

**Market Conditions and Housing Choices:
A Comparison of Homeownership across Three Decades**

by

Thomas P. Boehm*
Finance Department
University of Tennessee
Knoxville, TN 37996-0540
Phone: (865) 974-1723
Email: tboehm@utk.edu

and

Alan M. Schlottmann
Economics Department
University of Nevada – Las Vegas
Las Vegas, NV 89154-6005
Phone: (702) 895-0817
Email: alan.schlottmann@unlv.edu

Prepared for presentation
Lusk Center for Real Estate
University of Southern California
April 17, 2009

Results are preliminary and not for quotation without permission of the author(s)

*The author would like to acknowledge the financial support of the Finance Department of the University of Tennessee through a research grant to support this work and payment for the data used in the analysis.

Market Conditions and Housing Choices: A Comparison of Homeownership across Three Decades

Thomas P. Boehm¹ and Alan M. Schlottmann²

This paper uses information on out-of-pocket housing cost and house price appreciation along with the geo-coded version of the Panel Study of Income Dynamics to consider the differences in the impact of these and other variables on the tenure choices of sample households across three time periods, the 1970s, the 1980s, and the 1990s. Specifically, an extended continuous time probability model is used to examine household's transitions from renting to a first owned home, and subsequent possible transitions either back to rental tenure or to a second owned home during the observation period. Coefficient estimates show that not only do financial variables such as house price appreciation, out-of-pocket housing cost, and family income play an important role in determining all the transitions, but also that their impact on the transition from rental tenure to homeownership has diminished over time. This is consistent with the development of alternative mortgage instruments and the evolution of subprime lending over the periods under study. In addition, the analysis demonstrates the interesting result that the cumulative likelihoods of homeownership derived from the model are consistently lower than the probabilities of an initial transition to homeownership. Finally, the magnitude, and timing of the impact of a government policy to promote homeownership by decreasing mortgage interest cost is shown to differ substantially across the three decades.

Introduction

If one examines the Federal Housing Finance Board's (FHFB) Monthly Interest Rate Survey and the Office of Federal Housing Enterprise Oversight (OFHEO) House Price Index over the 30 year period between 1970 and 2001, it is readily apparent that there have been dramatic changes in interest rates, and house prices appreciation over the years.³ In 1970 the average effective mortgage interest rate reported on all homes was 8.38 percent.⁴ By 2001 interest rates were slightly lower in nominal terms averaging 7.03 percent. In the interim, interest rates rose dramatically. House prices rose almost continuously throughout the entire period, but at different rates. From 1970 on, home mortgage interest rates rose steadily and reached an all time high in 1982 of 15.31 percent. However, even in the face of this dramatic increase in interest rates, prices of single family homes (and real estate in general) continued to rise. In the 1970s, price appreciation averaged approximately 8 percent reaching a peak of

¹ Finance Department, University of Tennessee, Knoxville, TN 37996-0540, Phone: (865) 974-1723, Email: tboehm@utk.edu

² Economics Department, University of Nevada – Las Vegas, Las Vegas, NV 89154-6005, Phone: (702) 895-0817, Email: alan.schlottmann@unlv.edu

³ In 2008 the Federal Housing Finance and Regulatory Reform Act made the FHFB and the OFHEO part of a single new entity, the Federal Housing Finance Agency. In the article, we will refer to them separately using the names they had during the majority of the period of our empirical analysis.

⁴ Note that effective interest rates combine the impact of the upfront fees paid by borrowers with the effect of contract interest rates on mortgage loans.

more than 13 percent in the 1978 and 1979 time periods. During the 1980s and 1990s house price appreciation diminished reaching its lowest level (around 2 percent) in the early 1990s.

Certainly, house prices, mortgage rates, and house price appreciation might be expected to be primary determinants of the timing and likelihood of renters becoming homeowners, of first-time homeowners moving up to other higher valued home(s), and even the possibility of homeowners transitioning back to renting if owning becomes too costly. Given the dramatic fluctuations in these factors in the U.S. economy over the decades of the 1970s 1980s and 1990s, it is surprising to see how little work has been done at the household level to consider how these factors affect family's housing decisions. One of the earlier papers to focus on these issues was Boehm (1984). This analysis used the national sample of the American Housing Survey coupled with housing cost and mortgage terms information to consider the impacts of inflation on residential mobility. In particular, a logit analysis was used to analyze the mobility decisions of families in the mid to late 1970s. The analysis suggests that housing costs and credit terms do play a role in determining the optimal housing consumption of families in the sample and, therefore their mobility.

Nakagami and Pereira (1991) present a theoretical model which considers both consumptive and investment demand for housing by households and focuses on the way in which house price appreciation and mortgage interest rates impact the optimal timing of moves from one unit to the next. As might be expected they demonstrate that rising interest rates inhibit such housing transitions. However, rapid house price appreciation should retard home purchase for renters, but stimulates transitions from one owned unit to the next once households initially become homeowners. Kiel (1994) employing a non-parametric estimating technique and the national sample of the American Housing Survey during the 1978-79 time period finds that older homeowners (over the age of 40) who have not moved for at least 5 years are more likely to move to another unit if their home experiences more than the average increase in prices. Because of the general stagnation of house price appreciation in the early 1990s, Chan (2001) employs a sample of households who originated adjustable rate mortgages with Chemical Bank in New Jersey, New York and Connecticut between November of 1989 and January of 1994. A proportional hazard model is used to determine that declining house values reduce mobility rates by approximately one third during this 4 year period. Quigley (2002) considers the impact of interest rates on mobility, again in the early 1990s. This study employs a cross-section of homeowners from the Panel Study of Income Dynamics during the 1990 – 92, time period. Again, a proportional hazard model is employed to update an earlier analysis, Quigley (1987). In this case, the empirical results suggest that interest rate changes do impact mobility, but when interest rates are low and changes are moderate these effects are quite small.

Finally, in a series of macroeconomic modeling papers Chambers Garriga and Schlagenhauf (2007a, 2007b, and 2008) examine the relationship between mortgages, housing tenure decisions, and the homeownership rate. Their models suggest that different household types prefer different mortgage structures; and that all such mortgage contracts will influence tenure decisions because of differences in their payment and amortization schedules, as well as their downpayment requirements. The authors also demonstrate, through the parameterization of their model, that one of the primary reasons for the rise in homeownership

rates in the United States between 1994 and 2005 was the introduction of new mortgage products.

The empirical studies described above have a number of limitations. First, none of the microeconomic studies considers the impacts of house prices and mortgage interest on first-time homeownership. In addition, the models do not allow for the investigation of a series sequential housing decisions made by a set of households over an extended period of time. That is to say, a family's decisions are not limited to renters moving into a first home, but include other subsequent moves to adjust the household's consumption of housing services and/or investment in housing capital over time. The optimal timing and nature of these housing adjustments will depend upon the way in which house prices, mortgage interest rates, other components of housing cost (e.g., utilities cost, property taxes, the relative cost of rented versus owned units), and household socioeconomic characteristics change over time. The empirical model described in the next section accounts for the effect of changing variables on the full spectrum of household housing adjustments in an inter-temporal context. As such, it goes well beyond the existing literature to allow empirical investigation of the impact of housing costs and house price appreciation on housing choice dynamics. In addition, the analysis considers how these relationships, and those between other variables and housing choice have changed in America over three decades (i.e., the 1970s the 1980s and the 1990s).

This study provides several fundamental insights. First, out-of-pocket housing cost and house price appreciation are found to be particularly important in determining all the transition probabilities; however their impacts are quite different across the different transitions and observation periods. Secondly, two crucial financial variables, the out-of-pocket cost of homeownership and family income, appear to diminish in terms of their impact on all transitions from rental tenure to homeownership from the 1970s through the 1990s. This observation suggests that policy initiatives designed to promote homeownership during these years has had an impact on housing choice. In particular, this type of change is consistent with the development of numerous alternatives to the traditional fixed-payment fully-amortized mortgages beginning in the early 1980s and, subsequently, the evolution of the subprime mortgage market in the 1990s. In addition, when coefficient estimates were used to generate a predicted cumulative probability of being a homeowner at any point in time, this likelihood is much higher in the 1990s than either of the two other decades. However, regardless of the decade, the likelihood of homeownership calculated from this model is systematically lower than the predicted probability of transition from renting to owning a first home, i.e., the likelihood of being a homeowner is not synonymous with the likelihood of a household initially transitioning to homeownership. Finally, the timing of the impact of government policies designed to increase the likelihood of homeownership by lowering mortgage interest rates different across time periods. In particular, we observe the total impact of a policy experiment to lower the effective cost of mortgage lending for the entire decade of the 1990s could be achieved in approximately half the time under the conditions of the 1970s and 1980s.

Model Specification

The empirical estimation employed in this analysis is a significant extension of the model developed in Boehm and Schlottmann (2004). For details of this dynamic probability model, see Appendix A. The empirical model used in this paper facilitates both implementation of the estimation procedure and interpretation of the results. In particular, the likelihoods of four possible housing tenure transitions are considered: (1) renting to first-time homeownership, (2) first-time homeownership to second-time homeownership, (3) first-time homeownership to renting, and (4) renting to second-time homeownership. The four sets of parameter estimates represent the impact of an appropriate set of independent variables on the transition between these tenure states for a given time period. In addition to the typical independent variables, this empirical model allows the estimation of a parameter (γ) that measures the impact of time in a particular state of housing tenure on the likelihood of making a transition out of that state into another. Having estimated the coefficients, the cumulative likelihood of a household making a given transition at a particular point in time can be calculated. Finally, these cumulative probabilities of tenure transition can be combined to produce the likelihood a household (or a group of households) being a homeowner at any point during the observation period. This probability of homeownership accounts for not only the households initial move from renting to owning over the period of study, but also the other three tenure transitions described above.

Turning to the empirical specification, broadly speaking there are three sets of variables that we hypothesize to influence the tenure transitions included in the estimated model: (1) housing cost and house price appreciation variables, (2) household income and wealth variables, and (3) household characteristics that might affect the household's preferences for a particular tenure type. For the purpose of empirical estimation the appreciation in the price of owner-occupied housing and the out-of-pocket cost of owning (in absolute terms or relative to renting) are included separately. A primary reason for keeping the two measures separate is that the former represents an opportunity cost associated with rental tenure and might be expected to influence only the investment demand for owned housing; whereas the latter represents a basic constraint on a household's ability to afford an owned home for consumptive or investment reasons. While house price appreciation is captured by including the OFHEO index in the model, calculation of the housing cost variables requires some explanation. The out-of-pocket cost of homeownership for a given household in a given market area in a given year ($COwn_{hmt}$) and the cost of renting in a given market area in a given year ($CRent_{mt}$) are calculated as follows:

$$COwn_{hmt} = DS_{mt} + Ptax_{mt} + Ins_{mt} + OUCost_{mt} + MCost_{mt} - [mtr_{ht} \times (Interest_{mt} - Ptax_{mt})]$$

$$CRent_{mt} = Rent_{mt} + RUCost_{mt}$$

where:

DS_{mt} = mortgage debt service in a market m in year t

$Ptax_{mt}$ = property taxes for owned homes in a market m in year t

Ins_{mt} = homeowner's insurance in market m in year t

$OUCost_{mt}$ = cost of utilities for owners in market m in year t

$MCost_{mt}$ = maintenance cost in market m in year t

mtr_{ht} = marginal tax rate for household h in year t

$Interest_{mt}$ = interest payment in market m in year t

$Rent_{mt}$ = cost of rent for owners in market m in year t

$RUCost_{mt}$ = cost of utilities for owners in market m in year t

The data and specifications used to capture each of these components of housing cost as well as other independent variables included in the model will be described in the next section.

Data

The Panel Study of Income Dynamics (PSID) collected by the Survey Research Center at the University of Michigan provides the ideal data to address this issue. Initiated in 1968, the PSID began gathering information annually on 5,000 American families regarding their socio-economic circumstances including detailed income and housing profiles. Over time additional families have been added to the sample as individuals leave a household to form new households (e.g., a husband and wife divorce and both new family units are followed, or a child leaves their parent's home to form their own household). In each case the primary households included in the sample will be those whose head is either white or African-American between 16 and 50 years of age in the initial year of each of three periods 1970-1979, 1980-1989, and 1990-2001.⁵ In all cases, the observations will be restricted to those families whose head is an individual who can then be tracked for the entire period from the first year in which they enter the sample. These criteria left us with 2,216 households in the 1970s, 3,087 households in the 1980s, and 2119 households in the 1990s.

To these primary datasets information on house prices, house price appreciation, loan information, property tax rates, and energy costs were added for the markets in which the households were living at a particular point in time. In order to match the most appropriate information from these data sources to the families in the primary sample, the geo-coded version of the PSID was used for this analysis.⁶ Housing cost information was obtained from several data sources. First, loan information was obtained from the FHFB's "Monthly Interest

⁵ Note that in 1997, the PSID changed from sampling every year to every other year. By extracting 1999 and 2001 data we have 10 data points for each observation in the last time period as we did for the first two decades, albeit over a slightly longer time frame.

⁶ Access to this sensitive data must be provided through a formal agreement between the University of Michigan and the institution at which the author is employed. For details of the process involved in obtaining the data contact the Survey Research Center at the University of Michigan.

Rate Survey". This includes the average contract interest rate, the average upfront fee paid at origination of the loan, the average loan to value ratio, and the average loan term. These data are available over time by state and major metro areas.⁷ If a household was not identified as being in one of the major metropolitan areas the state averages for these variables were allocated to them. The OFHEO housing price appreciation index was added for all states and as many metropolitan areas as were available in a given time period. Presently individual indices are calculated for 473 metropolitan areas by OFHEO. Information on median house prices, property tax payments, homeowner's insurance payments, rental payments, and utilities (heating, water, and electricity) payments for renters and owners was taken from the 1980 US Census of Population and Housing Five Percent Sample. This information was available for 273 metropolitan areas as well as all the states. These cost components were adjusted over time using two sources of information. Median house prices extracted from the 1980 Census were adjusted over time using the OFHEO house price appreciation index. Property taxes and insurance were calculated as a constant percentage of house prices in any given year. Median energy costs, for both owners and renters, and the median rental payment were adjusted through time using the Bureau of Labor Statistics (BLS) household rent and energy cost indices that are available over time for several major metropolitan areas and four regions (Northeast South Midwest and West).⁸

As noted in the previous section, a number of different data sources were combined to produce the out-of pocket cost of owning index. Debt service (DS_{mt}) was calculated using the FHFB contract interest rate, origination fees, loan to value ratio, and loan term information to construct an amortization factor⁹. This factor was then multiplied by the loan amount which was obtained by multiplying the FHFB loan-to-value ratio by the median house price in the area as established by the 1980 US Census data and adjusted over time by the OFHEO index of house price appreciation. The 1980 US Census data was used to establish Property taxes ($Ptax_{mt}$) and Insurance (Ins_{mt}) as a percentage of house value. In each year, as the house price index adjusted, these costs were calculated as a constant percentage of the house price index. Similarly, the cost of utilities was obtained from the 1980 US Census and adjusted by Bureau of Labor Statistics information on these cost components. Maintenance cost ($MCost_{mt}$) was estimated as a constant 1.25 percent of the house price in any given year.¹⁰ Because the interest deductibility will diminish each year as the mortgage amortizes, interest ($Interest_{mt}$) represents the average interest deduction over the first 5 years for the mortgage payment (or debt service) estimated above. Finally, using information from the PSID on marital status and

⁷ The major metropolitan areas for which FHFB data is collected are Atlanta, Baltimore, Boston, Chicago, Cleveland, Columbus OH, Dallas/Fort Worth, Denver, Detroit, Greensboro, Honolulu, Houston, Indianapolis, Kansas City, Los Angeles, Louisville, Miami, Milwaukee, Minneapolis/St. Paul, New York, Philadelphia, Phoenix, Pittsburg, Portland OR, Rochester NY, St. Louis, Salt Lake City, San Diego, San Francisco, Seattle, Tampa / St. Petersburg, and Washington DC.

⁸ The reason only the 1980 US Census was used for a base (and not, for example, the 1970 US Census for the 1970s and the 1990 US Census for the 1990s) is that far more metropolitan areas were able to be identified in the 1980 US Census. The consistency in terms of the way in which markets are defined should make the comparison of empirical results across decades for variables that make use of information on house prices, rents, etc. more meaningful.

⁹ For the purpose of this calculation it was assumed that the fees paid upfront for origination were financed as part of the loan.

¹⁰ This percentage has been used as an approximation of annual maintenance expenditure in a number of different studies. For a complete list see Rosen and Rosen (1980).

income for the households in the sample, households were assigned to marginal tax brackets using historical information on tax parameters (i.e., personal exemptions, standard deductions, and tax brackets) compiled by the Tax Policy Center of the Urban Institute and Brookings Institution. Thus, this housing cost measure will differ from one individual to the next within a given market area at a particular point in time to the extent that their marginal tax rates are different. Rental cost is also calculated as the sum of the median rent and cost of utilities paid by renters in a given market at a particular point in time. Once again, the initial value comes from the 1980 US Census and is adjusted over time the Bureau of Labor Statistics household rent and utilities cost indices. This measure of rental cost is used to compute a relative cost of owning to renting.

Regarding consistency in variable measurement over time, in addition to family income and the net wealth information, the PSID also contains a variable that measures whether or not the family had a checking and/or savings account. It is important to note that the information on net wealth and the existence of a checking or savings account is only available during the 1980s and 1990s. Consequently, to allow a consistent comparison across all three decades a version of the model without these two variables was estimated for the latter two periods.¹¹ There is very little change in most coefficient values in the alternative specifications for 1980 and 1990 and the explanatory power of the estimated equations is only slightly lower.¹² For these reasons the results for 1980 and 1990 without the Net Wealth and Checking/Savings variables are not presented in the paper, but are available from the authors upon request.

Empirical analysis

Table 1 contains the transition matrix for each of the three decades. In each case all the transitions included in the empirical estimation are shown (i.e., renting to owning a first home, renting to owning a second home, owning a first home back to renting, and owning a first home to owning a second home). In addition, households who do not make a transition have the same heading on the horizontal and vertical axis. Transition to a first owned home appears to be somewhat more likely in the 1970s (25.27%) and the 1990s (24.96%) as compared to the 1980s (21.28%). Interestingly, transition to a second owned home steadily increases over time. In the 1970s the likelihood of moving to a second owned home during the observation period is 25.28% (6.14% + 19.54%), in the 1980s this probability is 30.45% (7.09% + 23.36%) and in the 1990s 35.29% (8.82% + 26.47%). While we will explore the factors effecting these transitions in the next section, one might speculate that the pattern for first time homebuyers might have more to do with housing costs, house price appreciation, and household income and wealth; whereas, the pattern for transition to a second owned home might have to do with a gradual improvement in the alternatives available to minority

¹¹ Note that for the early years of the PSID authors have used asset income (which is available for all three time periods) as a proxy for wealth. We experimented with this variable, but it did not perform well and those results are not presented in the paper.

¹² In particular, in Table 4 the Pseudo R² for the estimation using the 1980-1989 sample is 0.360, and for the 1990-2001 period, it is 0.332. For the specifications excluding Net Wealth and Savings/Checking the Pseudo R²s are 0.341 and 0.312 respectively.

households and, in the later years, the evolution of alternative methods of financing including the development of subprime lending market and the movement toward automated underwriting.¹³

Table 2a presents the variable names for all the independent variables included in the estimation of the model of housing transitions. Table 2b presents the names and definitions of the various components used in the calculation of the cost of owned and rented housing units in a particular location at a particular point in time. Similarly, Table 3a provides means for all the independent variables included in the housing transition model for the first and the last year of each of the three observation periods. Table 3b provides information on select variables: family income, family net wealth, housing costs, and house price appreciation for each year for all three estimation periods. In addition, it shows the ways in which the various components used to calculate the cost of owning and renting vary by year throughout these time intervals.

Considering Table 3a first, the observed trends are what one might expect, average family income, family net wealth, the cost of owning, the level of household education and rooms per person appear to increase steadily over time. We observe married couples increasing during each time period while single female headed households diminish. Finally, house price appreciation fluctuated dramatically over these three time periods. How dramatically becomes more evident when we consider table 3b in which all years are shown for select variables. In column 5, one can see that house price appreciation reaches a high of 13.7 % in 1979 and a low of -1.75% in 1973. It is also clear that in the latter half of the 1970s house price appreciation was substantially higher than in any of the subsequent periods. Out-of-pocket housing costs trend continuously upward. This is due, in large part, to the generally continuous increase in house prices. Interestingly, the cost of owning relative to renting reaches a peak in the early 1980s and then diminishes. This pattern would appear be driven by the effective cost of mortgage lending which peaks in the early 1980s with the contract interest rate reaching a high of 14.59% and the origination fees peaking at 2.58% in 1982. As we will see in the next section, the out-of-pocket housing cost and price appreciation variables play an important role in determining the timing and likelihood of the various housing tenure transitions in the model.

Housing Hierarchy Transitions

Table 4 contains coefficient estimates for the four transitions for all 3 estimation periods. Considering first the initial transition by renters to owning for the first time, the majority of the variables in the model behave as expected and are significant. Family Income increases the likelihood of transitioning to homeownership for the first time as do Net Wealth and Saving/Checking in the second two periods. It is interesting to note that the impact of income drops dramatically over time. Specifically, the coefficient on family income in 1970 is 0.101, in 1980 it drops to 0.042 and in 1990 it drops to 0.0271 with the negatively signed squared terms adjusting proportionately to these primary effects. At first glance, one might say the dramatic drop off from the 1970s is a result of a positive correlation with wealth

¹³ The subprime market began to evolve in the mid 1990's, and Fannie Mae's Desktop underwriter was first used in 1995.

and the lack of a wealth term included in the 1970s equation; however, this is not the case. The 1970 coefficient for the same specification but excluding the wealth term is almost identical to the coefficient presented in Table 4 with a value of 0.108 and a comparable squared term. Such a result is consistent with various policies to promote homeownership in the 1980s and beyond; particularly policies designed to increase homeownership options for minorities, the development of alternative financing options, and the evolution of the subprime market.¹⁴

Single males and females, and older individuals are significantly less likely to transition to a first home. Household size, included to capture budget constraints associated with a larger family, only appears to have an impact during the 1990s. Similarly, the only period for which whites were more likely to be able to make this transition was during the 1980s. Interestingly, of the three periods, this was the decade that experienced slower economic growth throughout. Differences in the timing and likelihood of first-time homeownership not captured by other variables included in the model can be observed in the effect of time-in-state (γ) in the model. The likelihood of transition clearly increases significantly as time passes in all three periods, but the magnitude of the impact is quite different from one period to the next. This coefficient for the 1970s (0.623) is substantially larger than the size of γ in the 1980s (0.359) with the 1990s in between (0.474). This is consistent with the 1970s being an era in which the preference for homeownership increased substantially throughout the decade (particularly the investment demand) as compared to the other periods under consideration.

Turning to the out-of-pocket housing cost and house price appreciation variables, in general these factors appear to play an important role in determining the likelihood of making the transition from initially being a renter to becoming a homeowner for the first time. However, due to collinearity between Cost of Owning, Relative Cost of Own/Rent, and House Price Appreciation, all three variables cannot be included in a given specification. In any given period, the specification presented represents the best fit for that particular time interval, but with an eye toward allowing as many direct comparisons as possible. As one might expect, because of the dramatic inflation in house values in the late 1970s, House Price Appreciation is particularly important during this decade, while this variable still was significant in the 1980s the impact was not nearly as strong (0.072 versus 0.029) with no independent discernable impact in the 1990s. In the case of housing costs, higher costs of homeownership have the anticipated negative impact on the likelihood of this transition. Again, the strength of that impact appears to diminish as we move from the 1970s to the 1990s (-0.011 in the '70s, -0.003 in the '80s, and -0.001 in the '90s). Once again, such results certainly are consistent with the rise in various types of alternative financing options in the 1980s and, subsequently, the development of the subprime market during the 1990s.

Having achieved homeownership for the first time during the observation period, there are two potential tenure transitions that any household could make, moving to another owned home or alternatively back to rental tenure. Considering first the transition to a second owned

¹⁴ In his analysis of the subprime mortgage crisis, Brownell (2008) points out that outstanding subprime mortgage debt increased from \$33 billion in 1993 to \$332 billion in 2003.

home, there are some interesting differences across the three time periods. As might be expected a high Cost of Owning has a significant impact on this transition across the three decades, but the magnitude of that impact is much smaller in the 1980s and 1990s (-0.0055 in 1970s versus -0.0007 in 1980s and -0.0005 in 1990s). Again, because the mortgage debt service component of Cost of Owning is calculated as a fixed-payment fully-amortized loan, this result is consistent with the evolution of a variety of alternative mortgage instruments beginning in the 1980s and continuing to the present along with the evolution of the subprime market in the 1990s.

Household Size and Rooms per Person were included in the analysis to capture a potential adjustment constraint and the impact of crowding on the transition to a second owned home from a first. One might expect the impact of household size to be negative because the more people in the household, the higher the costs of moving for the family and larger the amount of family income that must be used for concerns other than housing. The higher the number of rooms per person, the less crowded the dwelling unit is, and the less the likelihood that a move to a larger unit would be necessary for this reason. While these two coefficients are negative in all years, the coefficients are significant and substantially larger in the 1980s and 1990s. For Household Size the coefficient estimates are -0.021 in 1970 compared with coefficient estimates of -0.242 and -0.199 in the '80s and '90s respectively. Similarly the coefficient estimates for Rooms per Person are -0.033, -0.144, and -0.166 for the 1970s, '80s, and '90s respectively. These findings are consistent with the 1970s being an era in which the investment demand for housing was a relatively more important reason for a household to move up to a higher valued house as compared to the latter two decades in which consumptive demand for housing services is in all likelihood the primary driver of such an adjustment. Another variable whose coefficient estimates are consistent with the above observations is the categorical variable Single Male. The impact of the variable Single Male is positive in all decades, but only in the 1970s are they significantly more likely to move to another home from their first.

In contrast to the variables discussed above that suggest movement from one owned home to the next is different for the 1970s as compared to the 1980s and 1990s, the coefficient on time-in-state (γ) and race (White) demonstrate that, in some ways, the transition from a first owned home to a second in 1980s appears quite different from the 1970s and the 1990s. In particular, while these variables are significant and have a positive sign across the board, the impact of time-in-state on the likelihood of any household moving from one home to the next is twice as large in the 1970s and 1990s as it is in the 1980s (0.322 in the 1970s and 0.309 in the 1990s as compared to 0.151 in the 1980s). A similar comparison is evident for whites as compared to African-Americans (0.402 in 1970 and 0.458 in 1990 versus 0.251 in 1980). Thus, in general households are less willing and/or able to move up to a second owned home from a first in the 1980s and this behavior is more pronounced among African-American households. Finally, across all three time periods, older households are significantly less likely to move to a new owned home. This result is consistent with older households having substantially higher adjustment costs than their younger counterparts.

For a first-time owner, the other possible transition is back to rental tenure. Certainly, this type of transition could be the result of a divorce or the death of a spouse. Consistent

with this type of traumatic family experience are the significant positive signs across all three time periods for the variables Single Male and Single Female. Also, as might be expected, the variables Family Income, Net Wealth and Savings/Checking are significant and reduce the likelihood of undergoing such a transition. Certainly, those families with low income, low (or negative) net wealth, and/or without a savings or checking account, would be more likely to be in a financial situation that would require them to liquidate an owned home. Once again, the magnitude of the coefficient for income is much higher in the 1970s than the 1980s or 1990s. These coefficients are -0.049 -0.012 and -0.014 respectively. As was the case with the transition to a first home from renting, the magnitude of the 1970 coefficient is virtually unchanged when net wealth is excluded from the specification. Thus, we observe substantial symmetry in the way in which the impact family income on the transition out of and back into rental tenure diminishes after the 1970s. Turning to the appreciation of house prices and out-of-pocket housing cost, House Price Appreciation has a significant negative impact on the transition out of homeownership in the 1970's and 1990's, but this variable has no significant effect in the 1980s. During the 1970's high owned housing costs do not influence this choice whereas in the 1980s and 1990s they appear to do so. As noted previously, the 1970 was the period with the highest average appreciation rate for housing and the lowest relative out-of-pocket cost of any of the three time periods. This characterization of the differences in these periods is consistent with the observed empirical results. Finally, unlike the other tenure transitions modeled, time-in-state (γ) is only marginally significant in any year and the coefficient estimates are quite small. This result is consistent with a housing transition that is likely to be caused by an idiosyncratic family problem, rather than by a family's continuing effort to achieve a particular transition over time.

For households that return to rental tenure, a final transition that was modeled is the possible move back to ownership again. As might be expected, the likelihood of this transition is significantly and positively related to income in all three time periods. However, there are a number of coefficients that change substantially across these periods of observation. The coefficients on time-in-state (γ) are remarkably consistent in terms of their magnitude and statistical significance during the 1970s and 1980s (-0.294 and -0.313 respectively). In these two cases the longer the time spent in rental tenure, the less likely that a household will again achieve homeownership. In contrast, during the 1990s this variable becomes insignificant and the magnitude of the coefficient drops dramatically (-0.086). Similarly, the relative costs of renting to owning appear consistently important in influencing this transition in the first two periods, but this effect also diminishes substantially in the 1990s. In the 1970s and '80s the coefficient estimates are -1.12 and -1.45 respectively; whereas in the 1990s the impact of this variable diminishes to -0.965. Also, the coefficient on Family Income is approximately 10 times smaller in the in the 1990s than in the 1970 or 1980s (0.029, 0.042, and 0.005 respectively). These results are consistent with those observed previously for households' initial transition from renting to homeownership. Together they suggest that in the 1990s both transitions to homeownership from rental tenure have gotten easier from a financial perspective. As noted previously, such results are consistent with a housing market in which homeownership options are expanding through the development of various alternative mortgage options to the conventional fixed-payment fully-amortized loan and the expansion of subprime lending.

Alternatively, there are a number of variables that suggest avenues through which the 70s and 90s appear very different than the 1980s. In particular, house price appreciation has an independent influence on the likelihood of transition only in the 1970's and 1990s, albeit the effect is much larger in the latter period (0.032 versus 0.116). Although opposite in sign this pattern of significance for House Price Appreciation is comparable to the pattern observed for the transition from first-time homeownership to renting. In the case of Rooms per Person, it is not clear why the variable has the sign and significance it does; however it is significant with a comparable magnitude and sign in the 1970s and 1990s. Finally, single females and African-American households do appear much less likely to make the transition back to homeownership in the 1970s and 1990s than the 1980s, although these effects appear muted in the 1990s. Thus, we see a number of factors that would contribute to the transition from rental tenure to a second owned home being much different during the 1980s.

Given, the differences that we have observed in the behavior of many of the factors included in the model, it is clear that one might expect different outcomes for households considering the same housing transitions across these three different time periods. What is unclear is exactly how these differences (in the way in which variables in the model affect the probability of various tenure transitions) translate into the likelihood that a particular household type will be a homeowner at a particular point in time. In addition, it is unclear how a specific government policy strategy might impact the cumulative probability of being a homeowner across different time periods. These questions are addressed in the next sections of the paper.¹⁵

Cumulative Ownership Probabilities

In the literature, the traditional estimation approach to the likelihood of homeownership generally involves a logit (or probit) specification with the likelihood of “owning-renting” subsequently evaluated at the mean values of the sample.¹⁶ This likelihood is an average value over the sample period. Our model specification provides the opportunity to calculate a “cumulative probability” that varies over time and across different household types. Specifically, the cumulative probability of owning a home during any of the time periods in question can be calculated using the probabilities of transition between housing tenure states as follows.¹⁷

Utilize the following numerical scheme for subscripts i and j below, $0 = \text{rent}$, $1 = 1^{\text{st}}$ home owned, and $2 = 2^{\text{nd}}$ home owned, for transitions: 0 to 1 , and 0 to 2 the cumulative probability of making the transition is:

¹⁵ One other issue associated with the estimation of such a model is right side truncation. That is to say, these households do have a housing tenure history prior to the period of observation for our analysis. Experiments were conducted in which variables that measured prior tenure experience (length of time in tenure status in which we first observed them, whether renters at the start of the observation period had ever been owners, etc.) were included. Generally, these variables were insignificant and, therefore, not included in the specifications of the model presented in this paper.

¹⁶ See the references in Boehm and Schlottmann (2004).

¹⁷ Equations 1 and 2 below represent the computational specifics of the general form of the cumulative probability presented in equation (2a) in the appendix to the paper.

$$CP_{ijt} = \sum_{t=1}^m \left\{ (1 - e^{-\delta_t}) - (1 - e^{-\delta_{t-1}}) \right\} \quad (1)$$

For transitions: (1 to 2, and 1 to 0) cumulative probability of making the transition is:

$$CP_{ijt} = \sum_{t=1}^m \left\{ \left[\frac{e^{\beta_{ij}X_t}}{e^{\beta_{ij}X_t} + e^{\beta_{ik}X_t}} \right] \cdot [(1 - e^{-\delta_t}) - (1 - e^{-\delta_{t-1}})] \right\} \quad (2)$$

where:

$$\delta_t = e^{\beta_{ij}X_t} \cdot H(\alpha_t) + e^{\beta_{ik}X_t} \cdot H(\alpha_t)$$

$$\delta_{t-1} = e^{\beta_{ij}X_{t-1}} \cdot H(\alpha_{t-1}) + e^{\beta_{ik}X_{t-1}} \cdot H(\alpha_{t-1})$$

$$H(\alpha_t) = \alpha_t^{(\gamma_{ij} + 1)} / (\gamma_{ij} + 1)$$

CP_{ijt} = the cumulative probability of making the transition from housing tenure i to housing tenure j by the end of period t.

$\beta_{ij}X_t$ = vector of coefficients estimated for the transition from housing tenure i to housing tenure j multiplied by the corresponding variable values from period t.

γ_{ij} = the coefficient for duration dependence estimated for the transition from housing tenure i to housing tenure j

$$\alpha_{t-1} = \left[-\ln \{1 - CP_{ijt-1}\} \right] / e^{\beta_{ij}X_t}$$

$$\alpha_t = \alpha_{t-1} + 1/m$$

The difference in the way the two cumulative probabilities are calculated in equations (1) and (2) is derived from the fact that for the first set of housing tenure transitions it is possible to exit into only one alternative state of existence; whereas in the second set it is possible to exit into one of two possible alternative states. The extra term represents the likelihood of exiting into one possible tenure state versus another.

Once determined, the cumulative probabilities of transition from one housing tenure category to another are used to calculate the cumulative probability of households in the sample being in a particular tenure state at a particular point in time. Note that the sample used to estimate the model contains both renters and owners in the initial period of observation. Consequently, in addition to the likelihood of transitions estimated using CTM, a logit model can be estimated for the first period to predict the probability that households initially start out as owners, $P(O)$, or alternatively that they are renters, $P(R) = 1 - P(O)$.

However, if these cumulative probabilities are estimated for a subgroup of families who are all initially owners or renters at the start of the observation period it is not necessary to estimate $P(O)$ because in the former case $P(O) = 1$ and $P(R) = 0$; while in the latter $P(O) = 0$ and $P(R) = 1$.

In this context if, as previously, 0 = rent, 1 = the 1st home owned during the observation period, and 2 = 2nd home owned, then:

$$CP_{1t} = P(O) - [P(O) \cdot CP_{10t}] - [P(O) \cdot CP_{12t}] + [P(R) \cdot CP_{01t}] \quad (3)$$

Thus, the cumulative probability of owning your first home at time t of the observation period (CP_{1t}) is determined by calculating the likelihood that a give household was initially an owner and adjusting this probability by subtracting the likelihood that it left its first owned home either to rent or to own its second home during the period, and adding the probability that it rented, and subsequently made the transition to first-time homeownership. Similarly, let CP_{2t} represent the cumulative probability of achieving a second owned home. These cumulative probabilities will take a different form depending upon the time period and the possible transitions that could have occurred. Specifically, in the first period the only way to transition to a second owned home is possible is if you were initially an owner and moved to another owned home during the period. In the second period, households could transition directly to a second owned home from a first having either initially been an owner, having achieved ownership of a first home during the observation interval, or households who are initially renters could transition to a first and, subsequently a second owned home. Thereafter, we add the possible transition path in which a household who initially rents transitions to a first owned home and then back to rental tenure followed by a move back to ownership of a second owned home.

For, $t = 1$:

$$CP_{2t} = P(O) \cdot CP_{12t}$$

For, $t = 2$:

$$CP_{2t} = [P(O) \cdot CP_{12t}] + [P(O) \cdot CP_{10t} \cdot CP_{02t}] + [P(R) \cdot CP_{01t} \cdot CP_{12t}]$$

For, $t \geq 3$:

$$CP_{2t} = [P(O) \cdot CP_{12t}] + [P(O) \cdot CP_{10t} \cdot CP_{02t}] + [P(R) \cdot CP_{01t} \cdot CP_{12t}] + [P(R) \cdot CP_{01t} \cdot CP_{10t} \cdot CP_{02t}]$$

Finally, the cumulative probability of owning a home at a given time t , $CP(\text{Own})_t$, is the sum of the probabilities that a household would own a 1st and 2nd owned unit.

$$CP(\text{Own})_t = CP_{1t} + CP_{2t} \quad (4)$$

Table 5a and 5b contain the means and Table 6 contains the cumulative likelihood of homeownership ($CP(Own)_t$) for a subgroup of homeowners of particular policy interest, those families who initially were renters attempting to achieve homeownership for the first time.¹⁸ These probabilities were obtained by multiplying the coefficients estimated for each observation period (Tables 4) by the annual means for the variables included in the estimated equations (see Tables 5a and 5b for the means for those households who initially rent). Some obvious differences are readily apparent. To begin with, the cumulative likelihood of becoming a homeowner is much higher for the 1990s (44.94%) than for either of the preceding decades (29.72% for the 1970s and 24.67% for the 1980s). Interestingly, although the cumulative likelihood of being an owner is not that different by the end of the 1970s and 80s, midway through each decade $CP(Own)_t$ is approximately 77% higher in the 1970s ($[19.01 - 10.72] / 10.72$) than the 1980s. That is to say the time paths associated with achieving a given probability of ownership across the two decades is different.

While it would be very difficult to identify every factor that contributes to this difference, it would seem clear that this disparity in the time path to homeownership can in large part be attributed to the unprecedented heights reached by effective interest cost in the early 1980s, with a high of 14.64 % for contract interest rates and 2.58% for loan origination fees both being achieved in 1982. The rate of change in the cumulative probability of being a homeowner is, in part, a reflection of comparable patterns in the initial transition from renting to a first home. However, the cumulative probabilities of ownership are also a function of quite a different pattern that emerges over time for the possible transition from ownership back to rental tenure and the possibility of a subsequent transition back to ownership again. In the third and fourth columns of Table 6, we can observe the overall likelihood and (to a somewhat lesser degree) the timing of these probabilities of transition in the 1970s and 1980s are remarkably similar. By 1979 the cumulative probability of making the transition from a first home to rental tenure is 16.31% while the likelihood of transitioning to a second owned home from renting to a second owned home is 10.12%. In the 1980s these probabilities are 17.50% and 10.79% respectively. However, in the 1990s these probabilities are substantially different; by the end of the period the likelihood of transitioning back to rental tenure is only 10.10% while for those that do return to rental tenure the likelihood of again achieving homeownership is 19.51%. Such differences in these probabilities of transition contribute to the higher overall likelihood of homeownership in the 1990s.

Also worth noting for the 1990s is that the likelihood of returning to rental tenure having been an owner actually reaches a peak in 1996 and then diminishes for the remainder of the observation period. This is of course possible if, over time, those forces that would encourage such a transition are overcome by those that would tend to reduce the likelihood of such an adjustment. In this case, increases in Family Income, Net Wealth and House Price Appreciation dominate the positive impact of time-in-state (γ) to produce this result. Time-in-state (γ) is of particular import to explaining the differences in these two transition probabilities for the 1990s. For both transitions γ is much smaller in the 1990s than in the other two decades. This result for the 1990s is consistent with a market in which reaching ownership status and, subsequently, maintaining it is easier than in other periods. As we have noted, in the 1990s policy emphasis continued to be directed at promoting homeownership in

¹⁸ Note that by definition $P(O) = 0$ and $P(R) = 1$ for the computation of these cumulative probabilities.

a variety of ways. Thus during the 1990s, holding other factors constant, it would seem less likely that a household would transition back to rental tenure, and more likely that if they did they could once again achieve homeownership.

Finally, regarding the transition to a second owned home from a first, the 1970s is a period in which the likelihood of this transition is much lower than in either of the other periods. The cumulative probability of making this transition in the 1970s is only 12.92%. In comparison, by the 1990s this probability has increased to 25.05%. In part, this difference is due to the fact that higher family income has a significant positive coefficient in the 1990s, whereas it was insignificant in the 1970s. Also, the cost of owned housing has a much smaller impact during the 1990s. Indeed, if one compares the Cost of Owning to Family Income across the three periods, the 1990s are by far the lowest with an average over the period of 24.4% for households that initially are renters as compared to 27.85% for the 1970s and 36.98% for the 1980s.¹⁹

Finally, it is worthwhile to note that if only the initial transition to homeownership were considered, and the assumption made that this probability of this transition is synonymous with the probability of being in a homeowner at a particular point in time; the latter probability would be systematically over stated. The likelihood of an initial transition to homeownership is about 17% higher than the probability of being an owner by the end of the 1970s and 1980s ($[34.82\% - 29.72\%]/29.72\%$ and $[29.23\% - 24.67\%]/24.67\%$ respectively). For the 1990s this difference is about 9% ($[48.92 - 44.94\%]/44.94\%$). Thus, to understand the impact various policy measures on the likelihood of homeownership over a period of time, one must consider more than just a household's initial transition to an owned home. That said, the question still remains as to the extent to which the impact of government housing policy initiatives might be expected to differ across different time periods with quite different housing market conditions. In the next section, this issue is explored.

Effective Interest Cost and Housing Choice: A Policy Experiment

We have demonstrated that out-of-pocket housing cost plays a significant role in most of the housing transitions modeled above across all three time periods examined. The primary determinant of the cost of owned housing is debt service. The contract interest rates and upfront fees that determine the effective cost of mortgage debt are not only critical determinants of debt service, but also potentially the focus of government policy initiatives. Indeed in the wake of the recent housing market collapse and subprime lending debacle, some policymakers have proposed new low interest loan programs to stimulate housing market activity.²⁰ In addition, contract interest rates have fluctuated substantially during the three

¹⁹ These ratios were obtained using the family income and cost of owned housing information presented in Table 5b.

²⁰ The U.S. Treasury Department is currently considering a plan to revive the housing market and mortgage lending by reducing mortgage interest rates to 4.5%. For more about the proposal and its advantages and disadvantages, you can find a very informative interview with one of the plan's proponents Christopher J. Mayer, a senior vice dean of the Columbia Business School on the National Public Radio website at <http://www.npr.org/templates/story/story.php?storyId=97826104>

periods under consideration in this analysis. For these reasons, contract interest rates and up-front loan fees are the subject of the policy experiment considered below.

Our policy experiment is to reduce contract interest rates and up-front fees by 20 % from their actual levels in any given year across the three decades. The cumulative probabilities presented in Table 7 represent the same probabilities of tenure transition and homeownership as Table 6, albeit after the policy change. The differences, as compared to the comparable probabilities in Table 6, are expressed in terms of absolute percentage points and as a percent of Table 6 values. Considering the individual tenure transitions presented in Table 7, the greatest affects of this interest rate experiment are found during the 1980s, the decade in which interest rates and origination fees were at their highest. The impact is more pronounced across all the transitions except the transition from a first owned home to a second owned home. In this case the impacts are greater for the 1970s. The largest impact differential appears in the transition from renting to owning a second home. Depending upon the amount of time that has passed, the probabilities in Table 7 are approximately 21 to 31% higher because of these changes in the effective interest cost. In percentage terms, these changes are 2 to 3 times the policy impact in the 1970s and the 1990s.

Turning to the likelihood of being a homeowner (the P(Own) columns in Table 7), the most obvious result of the experiment is that this policy measure has much less of an impact in the 1990s than in the other two decades. This observation is consistent with the lower cost of housing relative to income during this decade, as well as the ever increasing variety of mortgage products available during this time period. The most dramatic effect on the overall probability of homeownership occurs in the 1970s. In Table 6, the likelihood of homeownership achieved by the end of the 1970s is 29.72 %. When a 20% reduction in the contract interest rate and the origination fees are introduced, this probability of ownership increases to 35.49 % (Table 7). In addition to the magnitude of this policy differing across the decades, the timing of the impact is quite different as well. Specifically, in the 10 year period between 1990 and 1999 this policy initiative would have increased the likelihood of homeownership by only 2.39%. In contrast, in the 1980s this same impact would have been achieved in approximately 5.33 years and in 1970 approximately 4.22 years.²¹ Thus, the estimated model and the inter-temporal probabilities of housing transition that were calculated can give us greater insight as to the economic conditions under which our policy actions will have the most impact the most quickly. Static probability models and those that do not model all possible housing tenure transitions will not provide comparable insights with regard to policy effects.

²¹ In Table 7, 1984 the change in the cumulative probability of being an owner was 2.232 percentage points. In 1985 it was 2.717. Therefore, since 1984 is the 5th year of observation $5 + [(2.385 - 2.232) / (2.717 - 2.232)] = 5.33$ years. Similarly, 1973 is the 4th year of observation and $4 + [(2.385 - 2.401) / (3.175 - 2.401)] = 4.22$ years.

Conclusion

In this analysis, housing price and cost information from the 1980 US Census 5 Percent sample, information of mortgage terms from the FHFB Interest Rates and Terms Series, the OFHEO House Price Appreciation Index, the BLS Housing Rent and Utilities Cost Indices, and marginal tax rate information from the Tax Policy Center of the Urban Institute and Brookings were all matched with household's from the geo-coded version of the PSID to capture as accurately as possible the out-of-pocket housing costs and house price appreciation (an opportunity cost) faced by households in the primary data base as they made decisions on housing tenure transitions across the 1970s, 1980s and 1990s. This is the first time out-of-pocket housing costs and house price appreciation have been measured with this degree of intertemporal and geographic accuracy across these different time periods and in the context of a continuous time model in which the set of possible tenure transitions include not only the household's initial tenure transition, but also the transitions out of a first home back to rental tenure or, alternatively, to a second home either from rental tenure or directly from a first home owned.

In general, the coefficient estimates are substantially different across the decades. This result was anticipated since the later half of the 1970s was characterized by unprecedented house price appreciation, the first half of the 1980s was characterized by unprecedented effective interest cost of mortgage lending, and the 1990s was characterized by increases in the alternative mortgage instruments including subprime alternatives. More specifically there appears to be a substantial reduction in the impact of several very important variables over time. For all these tenure transitions the cost of owned housing (either in absolute terms or relative to the cost of renting) and/or house price appreciation are statistically significant and have the expected sign. However, it is particularly interesting to note that when it comes to achieving homeownership from renting (either initially or a second time) the impact of the out-of-pocket cost of owned housing (either in absolute terms or relative to the cost of renting) diminishes over time with the largest impact being in the 1970s and the smallest being in the 1990s. Similarly, the impact of family income on achieving and maintaining homeownership was much stronger in the 1970s than in the 1980s or the 1990s. This change in the impact of critical financial variables on the likelihood of achieving homeownership is consistent with policy changes which began in the 1980s with the advent of a variety of alternative mortgage instruments and continued in the 1990s with further growth in alternative mortgage products and the development of the subprime mortgage lending sector. However, it is also the case that the 1980s represent a period that in a number of ways appears different from the other two. For example, when considering the transition from rental tenure to a second owned home, single women and African-Americans appear substantially less likely to make this transition in the 1970s and 1990s than in the 1980s as compared to couples and whites. In any event, the dynamics of housing tenure choice appear quite different across the three periods.

When the model coefficients for each time period are combined with mean values for all households who were renters at the start of the period to produce cumulative probabilities of each of the possible tenure transitions, we see some interesting differences. In particular, the transition to a first owned home is much more likely in the 1990s and (to a lesser extent)

the 1970s than in the 1980s. However, for both the 1970s and the 1980s it appears substantially more likely that first-time homeowners will return to rental tenure, and be less likely to return to homeownership again. Finally, there appears to be a steady growth from the 1970s through then 1990s in the likelihood that households will make the transition directly from a first owned home to a second. By combining the cumulative probabilities of these transitions into the cumulative probability of being a homeowner, it becomes very clear that the predicted likelihood of being a homeowner over the period is substantially higher in the 1990s than the other two decades. Also, although the probability of being an owner is not that different by the end of the 1970s and 1980s, the time path of the likelihood of this probability is quite different for the two periods. In particular, halfway through the period the probability of being a homeowner is almost twice as large in the 1970s as the 1980 (19.01% and 10.72% respectively). It is also apparent that any model that considers the likelihood of transition to a first owned home to be synonymous with the likelihood of homeownership systematically overstates this probability. By the end of the decade of the 1970s and 1980s the likelihood of an initial transition to homeownership is approximately 17 % higher than the probability that a household will be a homeowner. For the 1990s this difference is about 9%.

To explore the potential differences in the impact of government policy action across the time periods, we considered changes in the effective cost of mortgage lending for a number of reasons. Interest rates are a traditional policy focus of government economic policy, they vary substantially across and within the three periods of observation, and they are one of the primary determinants of our out-of-pocket housing cost measure. Specifically, for the households who were initially renters, we considered how the cumulative probabilities of the various tenure transitions and, thereby, homeownership would change if policies were adopted that reduced contract interest rates and up-front fees 20% below their actual values in any given year. The effects of such a policy were greatest during the 1980s for the three transitions between renting and owning. This seems reasonable given that both contract interest rates and up-front fees are highest during the 1980s, and particularly so during the first half of this period. Interestingly, this is not the case for the transition from a first to second owned home in which case both the absolute changes and percentage changes are greatest in the 1970s. When the probabilities of these tenure transitions are combined to produce the impact of this reduction in the effective cost of mortgage debt on the likelihood of being a homeowner at a given point in time, we clearly see the absolute and percentage changes in the probability of being a homeowner during the period as being much higher in the 1970s and 1980s than the 1990s. One advantage of such modeling for policy analysis is that policymakers can observe not only the differential magnitude of the impact of their policy measures across different time periods, but also they can see how quickly their policy actions would take effect. In the 10 year period between 1990 and 1999 this policy initiative would have increased the likelihood of homeownership by a total of 2.39%. In contrast, in the 1980 this same impact would have been achieved in approximately 5.33 years and in 1970 approximately 4.25 years. Consideration of the dynamic difference in the speed with which any policy action could be expected to gain traction under different economic circumstances is simply not possible with any static probability model of homeownership.

Finally, as data becomes available, a particularly interesting application of this model could be in the examination of the next decade (2000 – 2010) and households' likelihood of being

homeowners in the wake of the subprime mortgage market crisis. In particular, using the PSID's information on reasons for household moves, as well as information on family income, mortgage payments, house value, and mortgage principal balance, it might be possible to modify the model presented in this paper by separating homeowners who transition back to rental status into two categories: those who make this transition because of mortgage default (or the risk of impending default), and those who make the transition for other reasons. One could then consider how different the possibility of transition back to an owned home would be for these two different groups. In any event, it is only through the consideration of all the relevant tenure transitions in the context of a dynamic probability model that we can get a clear picture of how changing economic factors like out-of-pocket housing cost, house price appreciation, income, etc. affect the timing and likelihood of possible tenure transitions and, ultimately, the likelihood homeownership. Regardless of the time period in question, this type of probability model is the best way to assess the impact of any policy designed to affect families' housing choices and, thereby, the US economy.

Table 1
Homeownership Transition Matrices^a

1970 - 1979			
Transition from/to	Renting	First Owned	Second Owned
Renting	664	560	136
Percent of Sample Size	29.96%	25.27%	6.14%
Mean Duration^b	7.77	3.60	2.04
First Owned	247	939	433
Percent of Sample Size	11.15%	42.37%	19.54%
Mean Duration^b	3.18	8.32	3.53
Total Number of Households	2,216		
1980 - 1989			
Transition from/to^b	Renting	First Owned	Second Owned
Renting	968	657	219
Percent of Sample Size	31.36%	21.28%	7.09%
Mean Duration^b	7.29	4.01	2.14
First Owned	359	1,118	721
Percent of Sample Size	11.63%	36.22%	23.36%
Mean Duration^b	1.98	5.53	2.29
Total Number of Households	3,087		
1990-2001			
Transition from/to^b	Renting	First Owned	Second Owned
Renting	414	529	187
Percent of Sample Size	19.54%	24.96%	8.82%
Mean Duration^b	6.22	4.04	2.31
First Owned	267	936	561
Percent of Sample Size	12.60%	44.17%	26.47%
Mean Duration^b	3.05	8.15	4.34
Total Number of Households	2,119		

^a As described in the text, the transitions come from the Michigan Panel Study of Income Dynamics over the time period indicated

^b measured in years

Table 2a
Variable Names and Definitions

Variable Name	Variable Definition
Age	Age of the household head (averaged with that of the wife if applicable) at the beginning of the observation period
Household Size	Number of persons in the household
Persons per Room	Number of persons per room in the current dwelling unit
Family Income	Total annual family income measured in thousands of dollar units
Net Wealth ^a	Net wealth of the household measured in thousands of dollar units
Couple	1 = head married or otherwise living as a couple; 0 = otherwise
Single Male	1 = head single male; 0 = otherwise
Single Female	1 = head single female; 0 = otherwise
Not High School Graduate	1 = head (or wife if applicable) highest level of education not high school graduate; 0 = otherwise
High School Graduate	1 = head (or wife if applicable) highest level of education high school graduate; 0 = otherwise
Post Secondary	1 = head (or wife if applicable) highest level of education some post secondary training; 0 = otherwise
College or More	1 = head (or wife if applicable) highest level of education college graduate or more; 0 = otherwise
Veteran	1 = head (or wife if applicable) veteran; 0 = otherwise
Disabled	1 = head (or wife if applicable) has disability limiting type and amount of work; 0 = otherwise
Savings/Checking ^a	1 = household had a saving and/or checking account during the period; 0 = otherwise
White	1 = household is white; 0 = household is African American
Cost of Owning	Monthly out-of-pocket cost of owneroccupied housing for the MSA or rural area of the state where a resident resides at a given point in time [(mortgage debt service + owner's property taxes + home maintenance + insurance + owner's cost of utilities - (property taxes x marginal tax rate) - (mortgage interest x marginal tax rate)]
Relative Cost of Own/Rent	Monthly cost of ownig / Monthly cost of renting; the cost of owning is defined as above and the cost of renting is rent + renter's cost of utilities
House Price Appreciation	The OFHEO index of annual appreciation in house value expressed as a percent in the PMSA or state in which the household is located at a given point in time.

^a These variables are only available for the 1980's and 1990's

Table 2a
Housing Cost Component Names and Definitions

Component Name	Component Definitions
House Value	Median house value for the PMSA (or state if in rural area) in which the household is located at a given point in time. The initial values are established using the 1980 US Census 5 percent sample and adjusted over time using the OFEHO house price appreciation indices
Contract Mortgage Rate	Federal Housing Finance Board average annual contract interest rates for select MSAs, states, and/or the United States
Origination Fees	Federal Housing Finance Board average annual loan origination fees for select MSAs, states, and/or the United States
Loan to Value	Federal Housing Finance Board average annual loan-to-value ratios for select MSAs, states, and/or the United States
Loan Term	Federal Housing Finance Board average annual loan term for select MSAs, states, and/or the United States
Mortgage Debt Service	House Value x Loan to Value x the monthly amortization factor calculated using the values for Contract Mortgage Rates, Origination Fees, and Loan Term defined above
Mortgage Interest	This value represents the average annual deduction over the first 5 years of an amortization schedule calculated using the monthly amortization factor used to calculate Mortgage Debt Service above
Owner's Property Taxes	Median property taxes for owned homes in the PMSA (or state if in rural area) in which the household is located at a given point in time. The initial values are established using the 1980 US Census 5 percent sample and kept a constant proportion of house value as that index increases
Owner's Insurance	Median insurance for owned homes in the PMSA (or state if in rural area) in which the household is located at a given point in time. The initial values are established using the 1980 US Census 5 percent sample and kept a constant proportion of house value as that index increases
Owner's Utilities Cost	Median cost of electricity, water, gas, and other heating fuel for owned homes in the PMSA (or state if in rural area) in which the household is located at a given point in time. The initial values are established using the 1980 US Census 5 percent sample and adjusted over time using rental housing cost data collected by the Bureau of Labor Statistics
Home Maintenance	Calculated to be 1.25 percent of the House Value index above for a particular time period ^a
Marginal Tax Rate	Data on marginal federal income tax rates, personal exemptions, and standard deductions were obtained from the Urban Institute and Brookings Tax Policy Center for the 1970s, 1980s and 1990s. This information along with information on family income and marital status for the households in the PSID were used to establish marginal federal income tax rates for the household's included in the analysis.
Renter's Utilities Cost	Median cost of electricity, water, gas, and other heating fuel for rented homes in the PMSA (or state if in rural area) in which the household is located at a given point in time. The initial values are established using the 1980 US Census 5 percent sample and adjusted over time using rental housing cost data collected by the Bureau of Labor Statistics
Rent	Median monthly rent for rental units in the PMSA (or state if in rural area) in which the household is located at a given point in time. The initial values are established using the 1980 US Census 5 percent sample and adjusted over time using rental housing cost data collected by the Bureau of Labor Statistics

^a For a explanation of why this percentage was used see the discussion in the Empirical Analysis section of the paper

Table 3a
All Sample Households
Variable Means - First and Last Year

Variable Names	1970	1979	1980	1989	1990	2001
Age ^a	34.968	34.968	32.399	32.399	34.445	34.445
Household Size	4.125	3.630	3.121	3.453	3.283	3.131
Rooms per Person	1.610	1.973	2.009	2.082	2.090	2.525
Family Income ^b	10.026	24.216	22.213	44.079	45.464	81.203
Net Wealth ^{b, c}	na	na	6.931	11.376	9.357	21.121
Couple	0.668	0.711	0.659	0.694	0.664	0.723
Single Male	0.064	0.091	0.079	0.113	0.120	0.140
Single Female	0.269	0.198	0.262	0.193	0.215	0.137
Not High School Graduate ^a	0.305	0.305	0.176	0.176	0.089	0.089
High School Graduate ^a	0.206	0.206	0.202	0.202	0.299	0.299
Post Secondary ^a	0.313	0.313	0.367	0.367	0.266	0.266
College or More ^a	0.176	0.176	0.255	0.255	0.346	0.346
Veteran ^a	0.387	0.387	0.304	0.304	0.239	0.239
Disabled	0.146	0.217	0.110	0.233	0.143	0.219
Savings/Checking ^{a, c}	na	na	0.739	0.739	0.843	0.843
White ^a	0.641	0.641	0.636	0.636	0.739	0.739
Cost of Owning	202.442	449.119	575.181	788.345	806.797	996.508
Relative Cost of Own/Rent	1.363	1.785	2.058	1.757	1.737	1.725
House Price Appreciation	5.351	13.697	7.591	5.168	3.053	7.208
Number of Observations	2,216		3,087		2,119	

^a Variable value is for the beginning of the period with the exception of Savings/Checking which measures whether or not the household had such an account at any time during the observation period.

^b Variable measured in thousands of dollars

^c Variable not available for the 1970 - 1979 observation period

Table 3b
All Sample Households
Select Variable Means for All Years

Year	Income and Wealth		Housing Cost Variables				Housing Cost Components						
	Average Annual Family Income	Average Annual Family Net Wealth	Average Monthly Cost of Owning	Average Cost of Owning to Renting	Average Annual House Price Appreciation	Median Price of Owned Homes	Average Annual Contract Mortgage Interest Rate	Average Mortgage Origination Fees	Average Mortgage Loan to Value	Average Mortgage Loan Term	Median Energy Cost Owners	Median Monthly Renting	Median Energy Cost Renters
1970	\$ 10,025.58	na	\$ 202.44	1.3634	5.35%	\$ 25,809.32	8.18%	0.92%	71.65%	23.43	\$ 27.48	\$ 136.62	\$ 14.23
1971	\$ 11,026.36	na	\$ 207.06	1.3317	4.13%	\$ 26,874.48	7.52%	0.77%	74.36%	24.63	\$ 29.35	\$ 142.69	\$ 15.21
1972	\$ 12,145.66	na	\$ 214.14	1.3353	4.57%	\$ 28,029.71	7.36%	0.80%	76.59%	26.03	\$ 30.55	\$ 146.86	\$ 15.88
1973	\$ 13,575.79	na	\$ 217.92	1.3033	-1.75%	\$ 27,576.01	7.76%	0.98%	75.21%	23.94	\$ 32.63	\$ 152.70	\$ 16.99
1974	\$ 14,930.48	na	\$ 251.87	1.4110	11.57%	\$ 30,685.85	8.72%	1.14%	73.29%	24.02	\$ 40.82	\$ 159.73	\$ 21.28
1975	\$ 16,090.19	na	\$ 278.19	1.4666	9.57%	\$ 33,630.93	8.87%	1.24%	74.11%	24.82	\$ 46.72	\$ 167.86	\$ 24.33
1976	\$ 17,934.32	na	\$ 294.81	1.4671	6.81%	\$ 35,871.83	8.82%	1.18%	74.31%	25.12	\$ 51.38	\$ 176.91	\$ 26.75
1977	\$ 19,565.50	na	\$ 323.91	1.4994	10.23%	\$ 39,773.49	8.77%	1.18%	75.40%	26.21	\$ 58.09	\$ 188.45	\$ 30.31
1978	\$ 21,807.38	na	\$ 366.12	1.5820	13.02%	\$ 45,070.41	9.32%	1.26%	75.00%	26.61	\$ 62.88	\$ 201.34	\$ 32.86
1979	\$ 24,216.43	na	\$ 449.12	1.7852	13.70%	\$ 51,285.87	10.47%	1.47%	73.77%	26.99	\$ 71.86	\$ 216.25	\$ 37.48
1980	\$ 22,213.10	\$ 6,931.33 ^a	\$ 575.18	2.0575	7.59%	\$ 54,923.54	12.35%	1.88%	73.32%	27.08	\$ 86.25	\$ 232.83	\$ 45.63
1981	\$ 24,553.86	\$ 6,931.33 ^a	\$ 613.54	1.9983	4.78%	\$ 57,843.43	14.26%	2.31%	73.30%	26.50	\$ 100.74	\$ 253.43	\$ 53.20
1982	\$ 26,106.92	\$ 6,931.33 ^a	\$ 667.27	2.0036	3.26%	\$ 59,837.04	14.59%	2.58%	73.82%	25.93	\$ 111.81	\$ 273.04	\$ 59.28
1983	\$ 28,692.68	\$ 6,931.33 ^a	\$ 646.04	1.8371	3.88%	\$ 62,278.64	12.27%	2.42%	75.46%	26.25	\$ 118.41	\$ 288.73	\$ 62.90
1984	\$ 32,009.20	\$ 6,931.33 ^a	\$ 673.69	1.8285	4.42%	\$ 65,178.47	11.93%	2.68%	78.17%	27.01	\$ 122.51	\$ 302.74	\$ 65.28
1985	\$ 34,197.80	\$ 7,820.18	\$ 676.86	1.7508	5.21%	\$ 69,077.18	11.08%	2.65%	76.80%	25.88	\$ 123.35	\$ 319.40	\$ 65.94
1986	\$ 36,295.43	\$ 8,709.04	\$ 662.68	1.6520	6.66%	\$ 74,499.13	9.80%	2.27%	75.27%	25.53	\$ 118.00	\$ 336.13	\$ 63.30
1987	\$ 38,584.98	\$ 9,597.90	\$ 678.69	1.6334	6.95%	\$ 80,813.76	9.02%	2.18%	75.99%	26.49	\$ 116.04	\$ 347.89	\$ 62.40
1988	\$ 41,610.74	\$ 10,486.75	\$ 723.33	1.6813	5.55%	\$ 86,315.72	9.04%	2.11%	76.58%	27.13	\$ 117.05	\$ 358.20	\$ 63.08
1989	\$ 44,078.81	\$ 11,375.61	\$ 788.35	1.7573	5.17%	\$ 91,849.69	9.83%	2.05%	75.54%	26.87	\$ 120.46	\$ 370.84	\$ 64.78
1990	\$ 45,464.02	\$ 9,356.81	\$ 806.80	1.7372	3.05%	\$ 94,627.17	9.77%	1.89%	75.20%	26.51	\$ 122.98	\$ 385.17	\$ 65.67
1991	\$ 48,147.05	\$ 10,077.42	\$ 792.49	1.6609	1.94%	\$ 95,396.04	9.13%	1.62%	75.16%	26.06	\$ 125.48	\$ 398.33	\$ 67.12
1992	\$ 52,284.63	\$ 10,798.02	\$ 778.80	1.6093	2.91%	\$ 96,638.04	7.91%	1.58%	76.98%	24.76	\$ 127.02	\$ 406.63	\$ 68.14
1993	\$ 56,096.22	\$ 11,518.63	\$ 757.75	1.5391	2.55%	\$ 97,966.35	6.98%	1.19%	77.54%	24.99	\$ 130.78	\$ 415.85	\$ 70.13
1994	\$ 57,749.60	\$ 12,239.23	\$ 783.58	1.5658	2.76%	\$ 98,810.86	7.36%	1.11%	79.76%	26.67	\$ 131.04	\$ 425.49	\$ 70.41
1995	\$ 61,407.43	\$ 14,015.67	\$ 803.66	1.5757	3.07%	\$ 101,068.20	7.73%	1.01%	79.75%	27.01	\$ 130.55	\$ 436.43	\$ 70.12
1996	\$ 63,159.28	\$ 15,792.10	\$ 821.07	1.5706	3.78%	\$ 103,617.92	7.59%	0.96%	79.15%	26.52	\$ 135.28	\$ 447.55	\$ 72.72
1997	\$ 73,849.15	\$ 17,568.54	\$ 836.74	1.5559	3.59%	\$ 107,261.18	7.53%	0.97%	79.43%	27.30	\$ 137.93	\$ 460.74	\$ 74.27
1999	\$ 72,915.37	\$ 19,344.97	\$ 884.90	1.5599	4.84%	\$ 119,475.29	7.16%	0.73%	78.90%	28.06	\$ 132.36	\$ 492.25	\$ 71.17
2001	\$ 81,203.48	\$ 21,121.41	\$ 996.51	1.7248	7.21%	\$ 137,969.92	6.94%	0.55%	77.35%	27.61	\$ 153.17	\$ 488.53	\$ 86.59

^aNote, family net-wealth information was not collected prior to 1984. Thus the net-wealth entry for the years prior to 1984 is the 1984 wealth level

Table 4
CTM Coefficients and t-statistics
Net Wealth and Savings/Checking included in 1980s and 1990's

Housing Transitions	1970 - 1979		1980 - 1989		1990 - 2001	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Renting to First Owned Home						
Intercept	2.87848	7.456	0.81468	2.343	0.82912	2.056
Cost of Owning	-0.01055	-12.137	-0.00245	-9.753	-0.00109	-6.911
Realative Cost of Own/Rent	na	na	na	na	na	na
House Price Appreciation	0.07179	3.318	0.02943	3.316	na	na
House Price Appreciation Squared	-0.00598	-4.208	na	na	na	na
Household Size	0.01227	0.419	-0.08885	-2.351	-0.07449	-1.736
Rooms per Person	-0.02884	-0.489	0.00496	0.101	-0.02116	-0.394
Family Income	0.10107	5.584	0.04024	9.090	0.02710	6.051
Family Income Squared	-0.00150	-3.580	-0.00024	-8.393	-0.00011	-4.269
Net Wealth	na	na	0.00435	2.128	0.01263	2.129
Single Male	-0.72214	-3.553	-0.63355	-4.787	-0.36998	-2.612
Single Female	-0.57165	-4.404	-0.39039	-3.429	-0.32533	-2.347
High School Graduate	-0.07950	-0.564	-0.07307	-0.454	0.17006	0.881
Post Secondary	0.21043	1.543	0.07586	0.522	0.33392	1.710
College or More	0.12155	0.719	0.18085	1.132	0.26081	1.289
Veteran	0.05657	0.531	-0.17655	-1.725	-0.27906	-2.180
Disabled	-0.18866	-1.178	-0.15118	-1.114	-0.02614	-0.200
Age	-0.02679	-4.414	-0.01676	-2.679	-0.02480	-3.329
White	-0.06126	-0.526	0.23157	2.366	0.08036	0.715
Savings/Checking	na	na	0.43345	3.475	0.49006	3.364
γ	0.62332	7.973	0.35933	5.769	0.47370	7.338
Renting to Second Owned Home						
Intercept	-3.06327	-2.889	-1.51963	-1.931	-2.54875	-2.587
Cost of Owning	na	na	na	na	na	na
Realative Cost of Own/Rent	-1.11920	-2.324	-1.44945	-5.544	-0.96545	-3.076
House Price Appreciation	0.03197	1.634	na	na	0.11633	2.273
House Price Appreciation Squared	na	na	na	na	-0.01067	-1.895
Household Size	0.11930	1.787	0.00374	0.057	0.07186	0.897
Rooms per Person	0.22411	2.106	0.03621	0.396	0.17083	2.054
Family Income	0.02884	3.428	0.04247	6.220	0.00539	5.239
Family Income Squared	na	na	-0.00018	-4.946	na	na
Net Wealth	na	na	0.00228	0.359	0.01390	3.209
Single Male	-0.23221	-0.649	0.03315	0.159	-0.31594	-1.284
Single Female	-1.17163	-3.339	-0.45477	-1.815	-0.99172	-3.207
High School Graduate	-0.21825	-0.582	-0.06171	-0.198	0.96212	2.217
Post Secondary	0.22436	0.703	-0.14607	-0.515	0.68142	1.512
College or More	-0.15451	-0.417	-0.19124	-0.594	0.58302	1.306
Veteran	-0.12860	-0.503	0.10151	0.508	-0.01555	-0.067
Disabled	-0.35871	-1.141	0.06150	0.279	-0.02823	-0.136
Age	0.02145	1.520	0.01460	1.232	0.01336	0.938
White	0.78615	2.663	0.46971	2.170	0.52853	2.081
Savings/Checking	na	na	0.27407	1.093	0.48093	1.496
γ	-0.29368	-2.058	-0.31251	-2.874	-0.08613	-0.792

^a "na" for f indicates that it was not possible to estimate the non-parametric heterogeneity parameter for the particular transition in question

Table 4 (Continued)
CTM Coefficients and t-statistics
Net Wealth and Savings/Checking included in 1980s and 1990's

Housing Transitions	1970 - 1979		1980 - 1989		1990 - 2001	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
First Owned Home to Renting						
Intercept	1.23347	2.313	0.80988	1.625	0.15322	0.231
Cost of Owning	na	na	0.00077	2.531	0.00066	2.870
Realative Cost of Own/Rent	na	na	na	na	na	na
House Price Appreciation	-0.02996	-2.138	na	na	-0.08488	-4.265
House Price Appreciation Squared	na	na	na	na	na	na
Household Size	0.07118	1.320	0.01020	0.199	0.06957	1.119
Rooms per Person	0.12103	1.483	-0.08736	-1.328	0.07461	1.215
Family Income	-0.04875	-5.924	-0.01174	-3.750	-0.01401	-4.829
Family Income Squared	na	na	na	na	na	na
Net Wealth	na	na	-0.05375	-11.707	-0.03200	-4.707
Single Male	1.17296	3.942	0.74869	3.584	0.62305	2.602
Single Female	0.48608	2.128	0.56631	3.192	0.57152	2.515
High School Graduate	-0.67630	-2.582	-0.53762	-2.457	-0.14668	-0.497
Post Secondary	-0.15049	-0.681	-0.14279	-0.794	-0.13629	-0.436
College or More	0.22460	0.831	0.07286	0.331	0.12144	0.382
Veteran	0.08241	0.456	0.52357	3.561	0.34225	1.802
Disabled	-0.28560	-1.309	0.02797	0.176	0.29217	1.785
Age	-0.06385	-6.807	-0.05207	-5.937	-0.04763	-4.314
White	0.00613	0.030	0.12284	0.811	0.07870	0.409
Savings/Checking	na	na	-0.49746	-3.079	0.07375	0.328
γ	0.16096	1.635	0.07337	0.937	0.08304	0.875
First to Second Owned Home						
Intercept	2.24968	4.9542	2.46640	6.928	2.26636	4.740
Cost of Owning	-0.00553	-7.3564	-0.00070	-3.140	-0.00054	-3.051
Realative Cost of Own/Rent	na	na	na	na	na	na
House Price Appreciation	na	na	0.01320	1.740	na	na
House Price Appreciation Squared	na	na	na	na	na	na
Household Size	-0.02101	-0.4884	-0.24171	-5.364	-0.19921	-3.930
Rooms per Person	-0.03312	-0.4287	-0.14435	-2.820	-0.16634	-3.135
Family Income	-0.00684	-1.5654	0.00821	2.545	0.00158	2.105
Family Income Squared	na	na	-0.00004	-2.188	na	na
Net Wealth	na	na	0.00161	2.068	-0.00081	-0.555
Single Male	0.61729	2.5619	0.18894	1.173	0.18497	1.032
Single Female	0.24572	1.3442	0.14289	0.970	0.17392	0.981
High School Graduate	-0.23239	-1.3790	-0.33574	-2.052	-0.00738	-0.031
Post Secondary	0.14365	0.9231	-0.05306	-0.358	0.08084	0.330
College or More	0.41508	2.3873	0.26418	1.686	0.39598	1.645
Veteran	0.17882	1.6594	0.23690	2.849	0.02761	0.248
Disabled	0.05940	0.3717	-0.14329	-1.147	-0.02234	-0.179
Age	-0.05360	-8.6947	-0.06369	-11.420	-0.06116	-8.653
White	0.40154	2.5008	0.25132	2.310	0.45779	3.293
Savings/Checking	na	na	-0.09349	-0.716	0.06461	0.383
γ	0.32196	4.0743	0.15075	2.593	0.30920	5.248
Number of Observations	2,216		3,087		2119	
- Log Likelihood Function	2319.566		3329.0699		2469.670	
Cox and Snell Pseudo R²^a	0.388		0.360		0.346	

^a The formula for this R² measure is $1 - \exp[-2/n(LLUR - LLR)]$; where n = the number of observations, LLUR = the unrestricted log of the likelihood function, and LLR = the restricted log of the likelihood function

Table 5a
Households Initially Renters
Variable Means - First and Last Year

Variable Names	1970	1979	1980	1989	1990	2001
Age ^a	32.279	32.279	29.678	29.678	31.298	31.298
Household Size	3.704	3.572	2.668	3.361	2.999	3.189
Rooms per Person	1.611	1.932	2.006	1.952	1.869	2.296
Family Income ^b	7.790	19.986	15.230	34.942	29.624	65.612
Net Wealth ^{b, c}	na	na	2.765	5.086	2.566	8.379
Couple	0.482	0.585	0.364	0.550	0.439	0.591
Single Male	0.0885	0.0905	0.212	0.142	0.191	0.174
Single Female	0.4290	0.3249	0.423	0.308	0.370	0.235
Not High School Graduate ^a	0.524	0.524	0.436	0.436	0.413	0.413
High School Graduate ^a	0.185	0.185	0.207	0.207	0.308	0.308
Post Secondary ^a	0.291	0.291	0.357	0.357	0.279	0.279
College or More ^a	0.164	0.164	0.217	0.217	0.270	0.270
Veteran ^a	0.262	0.262	0.208	0.208	0.173	0.173
Disabled	0.172	0.242	0.122	0.235	0.123	0.212
Savings/Checking ^{a, c}	na	na	0.625	0.625	0.759	0.759
White ^a	0.496	0.496	0.489	0.489	0.570	0.570
Cost of Owning	212.558	484.608	645.965	853.620	881.804	1048.497
Relative Cost of Own/Rent	1.372	1.855	2.228	1.835	1.825	1.778
House Price Appreciation	5.351	14.099	8.008	5.616	2.964	7.410
Number of Observations	1,028		1,361		763	

^a Variable value is for the beginning of the period with the exception of Savings/Checking which measures whether or not the household had such an account at any time during the observation period.

^b Variable measured in thousands of dollars

^c Variable not available for the 1970 - 1979 observation period

Table 5b
Households Initially Renters
Select Variable Means for All Years

Year	Income and Wealth		Housing Cost Variables				Housing Cost Components						
	Average Annual Family Income	Average Annual Family Net Wealth	Average Monthly Cost of Owning	Average Cost of Owning to Renting	Average Annual House Price Appreciation	Median Price of Owned Homes	Average Annual Contract Mortgage Interest Rate	Average Mortgage Origination Fees	Average Mortgage Loan to Value	Average Mortgage Loan Term	Median Energy Cost Owners	Median Monthly Renting	Median Energy Cost Renters
1970	\$ 7,790.07	na	\$ 212.56	1.3724	5.35%	\$ 27,175.84	8.19%	0.90%	71.78%	23.63	\$ 27.43	\$ 143.20	\$ 13.72
1971	\$ 8,579.74	na	\$ 217.55	1.3425	4.13%	\$ 28,311.77	7.54%	0.76%	74.51%	24.84	\$ 29.27	\$ 149.52	\$ 14.68
1972	\$ 9,546.02	na	\$ 225.00	1.3474	4.57%	\$ 29,482.94	7.38%	0.79%	76.76%	26.25	\$ 30.45	\$ 153.70	\$ 15.35
1973	\$ 10,756.99	na	\$ 229.35	1.3156	-1.75%	\$ 29,046.15	7.78%	0.97%	75.37%	24.14	\$ 32.49	\$ 160.07	\$ 16.39
1974	\$ 11,799.76	na	\$ 265.69	1.4297	11.57%	\$ 32,305.79	8.73%	1.13%	73.45%	24.22	\$ 40.68	\$ 167.39	\$ 20.58
1975	\$ 12,902.28	na	\$ 293.09	1.4889	9.57%	\$ 35,351.02	8.89%	1.22%	74.28%	25.02	\$ 46.58	\$ 175.51	\$ 23.51
1976	\$ 14,554.23	na	\$ 312.20	1.4982	7.15%	\$ 37,845.84	8.84%	1.16%	74.48%	25.31	\$ 51.22	\$ 184.84	\$ 25.88
1977	\$ 15,904.92	na	\$ 344.35	1.5366	10.54%	\$ 42,097.44	8.79%	1.16%	75.56%	26.41	\$ 57.89	\$ 197.02	\$ 29.34
1978	\$ 17,798.97	na	\$ 391.16	1.6283	13.25%	\$ 47,823.04	9.34%	1.24%	75.17%	26.80	\$ 62.66	\$ 210.68	\$ 31.83
1979	\$ 19,985.59	na	\$ 484.61	1.8552	14.10%	\$ 54,613.36	10.48%	1.48%	73.85%	27.12	\$ 71.47	\$ 226.63	\$ 36.21
1980	\$ 15,229.63	\$ 2,765.11 ^a	\$ 645.96	2.2283	8.01%	\$ 58,104.46	12.38%	1.87%	73.14%	27.12	\$ 87.15	\$ 243.12	\$ 44.61
1981	\$ 17,605.46	\$ 2,765.11 ^a	\$ 670.63	2.1093	5.04%	\$ 61,233.73	14.29%	2.30%	73.07%	26.50	\$ 101.97	\$ 264.89	\$ 52.06
1982	\$ 19,010.18	\$ 2,765.11 ^a	\$ 722.25	2.0994	3.14%	\$ 63,083.35	14.64%	2.58%	73.54%	26.03	\$ 113.15	\$ 284.84	\$ 58.10
1983	\$ 21,408.37	\$ 2,765.11 ^a	\$ 696.88	1.9134	3.97%	\$ 65,875.35	12.26%	2.42%	75.27%	26.34	\$ 119.75	\$ 301.88	\$ 61.68
1984	\$ 24,066.15	\$ 2,765.11 ^a	\$ 726.22	1.9040	4.77%	\$ 69,082.48	11.92%	2.68%	77.98%	27.03	\$ 123.80	\$ 316.76	\$ 63.91
1985	\$ 25,984.90	\$ 3,229.32	\$ 734.07	1.8295	5.58%	\$ 73,788.77	11.09%	2.65%	76.68%	25.95	\$ 124.50	\$ 335.51	\$ 64.45
1986	\$ 27,813.01	\$ 3,693.53	\$ 718.33	1.7273	7.08%	\$ 79,577.48	9.79%	2.29%	75.24%	25.60	\$ 119.18	\$ 352.14	\$ 62.04
1987	\$ 29,811.89	\$ 4,157.74	\$ 731.25	1.6971	7.74%	\$ 86,784.41	9.02%	2.20%	75.92%	26.54	\$ 117.38	\$ 364.43	\$ 61.18
1988	\$ 32,579.58	\$ 4,621.95	\$ 779.06	1.7470	6.31%	\$ 93,352.02	9.03%	2.13%	76.53%	27.26	\$ 118.31	\$ 374.85	\$ 61.81
1989	\$ 34,942.31	\$ 5,086.17	\$ 853.62	1.8350	5.62%	\$ 99,753.86	9.82%	2.08%	75.50%	26.99	\$ 122.02	\$ 387.71	\$ 63.57
1990	\$ 29,624.01	\$ 2,565.63	\$ 881.80	1.8247	2.96%	\$ 102,881.13	9.76%	1.90%	75.22%	26.58	\$ 123.99	\$ 401.68	\$ 64.32
1991	\$ 32,520.58	\$ 2,813.66	\$ 858.95	1.7305	1.76%	\$ 103,176.71	9.11%	1.63%	75.24%	26.10	\$ 126.69	\$ 415.55	\$ 65.97
1992	\$ 37,173.78	\$ 3,061.70	\$ 835.98	1.6638	2.79%	\$ 103,932.87	7.89%	1.58%	77.17%	25.01	\$ 128.10	\$ 423.48	\$ 66.91
1993	\$ 40,269.91	\$ 3,309.73	\$ 810.40	1.5880	2.27%	\$ 104,909.29	6.97%	1.19%	77.77%	25.27	\$ 132.01	\$ 432.50	\$ 68.86
1994	\$ 42,350.22	\$ 3,557.77	\$ 830.20	1.6094	2.36%	\$ 104,120.05	7.35%	1.11%	79.83%	26.80	\$ 132.14	\$ 439.96	\$ 69.38
1995	\$ 44,940.12	\$ 4,521.93	\$ 847.93	1.6130	2.81%	\$ 106,168.80	7.71%	1.01%	79.89%	27.10	\$ 131.51	\$ 450.81	\$ 69.07
1996	\$ 47,505.87	\$ 5,486.09	\$ 862.96	1.6013	3.60%	\$ 108,122.31	7.59%	0.96%	79.20%	26.62	\$ 136.13	\$ 462.50	\$ 71.73
1997	\$ 55,458.44	\$ 6,450.24	\$ 879.04	1.5835	3.53%	\$ 111,790.25	7.53%	0.96%	79.33%	27.32	\$ 138.92	\$ 476.38	\$ 73.38
1999	\$ 57,708.79	\$ 7,414.40	\$ 929.20	1.5860	4.93%	\$ 124,794.96	7.15%	0.72%	78.88%	28.11	\$ 133.31	\$ 509.52	\$ 70.14
2001	\$ 65,612.45	\$ 8,378.56	\$ 1,048.50	1.7782	7.41%	\$ 145,749.59	6.94%	0.55%	77.17%	27.61	\$ 153.31	\$ 499.07	\$ 85.71

^a Note, family net-wealth information was not collected prior to 1984. Thus the net-wealth entry for the years prior to 1984 is the 1984 wealth level

Table 6
Probabilities of Transition and Homeownership
for
Renters at the start of the Period

Year	P(Own)	Probabilities of Transition			
		Rent to 1 st Home	Rent to 2 nd Home	1 st Home to Rent	1 st Home to 2 nd Home
1970	2.07%	2.07%	1.47%	2.09%	3.10%
1971	5.88%	6.16%	2.49%	4.58%	6.72%
1972	10.67%	11.42%	3.47%	6.78%	10.11%
1973	14.77%	16.27%	4.25%	9.66%	12.38%
1974	19.01%	20.89%	5.42%	9.54%	15.61%
1975	22.56%	25.36%	6.47%	11.81%	15.70%
1976	25.68%	29.11%	7.35%	12.72%	16.31%
1977	28.02%	31.89%	8.35%	13.24%	16.54%
1978	29.60%	33.84%	9.34%	13.80%	16.02%
1979	29.72%	34.82%	10.12%	16.31%	12.92%
1980	1.70%	1.70%	0.89%	3.65%	4.37%
1981	3.79%	4.09%	1.65%	7.27%	8.36%
1982	5.90%	6.59%	2.35%	10.73%	11.18%
1983	8.42%	9.60%	3.35%	12.66%	14.17%
1984	10.72%	12.59%	4.36%	15.48%	15.02%
1985	13.45%	15.84%	5.49%	15.95%	17.10%
1986	16.57%	19.44%	6.88%	15.90%	18.90%
1987	19.67%	23.10%	8.34%	16.18%	19.75%
1988	22.46%	26.43%	9.69%	16.67%	19.84%
1989	24.67%	29.23%	10.79%	17.50%	19.14%
1990	2.08%	2.08%	1.40%	2.69%	3.39%
1991	5.48%	5.83%	2.91%	6.00%	7.04%
1992	9.91%	10.71%	4.82%	7.83%	10.94%
1993	14.70%	16.18%	6.77%	9.77%	13.89%
1994	19.63%	21.95%	8.50%	11.58%	16.10%
1995	24.83%	27.85%	10.45%	12.13%	18.49%
1996	30.22%	33.80%	12.67%	12.14%	20.52%
1997	35.57%	39.59%	15.06%	11.97%	22.08%
1999	40.12%	44.27%	17.49%	11.37%	23.47%
2001	44.94%	48.92%	19.51%	10.10%	25.05%

Table 7
Probabilities of Transition and Homeownership
for
Renters at the start of the Period
with
Contract Interest and Origination Fees 20% Lower than Table 6

Year	Probabilities of Transition														
	P(Own)			Rent to 1 st Home			Rent to 2 nd Home			1 st Home to Rent			1 st Home to 2 nd Home		
	Cum. Prob.	Change in % Points	Change as a %	Cum. Prob.	Change in % Points	Change as a %	Cum. Prob.	Change in % Points	Change as a %	Cum. Prob.	Change in % Points	Change as a %	Cum. Prob.	Change in % Points	Change as a %
1970	2.43%	0.360	14.84%	2.43%	0.360	14.84%	1.63%	0.169	10.34%	2.06%	-0.024	-1.16%	3.33%	0.236	7.08%
1971	6.87%	0.993	14.45%	7.20%	1.038	14.41%	2.77%	0.276	9.97%	4.53%	-0.047	-1.04%	7.23%	0.512	7.08%
1972	12.45%	1.779	14.29%	13.31%	1.886	14.17%	3.85%	0.381	9.90%	6.69%	-0.089	-1.33%	10.90%	0.787	7.22%
1973	17.17%	2.401	13.99%	18.89%	2.615	13.85%	4.70%	0.458	9.74%	9.55%	-0.110	-1.15%	13.37%	0.986	7.37%
1974	22.18%	3.175	14.31%	24.30%	3.404	14.01%	6.03%	0.607	10.07%	9.26%	-0.287	-3.10%	16.92%	1.310	7.74%
1975	26.43%	3.868	14.64%	29.56%	4.203	14.22%	7.22%	0.750	10.39%	11.43%	-0.377	-3.30%	17.24%	1.535	8.91%
1976	30.15%	4.466	14.81%	33.98%	4.864	14.32%	8.22%	0.866	10.54%	12.28%	-0.439	-3.58%	17.99%	1.673	9.30%
1977	32.99%	4.971	15.07%	37.27%	5.385	14.45%	9.35%	1.004	10.74%	12.67%	-0.562	-4.43%	18.38%	1.843	10.03%
1978	35.03%	5.426	15.49%	39.65%	5.816	14.67%	10.51%	1.165	11.09%	13.03%	-0.771	-5.92%	18.10%	2.087	11.53%
1979	35.49%	5.775	16.27%	40.97%	6.143	15.00%	11.47%	1.350	11.77%	15.09%	-1.219	-8.08%	15.47%	2.550	16.49%
1980	2.04%	0.339	16.66%	2.04%	0.339	16.66%	1.29%	0.397	30.80%	3.42%	-0.228	-6.66%	4.57%	0.204	4.46%
1981	4.58%	0.787	17.18%	4.92%	0.824	16.76%	2.36%	0.708	30.01%	6.81%	-0.459	-6.74%	8.79%	0.430	4.89%
1982	7.18%	1.279	17.81%	7.95%	1.358	17.08%	3.35%	0.996	29.78%	10.03%	-0.705	-7.03%	11.85%	0.667	5.63%
1983	10.19%	1.765	17.33%	11.50%	1.899	16.52%	4.64%	1.285	27.72%	11.93%	-0.731	-6.13%	14.88%	0.707	4.75%
1984	12.96%	2.232	17.23%	15.02%	2.433	16.20%	5.94%	1.580	26.62%	14.61%	-0.871	-5.96%	15.87%	0.850	5.35%
1985	16.17%	2.717	16.80%	18.80%	2.954	15.72%	7.35%	1.855	25.24%	15.07%	-0.882	-5.85%	17.97%	0.869	4.84%
1986	19.73%	3.161	16.02%	22.87%	3.428	14.99%	8.98%	2.103	23.42%	15.11%	-0.793	-5.25%	19.71%	0.809	4.10%
1987	23.24%	3.572	15.37%	26.95%	3.855	14.30%	10.67%	2.336	21.89%	15.40%	-0.774	-5.02%	20.58%	0.827	4.02%
1988	26.43%	3.977	15.05%	30.69%	4.254	13.86%	12.28%	2.587	21.07%	15.81%	-0.856	-5.41%	20.78%	0.940	4.52%
1989	29.04%	4.375	15.06%	33.86%	4.632	13.68%	13.64%	2.843	20.85%	16.48%	-1.017	-6.17%	20.27%	1.121	5.53%
1990	2.27%	0.190	8.39%	2.27%	0.190	8.39%	1.64%	0.240	14.62%	2.51%	-0.184	-7.35%	3.48%	0.093	2.67%
1991	5.97%	0.487	8.16%	6.33%	0.495	7.82%	3.37%	0.458	13.59%	5.65%	-0.346	-6.12%	7.24%	0.204	2.82%
1992	10.71%	0.802	7.49%	11.52%	0.815	7.07%	5.49%	0.672	12.24%	7.45%	-0.387	-5.20%	11.19%	0.252	2.25%
1993	15.78%	1.079	6.84%	17.28%	1.102	6.38%	7.61%	0.846	11.11%	9.37%	-0.399	-4.26%	14.18%	0.291	2.05%
1994	21.01%	1.387	6.60%	23.35%	1.402	6.00%	9.52%	1.023	10.75%	11.07%	-0.503	-4.54%	16.53%	0.427	2.58%
1995	26.53%	1.697	6.40%	29.54%	1.691	5.72%	11.68%	1.229	10.52%	11.57%	-0.558	-4.82%	19.02%	0.529	2.78%
1996	32.18%	1.966	6.11%	35.74%	1.941	5.43%	14.11%	1.445	10.24%	11.60%	-0.548	-4.73%	21.10%	0.581	2.75%
1997	37.78%	2.207	5.84%	41.75%	2.152	5.15%	16.73%	1.667	9.97%	11.42%	-0.546	-4.78%	22.73%	0.646	2.84%
1999	42.50%	2.385	5.61%	46.57%	2.300	4.94%	19.37%	1.880	9.70%	10.83%	-0.536	-4.95%	24.18%	0.709	2.93%
2001	47.49%	2.549	5.37%	51.35%	2.431	4.73%	21.57%	2.063	9.56%	9.58%	-0.518	-5.41%	25.82%	0.770	2.98%

References

- Belsky, E.S. and Duda, M. (2002), "Asset Appreciation, Timing of Purchase and Sales, and Returns to Low Income Homeownership" in *Low-Income Homeownership: Examining the Unexamined Goal* edited by Retsinas, Nicholas P. and Belsky Eric S. Washington D.C., the Brookings Institution.
- Boehm, Thomas P. (1984), "Inflation and Intra-Urban Residential Mobility," *Housing Finance Review*, Vol. 3, No. 1, pp. 19-38.
- Boehm, Thomas P. and Alan M Schlottmann (2004), "The Dynamics of Race Income and Homeownership", *Journal of Urban Economics*, v.55, Issue 1, pp.113 – 130.
- Boehm, Thomas P. and Schlottmann, Alan M. (2002), "Housing and Wealth Accumulation: Intergenerational Impacts," in Low Income Homeownership: Examining the Unexamined Goal, Boston: Harvard's Joint Center for Housing Studies and The Brookings Institution.
- Boehm, Thomas P., and Alan M. Schlottmann (1999), "Does Home Ownership by Parent's have an Economic Impact on Their Children?" *Journal of Housing Economics*, Vol. 8, pp.217-232.
- Brownell, Charles (2008), "Subprime Meltdown from U.S. Liquidity Crisis to Global Recession", Ingram Book Group (ISBN 1438236611).
- Chan, Sewin (2001), "Spatial Lock-in: Do Falling House Prices Constrain Residential Mobility?" *Journal of Urban Economics*, v. 49, pp. 567 – 586.
- Di, Zhu Xiao, Eric Belsky, Yi Yang, and Xiaodong Liu (2005) "Do Homeowners Accumulate More Wealth? The Importance of Housing to the Accumulation of Household Net Wealth", unpublished manuscript, Joint Center for Housing Studies Harvard University, Cambridge, MA.
- Flinn, C.J. and J.J. Heckman, (1979) "Models for the Analysis of Labor Force Dynamics", *Advances in Econometrics*, Volume 1, JAI Press: 35 – 95.
- Flinn, C.J. and J.J. Heckman (1983) "The Likelihood Function for the Multi-State Multi-Episode Model in Models for the Analysis of Labor Force Dynamics", *Advances in Econometrics 2*, JAI Press: 225 – 231.
- Heckman, J.J. and B. Singer (1984), "A Method for Minimizing the Impact of Distributional Assumptions in Econometric Models for Duration Data", *Econometrica 52*: 271 – 320.
- Heckman, J.J. and B. Singer (1985a) "Social Science Duration Analysis", in: J. J. Heckman and B. Singer (eds.), *Longitudinal Analysis of Labor Market Data*, University Press, New York and Cambridge: 39-110.

- Heckman, J.J., V. J. Hotz and J. R. Walker (1985b) “New Evidence on the Timing and Spacing of Births”, *American Economic Review* 75: 179 – 184.
- Heckman, J.J. and J. R. Walker (1986) Using Goodness of Fit and Other Criteria to Choose Among Competing Duration Models: A Case Study of Hutterite Data, manuscript, University of Chicago, Chicago. A shorter published version appears in *Sociological Methodology* 87.
- Heckman, J.J. and J. R. Walker (1990), “The Relationship Between Wages and Income and the Timing and Spacing of Births: Evidence from Swedish Longitudinal Data”, *Econometrica*: 58(6): 1411-1441.
- Kiel, Katherine A. (1994), “The Impact of House Price Appreciation on Household Mobility”, *Journal of Housing Economics*, Volume 3, pp. 92 – 108.
- Nakagami, Yasuhiro and Alfred Pereira (1991), “Housing Appreciation, Mortgage Interest Rates, and Homeowner Mobility”, *Journal of Urban Economics*, Volume 30, pp. 271 – 292.
- Rosen, Harvey S. and Kenneth T. Rosen (1980), “Federal Taxes and Homeownership: Evidence from Time Series”, *Journal of Political Economy*, Volume 88, Number 1, pp. 59 – 75.
- Chambers, Matthew S., Carlos Garriga, and Don Schlagenhauf (2007a), “Mortgage Contracts and Housing Tenure Decisions”, Working Paper 2007-040A, Federal Reserve Bank of St. Louis, St. Louis MO.
- Chambers, Matthew S., Carlos Garriga, and Don Schlagenhauf (2007b), “Accounting for Changes in the Homeownership Rate”, Working Paper 2007-21, Federal Reserve Bank of Atlanta, Atlanta GA.
- Chambers, Matthew S., Carlos Garriga, and Don Schlagenhauf (2009), “The Loan Structure and Housing Tenure Decisions in an Equilibrium Model of Mortgage Choice”, Working Paper 2007-040A, Federal Reserve Bank of St. Louis, St. Louis MO.
- Quigley, John M. (1987), “Interest Rate Variations, Mortgage Prepayments, and Household Mobility”, *Review of Economics and Statistics*, Volume LXIX, Number 4, pp. 636 – 643.
- Quigley, John M. (2002), “Homeowner Mobility and Interest Rates: New Evidence from the 1990s”, *Journal of Real Estate Economics*, Volume 30, Issue 3, pp. 345 – 364.
- U.S. President’s Commission on Housing (1982), “The Report of the President’s Commission on Housing, Washington D.C.

APPENDIX A

Housing Choice within a Generalized Heckman Continuous Time Model (CTM)

The technique used to estimate the likelihood of transition between housing tenure states and, subsequently, the cumulative probabilities of homeownership at a given point in time was developed in Schlottmann and Boehm (2004). It is based on the basic multi-state multi-episode probability model developed in detail in Flinn and Heckman (1986, 1990), particularly the likelihood function, and in Heckman and Walker, (1984) and (1985a and 1985b), particularly the estimation. We briefly sketch this modeling approach below. For simplicity, we follow the common notational structure employed in these references.

The conditional hazard estimated in our analysis follows the literature above.²¹ Let T represent time until a change in tenure status occurs (i.e., renting to owning, owning a 1st home to owning a 2nd home, etc.). In this case the reference point will be the beginning of our observation period. Also, let t represent calendar time measured from that same reference point. The probability that a household remains in its initial tenure state at calendar time t , $\Pr(T \geq t)$, must be determined indirectly by estimating the hazard function h , the likelihood that the household achieves a change in tenure status in a very small interval from t to $t + \Delta t$, given $T \geq t$. This hazard rate can be made a function of a set of time varying covariates and specified more formally as:

$$h(t) = \lim_{\Delta t \rightarrow 0} \frac{\Pr(t \leq T \leq t + \Delta t \mid T \geq t)}{\Delta t} = \exp \left[\alpha + \beta X + \gamma \frac{t^\lambda - 1}{\lambda} \right] \quad (1A)$$

where X is a vector of exogenous variables as of calendar time $t + \Delta t$ and β is a vector of coefficients corresponding to the exogenous variables. Duration dependence (given the estimated parameter, γ) is captured by the term $(t^\lambda - 1)/\lambda$. If $\lambda = 0$ the hazard function has the Weibull form.²² Unobserved variables are permitted to be functions of time $(t + \Delta t)$.²³

From this estimable hazard function the literature suggests that the cumulative probability of transitioning out of the current state of existence can be expressed as:

$$CP = \sum_{k=1}^m \int_{\alpha_{k-1}}^{\alpha_k} h(t) \exp \left[- \int_0^t h(u) du \right] dt, \quad (2A)$$

where:

m = the total number of intervals (years, months, weeks, etc.) in the study period

α_k = k/m

α_{k-1} = $(k-1)/m$

²¹ See Heckman and Walker (1986) for a detailed discussion. Equation (1) above is our estimable form of Heckman and Walker (1986), equation 2.7, p. 1417. This is a development of Heckman and Singer (1985).

²² Note that the hazard function can take a number of other functional forms, e.g., exponential, quadratic, etc. For a more general specification of equation 1 see the Appendix to Yates Honore and Walker (1987).

²³ The software used for this analysis was developed by James Heckman, et al. at the University of Chicago and was converted from a mainframe application to a PC executable form at the University of Tennessee. The PC executable version of the program and user manual are available from the authors on request.