
Education of head (years)	0.057**	0.056**	0.058**	0.056**
	(1.78)	(1.76)	(1.78)	(1.76)
Black household (1 = yes)	−0.338	−0.337	−0.337	−0.336
	(1.57)	(1.57)	(1.57)	(1.56)
New family head (1 = yes)	1.365*	1.374*	1.364*	1.373*
	(6.71)	(6.74)	(6.68)	(6.70)
House value appreciation ($\times 10^4$)	0.020*	0.021*	0.021*	0.021*
	(2.09)	(2.13)	(2.17)	(2.13)
Loan to value ratio (fraction)	0.037	0.057	0.049	0.063
	(0.14)	(0.22)	(0.19)	(0.22)
Payment to income ratio (fraction)	−0.081	−0.129	−0.057	−0.129
	(0.15)	(0.21)	(0.11)	(0.21)
Chi-square	287.8	285.27	289.67	285.54

*Significant at the 5% level. **Significant at the 10% level.
Note: Asymptotic *t*-ratios in parentheses.

to put off refinancing decisions, even when interest rates decline (see Archer *et al.* 1997, as well as Chan 2001). In combination, the effect of increases and decreases in house values upon mobility is apparent in the significance of the results in Table 6. There is no indication that mobility decisions are responsive to loan-to-value ratios or to payment-to-income ratios.

Importantly, in these more complex proportional hazard models, there is still little evidence that mobility is responsive to the contractual terms of the mortgages held by these homeowners. In Model E, for example, the coefficient on the mortgage premium variable is significant only at about the 0.20 level.

Table 7 presents models that relax the assumption of proportionality in the relationship between mortgage terms and household mobility. Allowing for a nonproportional relationship between the valuation of mortgage terms and household mobility significantly increases the statistical power of the models. Moreover, the coefficient on the nonproportionality term is consistently negative and is of the same order of magnitude as the coefficient on the proportionality term. This suggests that, after several years of tenure, the possession of a mortgage on terms more favorable than the current market does cause households to postpone moving decisions.

The models in Table 7 are similar to those reported in Table 6, but with the addition of terms reflecting nonproportionality. The coefficients of the demographic variables are essentially unchanged. However, the coefficients of the variables reflecting mortgage conditions are larger and their t-ratios are higher. When the model is amended to permit a nonproportional response, the estimated effect of mortgage conditions upon mobility is larger, and the response is in the direction predicted by economic theory. The possession of mortgages on favorable terms does affect household mobility decisions, but its effect varies with the length of household tenure in its dwelling.

Implications and Conclusions

The reanalysis of homeowner behavior from the Panel Study of Income Dynamics provides additional evidence on the effects of interest rate changes on the valuation of homeowners' mortgages and the implications of these values for homeowner mobility. The more recent period analyzed, 1991–1992, was one of less volatility than the earlier period analyzed, 1979–1981, and, perhaps because of this, the statistical link is not as strong.

Nevertheless, when the effect of favorable mortgage terms on mobility behavior is allowed to vary with households' length of tenure, the results are quite consistent. After a few years of living at the same address, households become less likely to move as the value of their mortgages becomes larger relative to the cost of a new mortgage at current interest rates.

This result persists when value of the mortgage premium is measured in dollars or as a fraction of the value of the house. This general result is found in simple models (not reported here) that measure only the effects of mortgage terms upon mobility patterns and also in more complex models that measure household demographics as well.

The magnitude of these effects can be simulated using the statistical models reported in the section "New Results from the 1990s." Table 8 reports the

Table 7 ■ Expanded nonproportional hazard models of mobility.

Covariate	Model I	J	K	L
Proportional component				
Mortgage premium ($\times 10^4$)	0.157*			
	(2.07)			
Premium/house value		1.864**		
		(1.78)		
Premium * dummy for positive ($\times 10^4$)			0.077	
			(0.56)	
Premium * dummy for negative ($\times 10^4$)			0.341	
			(1.45)	
(Premium/Value)* (Dummy for positive)				0.700
				(0.36)
(Premium/Value)* (Dummy for negative)				3.096
				(1.43)
Increase in family size (number)	0.678*	0.676*	0.676*	0.676*
	(9.87)	(9.91)	(9.77)	(9.78)
Age of head (years)	−0.015**	−0.015**	−0.015**	−0.015**
	(1.88)	(1.84)	(1.86)	(1.83)
Education of head (years)	0.058**	0.058**	0.060**	0.058**
	(1.81)	(1.82)	(1.82)	(1.81)
Black household (1 = yes)	−0.347	−0.369**	−0.345	−0.358**
	(1.63)	(1.72)	(1.62)	(1.65)
New family head (1 = yes)	1.370*	1.377*	1.360*	1.364*
	(6.73)	(6.79)	(6.73)	(6.68)
House value appreciation ($\times 10^4$)	0.019*	0.021*	0.021*	0.021*
	(1.96)	(2.15)	(2.29)	(2.18)
Loan to value ratio	0.029	0.030	0.052	0.084
	(0.11)	(0.12)	(0.20)	(0.30)
Payment to income ratio	−0.111	−0.197	−0.071	−0.218
	(0.19)	(0.35)	(0.13)	(0.39)
Nonproportional component				
Premium * ln tenure ($\times 10^4$)	−0.067			
	(1.13)			
Premium * dummy for positive * ln tenure ($\times 10^4$)			−0.021	
			(0.21)	
Premium * dummy for negative * ln tenure ($\times 10^4$)			−0.164	
			(1.23)	
(Prem/val) * ln tenure		−0.173**		
		(1.70)		
(Prem/val) * dummy for positive * ln tenure				−0.582
				(0.40)
(Prem/val) * dummy for negative * ln tenure				−1.738**
				(1.68)
Chi-square	296.99	296.99	296.99	296.99

*Significant at the 5% level. **Significant at the 10% level.
Note: Asymptotic t-ratios in parentheses.

Table 8 ■ Effects of mortgage interest rate changes on cumulative homeowner mobility rates (from Model J).

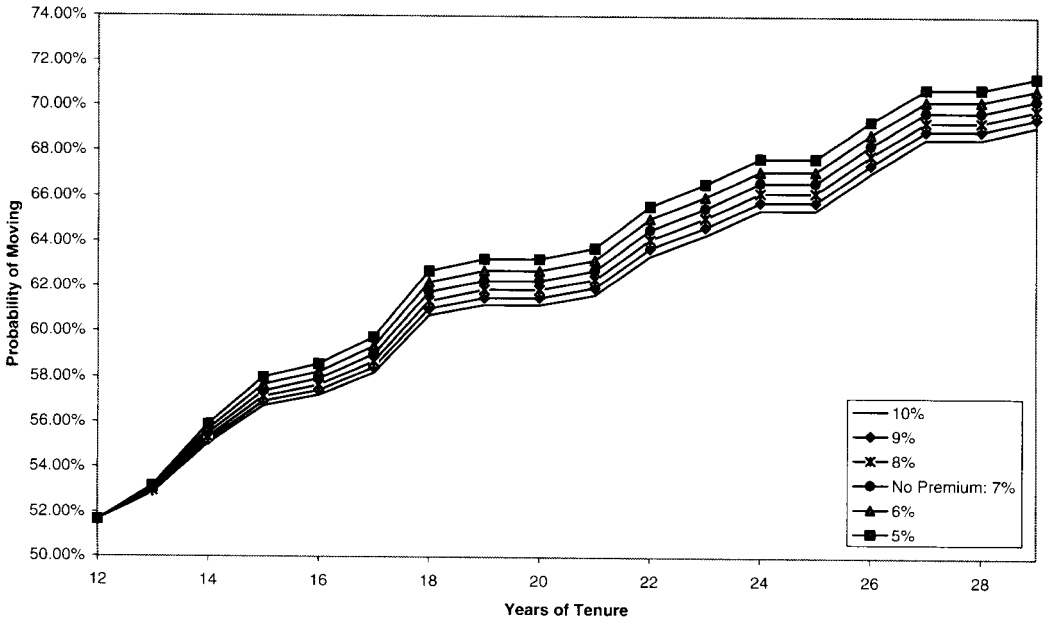
Years of Tenure	Cumulative Mobility Rate (%)						
	Increased Rates			Base Case	Decreased Rates		
	10%	9%	8%	7%	6%	5%	4%
12	51.67	51.67	51.67	51.67	51.67	51.67	51.67
13	52.85	52.90	52.92	53.01	53.09	53.17	53.27
14	55.04	55.17	55.32	55.49	55.68	55.91	56.19
15	56.72	56.91	57.13	57.37	57.66	57.99	58.38
16	57.20	57.41	57.64	57.91	58.22	58.57	58.99
17	58.18	58.42	58.68	58.99	59.34	59.75	60.22
18	60.71	61.01	61.36	61.75	62.19	62.70	63.28
19	61.18	61.50	61.86	62.26	62.72	63.24	63.84
20	61.18	61.50	61.86	62.26	62.72	63.24	63.84
21	61.63	61.95	62.32	62.73	63.20	63.73	64.34
22	63.37	63.72	64.11	64.54	65.04	65.59	66.23
23	64.30	64.66	65.06	65.50	66.00	66.57	67.21
24	65.41	65.77	66.18	66.63	67.13	67.70	68.34
25	65.41	65.77	66.18	66.63	67.13	67.70	68.34
26	67.07	67.43	67.83	68.28	68.77	69.33	69.65
27	68.56	68.92	69.30	69.74	70.22	70.76	71.36
28	68.56	68.92	69.30	69.74	70.22	70.76	71.36
30	69.11	69.46	69.84	70.26	70.73	71.26	71.86

sensitivity of cumulative mobility rates using Model J, the preferred specification. The column marked "base case" reports the cumulative mobility rate estimated from Model J assuming that a household of the sample average demographic characteristics takes out a level-payment 30-year mortgage to finance 80% of the purchase price of the average house, obtaining a 7% mortgage. For years 12 (the mean tenure of homeowners) through 30, the base case reports the cumulative changes in mobility arising from one additional year of age.

The other columns in Table 8 report the cumulative mobility rates, assuming that interest rates change in year 13 and then remain unchanged. The stream of payments remaining for 17 years is valued using the new interest rate. The mortgage premium P_i associated with the new interest rate r for each remaining year of tenure, $i = 13, 14, \ldots, 30$ is calculated as

$$P_i = C_i - \sum_{j=1}^{30} \frac{D}{(1+r)^{i-12}}, \tag{10}$$

Figure 2 ■ Cumulative mobility rate from changes in mortgage interest rates (from Model J).



where C_i is the unpaid mortgage principal remaining at year j, and D is the annual mortgage payment. In Table 8, P is expressed as a fraction of the house value, and the coefficients of Model J are used to estimate mobility rates.

As indicated in Table 8, the differences in mobility rates are small. They are certainly not negligible, however. They suggest that a six-percentage-point swing in interest rates is associated with about a three-percentage-point change in cumulative mobility rates over the remaining life of the mortgage. Figure 2 illustrates these mobility responses graphically.

Overall, the quantitative results confirm previous work suggesting that there are effects of interest rate changes on homeowner mobility in the housing market. Increased interest rates do inhibit the mobility of the holders of residential mortgages. More precisely, the empirical results demonstrate that *reduction* Δ in the premiums associated with the possession of mortgages on favorable terms are associated with *reduction* Δ in the disincentives of households to move. These reductions are larger for households whose tenure has been longer. However, under current conditions, where interest rate changes are moderate and mortgage interest rates are low, these mobility differences are quite modest.

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