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Empirical Evidence on Mortgage Choice as a Screening Mechanism for Default Risk

David M. Harrison and Thomas G. Noordewier

Abstract

This paper examines one of the most critical credit decisions made by consumers: selecting between a fixed-rate mortgage (FRM) and an adjustable-rate mortgage (ARM). This study employs a sample of 1,003 mortgage loans to empirically evaluate whether a borrower's choice between fixed and adjustable rate products is contingent upon both their transactions costs of default and default risk. The findings reveal that when a borrower's default costs are sufficiently small, high default risk borrowers disproportionately self-select into FRMs, while low default risk borrowers tend to self-select into ARMs.

How do borrowers select among the competing menu of loan products available to them at origination? Are these mortgage choice decisions based purely upon attempts to minimize the present value of the borrower's expected payments over the life of the loan, or do strategic considerations such as expected default risk and bankruptcy costs materially influence the selection of loan terms? As housing prices decline across many regions of the United States, and delinquencies and foreclosures rise within the $10+ trillion domestic mortgage industry, a better, more thorough understanding of the potential linkages between ex ante borrower expectations, preferences, and incentives and the resulting performance of the corresponding mortgage loan is clearly needed.

With literally hundreds of lenders in the mortgage marketplace, commercial banks, savings and loans, and credit unions must actively compete to create mortgage products with customer-desired attributes.[1] The dynamic nature of this competition and the importance of mortgage credit combine to make for an active marketplace, one in which consumer (borrower) choice prevails and lenders must adapt their product (mortgage credit) offerings in order to survive. Yet, despite the size and importance of the mortgage market, the academic literature offers surprisingly limited theoretical and empirical insight into how consumers ultimately choose among competing mortgage credit products.

This investigation into how borrowers select between fixed- and adjustable-rate mortgages (FRMs and ARMs) begins with an overview of the mortgage choice literature. Following this discussion is an outline of the sampling plan and specific variables used to create the dataset and test the hypothesis. Next is a discussion the results of an interaction logistic regression in which the effects of borrower default risk factors on the ARM-FRM decision are modeled as contingent upon borrower transaction costs of default. Finally, the empirical findings are summarized, followed by a discussion of their implications.

Traditional Approaches to Explaining Mortgage Choice Decisions by Borrowers

For reasons that are not fully understood, the share of ARM originations fluctuates widely from year to year. For example, in 1984, 62% of originations were for ARMs, the highest share ever reported (Freddie Mac, 2005). By the mid-1990s, ARM shares had dropped to roughly half their historic high, and have continued to fluctuate within the 10%–35% range over much of the recent past. Interestingly, as the recent housing downturn has deepened, the ARM market share has dropped precipitously—reaching an all-time low of only 2% by March of 2009 (Freddie Mac, 2010). The most recently available numbers (May 2010) show the ARM market share at 7%. Researchers interested in explaining the ARM-FRM choice and the sizable shifts in preference from year to year have, naturally enough, focused largely on the influence of two categories of variables: *mortgage price variables* and *borrower characteristics*.

Mortgage Price Variables

Mortgage price variables attempt to capture the (differential) price of ARM versus FRM credit. The most obvious price variable potentially influencing this choice is the initial ARM versus FRM interest rate (i.e., price) differential. A higher introductory ''spread'' (i.e., FRM minus ARM rate) between the two credit types should increase the probability that an ARM will be chosen (Brueckner and Follain, 1988). However, borrowers seeking to minimize mortgage loan expenses will also consider their expectations of future interest rate changes, since ARM interest-rate changes are linked to general interest-rate movements via one of a variety of ''indexes'' (Tucker, 1989). Research also points to the potential influence of such pricing factors as the level of fixed interest rates (i.e., with borrowers choosing ARMs, at lower initial rates, when they do not qualify at higher fixed rates) (Brueckner and Follain, 1988); housing ''affordability'' metrics, such as that produced by the National Association of Realtors, which incorporates the level of fixed interest rates, along with family income and house prices (Nothaft and Wang, 1992); or more generally the bond risk premium, which may well be driven by inflation expectations (Koijen, van Hemert, and van Nieuwerburgh, 2007).[2]

Borrower Characteristics

Borrower characteristics may also influence the ARM-FRM choice. For example, Brueckner and Follain (1988) observe that borrowers who do not expect to hold a property very long might prefer ARMs, since ARMs usually come with lower initial rates and mobile borrowers will more likely prepay before the occurrence of significant rate increases.[3] Similarly, they note that some borrowers might favor ARMs because they expect higher future incomes, enabling them to better absorb the interest rate risk of an adjustable-rate product. Dhillon, Shilling, and Sirmans (1987) consider self-employment as a potential explanatory borrower characteristic, noting that self-employed borrowers ''may find borrowing on their personal accounts cheaper than other debt they might use in their firm.'' They also note that earnings uncertainty may lead a borrower to select an FRM. On a related note, Boyd (1988) focuses on the role played by borrower assets, hypothesizing that asset position affects how sensitive ARM preference is to interest rates and household income. Similarly, Sa-Aadu and Shilling (1994), Chiang, Chow, and Liu

(2002), and Campbell and Cocco (2003) all investigate the role of borrower risk aversion in influencing mortgage choice decisions. The influences of other borrower characteristics on the ARM-FRM decision, such as the existence of a co-borrower, age, marital status, and amount of education, have been noted in the literature as well.

Limited Empirical Evidence

Surprisingly, only a handful of empirical studies have actually examined the simultaneous impact of borrower characteristics and mortgage price variables on the ARM-FRM decision. These investigations generally report that mortgage pricing variables play the most important role (Dhillon, Shilling, and Sirmans, 1987; Brueckner and Follain, 1988). For example, Dhillon, Shilling, and Sirmans report that ''pricing variables play a dominant role in the choice decision,'' with a weak ''tendency for some classes of borrowers, like households with co-borrowers, married couples, and short expected housing tenures, to have a preference for adjustable-rate mortgages.'' They note that this is consistent with the concept of perfect capital markets, in which borrower characteristics would be expected to be irrelevant, since ''all borrower actions are anticipated and reflected in the prices and terms of the contracts.'' Similarly, Brueckner and Follain (1988) report that mortgage price variables are important, and that ''among borrower characteristics, only income and intermetropolitan mobility appear to matter.'' However, not all empirical findings downplay the influence of borrower characteristics. Sa-Aadu and Sirmans (1995) report that in addition to the influence of mortgage pricing variables, borrower characteristics ''are important determinants'' of mortgage contract choice, with borrower mobility and age affecting the use of shorter term contracts.

Default Risk and Transaction Costs of Default

Mortgage lenders and insurers have long attempted to limit, through manual and automated underwriting procedures, their exposure to borrower *default risk*. Traditionally, these procedures have relied heavily upon objective underwriting criteria and benchmarks such as loan-to-value (LTV) ratios, payment-to-income ratios, credit scores, and verifiable employment characteristics. More recently, however, the literature has also begun to recognize the potentially important role that asymmetric information may play in the mortgage choice decision. For example, Fahey (2004) observes:

> With so much choice available, informed borrowers hold the upper hand over lenders. This is because of the asymmetry of information between the parties—borrowers know more about their own plans and intentions than lenders do. Borrowers' cards are held close to the vest; lenders' are face up. And competing lenders jostle each other to get in line to offer borrowers their best deal. Borrowers can be opportunistic in selecting loan terms that are most advantageous to them. They can choose the optimal loan, be it a fixed-rate or one of the many varieties of variable rate products, from among lenders' varied offerings to best suit their circumstances.

If borrowers do indeed possess unique, unobservable information about their risk type, they may well be able to exploit this informational advantage over lenders in the origination process by self-selecting into relatively underpriced (on a risk-adjusted basis) mortgage product types. Consistent with this notion, Posey and Yavas (2001) develop a

theoretical signaling model which proposes that, in the presence of asymmetric information, when a borrower's transaction costs of default are sufficiently small (high), high default risk borrowers will select FRMs and low default risk borrowers will select ARMs products. This separating equilibrium arises because relative to FRMs, ARMs have both additional benefits and costs. Specifically, on the benefit side, ARM borrowers may be able to avoid costly defaults even if current income levels decline, provided interest rates (and hence the associated mortgage payments) drop sufficiently. On the cost side of the equation, ARM borrowers may face payment shock induced default (even if current income levels remain unchanged or rise) provided interest rates rise sufficiently. Intuitively, risky borrowers are more likely to enjoy the additional ARM benefit (as they are more likely than safe borrowers to experience a decline in future income levels), and less likely to incur the additional ARM cost (as they are less likely to have income levels remain constant or rise).

A particularly interesting feature of the preceding paradigm is that it allows the transaction costs of default to influence the mortgage choice decision as a contingent variable. The proposition that mortgage choice is contingent upon transaction costs represents an interesting departure from conventional transaction cost analysis, with its focus on explaining governance phenomena; and offers the potential to significantly influence lender behavior and produce a more discriminating match between lender product offerings and borrower demand.

The unique data set employed here enables simultaneous operationalization of borrower default risks, mortgage price variables, and transaction costs of default, as well as an empirical examination of the determinants of mortgage product choice. This paper is both the first time the mortgage choice decision has been empirically tested using transaction cost reasoning, and also represents the first empirical evidence supporting a contingent relationship between borrower default costs and the associated influence default risk exerts on the ARM/FRM mortgage choice decision.

Data

This study analyzes 1,003 single-family home purchase mortgage loans to empirically evaluate the key determinants of ARM-FRM borrower choice decisions, including the proposed contingency hypothesis, obtained using a stratified random sampling plan from a nationwide mortgage lender's portfolio. The sample consists of 911 FRM and 92 ARM loans, with the two types of loans defining the binary dependent variable (*ARMFRM*). A robust array of explanatory variables, including measures of a borrower's transaction costs of default, ex ante borrower default risk, mortgage pricing characteristics, and broader economic conditioning variables, enable evaluation of these influences on mortgage choice. The specificity of the loan-level data minimize parameter estimate bias and model misspecification.[4] For convenience, a complete description of each variable is provided in Appendix A. Descriptive statistics for the ARMs and FRMs are provided in Exhibit 1. For example, the average origination loan-to-value ratio (LTV) for both ARMs and FRMs is about 76%. For FRMs, over 39% of the loans include a co-borrower with positive gross income (*ADDINC*), while for ARMs the percentage is 35.9%. The average total debt ratio (*TOTDEBT*) of borrowers is 29.9% for FRMs and 27% for ARMs. The typical FRM borrower

Exhibit 1. Descriptive Statistics: ARMs vs. FRMs

Variable	Overall Mean	ARM Mean	FRM Mean
FICO	697 (58)	688 (61)	698 (58)
LTV	75.7% (8.2%)	76.3% (5.1%)	75.7% (8.4%)
ADDINC	38.8% (48.8%)	35.9% (48.2%)	39.1% (48.8%)
TOTDEBT	29.6% (9.6%)	27.0% (9.1%)	29.9% (9.7%)
LIQUID	109.3% (167.5%)	150.1% (200.8%)	105.2% (163.3%)
SELFEMP	7.3% (26.0%)	6.5% (24.8%)	7.4% (26.1%)
TCDEFAULT	43.7% (50.0%)	46.7% (50.2%)	43.3% (49.6%)
ARMWTERM	11.5% (31.9%)	15.2% (36.1%)	11.1% (31.4%)
PFRMARMDIFF	1.79% (0.26)	1.81% (0.25)	1.79% (0.26)
INTGCHOR	0.05 (0.01%)	0.05 (0.01%)	0.05 (0.01%)
OWNOCCUP	85.5% (35.2%)	82.6% (38.1%)	85.8% (34.9%)
APPREC	9.0% (3.9%)	8.9% (4.0%)	9.1% (3.9%)

Note: Standard deviations appear in parentheses.

has liquid assets (*LIQUID*) equal to 105.2% of annual gross income, while for ARM borrowers this value is 150.1%.

Transaction Costs of Default

Critical to testing the focal proposition is distinguishing between high and low borrower (transaction) default costs. As stated, transaction costs of default refer to costs associated with a borrower's defaulting on a mortgage, and include damage done to a borrower's credit rating, psychic adjustment costs due to relocation, search and legal costs arising from having to purchase a new house, and other default disutilities.[5] The operationalization of high versus low default costs makes use of state foreclosure rules pertaining to the property, reflecting the ease with which a lender can foreclose on a borrower's property.

Significantly, states differ according to whether they permit ''power of sale'' (i.e., non-judicial) foreclosure or require judicial foreclosure. In ''power of sale'' states, the lender can initiate the foreclosure process once the borrower defaults on the terms of the contract, without having to file a lawsuit to obtain court action. By contrast, in states with judicial foreclosure laws, the lender must take the borrower to court in order to foreclose on the property. Clauretie (1987) notes that judicial foreclosure is usually more

costly and time-consuming than non-judicial foreclosure, thereby reducing the lender's incentive to foreclose upon default. Thus, judicial foreclosure reduces the borrower's expected default cost. In a non-judicial foreclosure state, foreclosure is easier, and the borrower's expected default cost is higher.[6]

The high expected default costs is proxied by an indicator variable (*TCDEFAULT*) that is ''flagged'' (i.e., set equal to 1) if a borrower has a mortgage located in a non-judicial foreclosure state.

Borrower Default Risk

The contingency hypothesis identifies borrower default risk as a potential determinant of ARM-FRM choice, with risky borrowers (i.e., higher default probability borrowers) potentially self-selecting into different mortgage products than their safe borrower counterparts. In practice, a wide variety of observable borrower-specific attributes may materially influence an individual's default risk. This study empirically examines the potential influence of several of these risk characteristics on mortgage choice.

Credit Scores. The first borrower-specific default risk measure is the primary borrower's Fair, Isaac and Co. credit score (FICO). In the mid-1990s, both Fannie Mae and Freddie Mac endorsed the use of FICO scores in the mortgage underwriting process, based on the scores' ability to predict mortgage performance (i.e., delinquency outcomes). Even before this endorsement, FICO scores were being used pervasively by residential mortgage lenders to summarize credit bureau information and quantify borrower creditworthiness. FICO scores range from the mid-300s to the mid-800s, with higher scores indicative of lower expected default/delinquency risk.

Loan-to-Value Ratio. Traditionally, lenders have paid considerable attention to the borrower's loan-to-value ratio (LTV). This metric is an inverse measure of a borrower's equity stake in the property. Lower values of the ratio give the borrower a greater incentive to meet scheduled mortgage payments, thereby avoiding default and a foreclosure-induced equity loss. In the event of declining property values, the LTV ratio can exceed 100%, creating a negative equity situation and increasing the borrower's default risk.[7]

Co-Borrower Income. In addition to LTV ratios, the data also indicate whether the mortgage includes a co-borrower with positive income (*ADDINC*). A co-borrower is equally liable (with the borrower) for the payment terms of the mortgage contract. However, it is not legal liability per se that is of interest, but rather the financial contribution a co-borrower with positive income can make to satisfy the mortgage payment obligation if the principal borrower suffers an income reduction. Specifically, a co-borrower with positive income may be able to satisfy the payment obligations and insulate the loan from default (i.e., make it safer).

Total Debt-to-Income Ratio. Another borrower risk variable available in the data set is the total debt-to-income ratio (*TOTDEBT*). This metric takes into account both mortgage and non-mortgage debt, with non-mortgage debt encompassing credit card debt, car payments, and other revolving and non-revolving payment obligations. As this ratio increases, the borrower is less able to absorb unexpected expenses, and hence experiences a greater probability of defaulting, ceteris paribus.

Liquid Assets. Similarly, a borrower may own assets that can be used to meet mortgage payment obligations if regular income is unavailable. For example, a job change might disrupt the borrower's income stream, necessitating the liquidation of savings, stocks, bonds, or other assets to buffer against default. Accordingly, borrowers with more liquid assets (*LIQUID*) are expected to pose less default risk.

Self-Employment Risk. Finally, a widely-recognized borrower risk factor is risk attributable to self-employment. In an empirical study of entrepreneurship, wealth concentration, and mobility, Quadrini (1999) reports that the average annual exit rate from entrepreneurship for new self-employed businesspersons (i.e., those with one year of business tenure) is 35.2%. This rate declines to 19.1% for entrants with two years of business tenure, and to 7.2% for those with three or more years of entrepreneurial tenure. Additionally, there is evidence that entrepreneurs exhibit higher income volatility than ''wage-earners with comparable characteristics,'' (Rosen and Willen, 2002). A dichotomous variable (*SELFEMP*) represents self-employed borrowers who have three or fewer years of tenure.

Mortgage Price Variables

Note that one of the primary objectives is to empirically examine the impact of borrower default risk on mortgage choice, *contingent* on transaction default costs. To legitimately evaluate the determinants of mortgage choice and minimize model misspecification, the analysis must therefore also include mortgage price variables that have been shown to influence the ARM-FRM choice. Thus, several proxies are included to account for the price difference between ARM and FRM credit.

Market Interest Rate Differential between ARMs and FRMs. A variable is included that captures the difference between the prevailing market rate of interest on ARM and FRM products at the time of loan origination (*PFRMARMDIFF*). Given the efficient market view that applicants will choose the least expensive mortgage (Tucker, 1989), this is obviously an important mortgage price control to include in the model. The prevailing market rates for all mortgage products are based on data from Freddie Mac's Primary Mortgage Market survey. Points and fees are included into the calculation of effective rates assuming all loans terminate after 40% of their original term.[8] The larger the difference between fixed and adjustable rates, the greater the compensation the borrower receives for assuming the interest rate risk associated with the loan. Consistent with the literature, it is hypothesized that larger values of *PFRMARMDIFF* will be associated with increased probabilities of selecting adjustable-rate products.

Interest Rate Volatility. Higher levels of interest rate volatility are expected to tilt borrowers away from the uncertainty of ARMs towards the greater certainty of FRM credit pricing. A measure of interest rate volatility is included to control for this effect. Specifically, the conditional volatility of the 10-year constant maturity treasury rate is used that employs an exponential GARCH specification (*INTGCHOR*).[9]

Loan Qualification Signal. Whether an applicant would qualify for conventional financing at the prevailing market adjustable-rate but *not* at the prevailing market fixed-rate is used as a loan qualification signal to control for this effect. Loans for which the applicant only qualifies using the (lower) initial ARM rate are flagged (i.e.,

A*RMWTERM*=1). In circumstances where *ARMWTERM* is flagged, the applicant likely receives the ''correct'' incentive (or information signal), and will more likely select an ARM. Inclusion of this variable helps control for the possibility that the ARM-FRM decision is influenced by lenders pushing riskier applicants into ARMs for which they will qualify.

Economic Conditioning Variables

Information on the occupancy status of the home securing the mortgage note, recent home price appreciation trends, and time flags are included to control for potential variation in economic conditions and motivations across borrowers, location, and time. Specifically, owner occupants may well be characterized by longer expected holding periods for individual properties, and thus, may well exhibit an enhanced proclivity to select FRM products. These mobility-related considerations are controlled by including a binary variable (*OWNOCCUP*), which takes on the value of one if the property securing the lien is occupied by the borrower, zero otherwise. Next, as increasing house prices may influence a prospective borrower's willingness and ability to accept additional uncertainty through the assumption of interest rate risk on ARM loans, the recent level of local housing appreciation (*APPREC*) is also controlled. Specifically, the average annualized rate of housing appreciation over the past five years is calculated for each loan in the dataset for the community in which the property is located using Freddie Mac's Conventional Mortgage Home Price Index (*CMHPI*). For loans made on properties outside of localities explicitly covered by the CMHPI, a corresponding CMHPI appreciation rate is substituted for the state in which the property is located. Finally, a series of dummy variables identifying the calendar year and quarter in which each sample loan was originated is included to control for unobserved heterogeneity in underwriting standards and economic conditions across time. While the sample loans were all originated within a relatively short (seven quarter) interval, and thus would not be expected to materially influence the results, such ''vintage'' controls should help mitigate the potential for model misspecification through omitted variable biases.

Analysis

The following binary logistic equation with interaction terms is used to empirically evaluate the determinants of mortgage choice, including the proposed contingent hypothesis regarding default costs and default risk:

$$\log\left\{\frac{\Pr(ARMFRM = 1|\mathbf{x})}{1 - \Pr(ARMFRM = 1|\mathbf{x})}\right\} = \beta_0 + \mathbf{x}'\boldsymbol{\beta},$$

where $\mathbf{x}' = (x_1, \ldots, x_p)$ is the vector of p explanatory variables, β_0 is the intercept parameter, $\boldsymbol{\beta}$ is the vector of slope parameters, and the dichotomous dependent variable *ARMFRM* takes on the value 1 if the loan is an ARM; 0 if it is an FRM. The interaction variables are constructed as cross-products of *TCDEFAULT* with each of the borrower default risk variables. All ''constitutive'' components comprising the interaction variables are included to avoid model misspecification (Allison, 1977; Brambor, Clark, and Golder, 2006).

The estimated coefficients for a model that includes the six interaction terms, all constitutive variables, and the mortgage price and economic conditioning controls are

Exhibit 2. Estimated Logistic Regression Coefficients: Initial Model

Variable	Beta Coefficient	Standard Error
Intercept	−1.429	5.638
Borrower Risk Variables		
FICO	−0.004	0.005
LTV	0.046	0.024*
ADDINC	−0.374	0.550
TOTDEBT	−0.103	0.032***
LIQUID	0.003	0.002**
SELFEMP	−2.031	0.589***
Transaction Costs of Default Variable		
TCDEFAULT	−3.733	6.879
Interaction Terms		
*TCDEFAULT*FICO*	0.003	0.007
*TCDEFAULT*LTV*	−0.009	0.039
*TCDEFAULT*ADDINC*	0.530	0.720
*TCDEFAULT*TOTDEBT*	0.100	0.065
*TCDEFAULT*LIQUID*	−0.001	0.003
*TCDEFAULT*SELFEMP*	2.491	1.146 **
Mortgage Price and Economic Conditioning Variables[a]		
ARMWTERM	0.699	0.568
PFRMARMDIFF	1.383	3.137
INTGCHOR	−35.999	63.081
OWNOCCUP	0.004	0.535
APPREC	0.001	0.052

Notes: The dependent variable is *ARMFRM*. The number of observations is 1,003. The Nagelkerke's R^2 is 0.174, the Cox and Snell's R^2 is 0.074.

[a] The six "dummy" variables indicating origination quarter (i.e., *ENTRY90Q1, ENTRY90Q2,* etc.) are included in the model, but not displayed in the table. None of the estimated dummy entry coefficients are statistically significant.

* Statistically significant at the 0.10 level.

** Statistically significant at the 0.05 level.

*** Statistically significant at the 0.01 level.

shown in Exhibit 2. This model, with 25 parameters, has a log likelihood statistic (−2lnL) of 475.47. Since a model with constant term-only has a log likelihood statistic of 552.18, the likelihood ratio test statistic comparing the two models has a *p*-value of $P[\chi^2\ (24) > 76.71] < .001$. The null hypothesis that all of the population coefficients for the variables excluded are zero is therefore rejected.

The Wald test statistics for the coefficients to the interactions involving total debt ratio and self-employment risk (i.e., *TCDEFAULT*TOTDEBT* and *TCDEFAULT*SELFEMP*) yield *p*-values of .125 and .03, respectively, suggesting the need for further investigation. On the other hand, the Wald statistics of the coefficients to the interactions involving FICO score (*TCDEFAULT*FICO*), LTV ratio (*TCDEFAULT*LTV*), additional co-borrower income (*TCDEFAULT*ADDINC*), and liquidatable assets (*TCDEFAULT*LIQUID*) all have associated *p*-values greater than .45. Because of limitations with the Wald test as an inferential tool (Hauck and Donner, 1977), likelihood ratio tests of the significance of the interaction terms are performed. First, consider a test of the null hypothesis that the coefficients for the interaction terms (as a set) are equal to zero. The likelihood ratio test

comparing a main effects only model (i.e., excluding all interaction terms) with the model that includes the six interaction terms has a *p*-value of $P[\chi^2(6) > 15.45] = .017$, indicating that the interaction terms represent a significant enhancement over a model that contains only main effects. Since rejection of the null hypothesis does not mean that all of the interaction coefficients are different from zero, a likelihood ratio test comparing the model containing all six interaction terms to a model that excludes the four interaction terms whose coefficients the Wald tests strongly indicated to be insignificant is performed (i.e., *TCDEFAULT*FICO*, *TCDEFAULT*LTV*, *TCDEFAULT*ADDINC*, and *TCDEFAULT*LIQUID*).[10] The result is a test statistic with a *p*-value of $P[\chi^2(4) > 2.34] = .673$. Accordingly, the null hypothesis that the coefficients to the four interaction terms are equal to zero is not rejected. On the other hand, comparing a model that contains all six interactions to a model that excludes the two interaction terms *TCDEFAULT*TOTDEBT* and *TCDEFAULT*SELFEMP* (i.e., the two interaction terms warranting further investigation, as suggested by the initial Wald test statistics) results in a likelihood ratio test statistic with a *p*-value of $P[\chi^2(2) > 11.61] = .003$, and rejection of the null hypothesis that the coefficients to the interaction terms are zero. Based on the tests described, a reduced model containing two interaction terms, namely *TCDEFAULT*TOTDEBT* and *TCDEFAULT*SELFEMP*, is employed. The estimated coefficients to this model, along with corresponding constitutive terms, borrower risk and mortgage price, along with economic conditioning variables, are displayed in Exhibit 3.

Although none of the mortgage price and economic conditioning variables have statistically significant coefficients, they are retained in the model based upon reasonable priors for their inclusion. Consistent with Brambor, Clark, and Golder (2006), the coefficients to the constitutive variables in the model are not interpreted, since they do not represent unconditional effects.[11]

Turning to the focal contingency proposition, odds ratios are estimated for the effects of *TOTDEBT* and *SELFEMP* on ARM/FRM choice, corresponding to the low and high borrower default cost conditions (*TCDEFAULT*). In the absence of any interactions in the model, the odds ratio for the effect of any specific variable is *e* raised to the estimated coefficient of that variable. The confidence interval for the odds ratio is calculated using the standard error of the estimated coefficient (routinely provided by most logistic software programs). However, with an interaction model, the situation is more complex, and the estimated odds ratio for the effect of a variable is obtained by exponentiating a linear function that includes the coefficients to that variable and the coefficients to the interaction terms in the model. Moreover, to obtain a confidence interval for this odds ratio (necessary for hypothesis testing), the estimated variance is properly calculated as a linear combination of the variances and covariances of the estimated coefficients (Hosmer and Lemeshow, 1989; Kleinbaum and Klein, 2002).[12]

Consider the borrower default risk variable *SELFEMP*. The interest is in the effect of *SELFEMP* on mortgage choice, contingent on the transaction costs of default. Following the approach described in Appendix B, odds ratios and 95% confidence intervals corresponding to the two transaction default cost conditions (*TCDEFAULT* = 0 and *TCDEFAULT* = 1) are determined. As shown in Exhibit 4, when borrower transaction costs of default are low (i.e., *TCDEFAULT* = 0), the point estimate of the odds ratio for

Exhibit 3. Estimated Logistic Regression Coefficients: Reduced Model

Variable	Beta Coefficient	Standard Error
Intercept	−2.070	4.405
Borrower Risk Variables		
FICO	−0.003	0.003
LTV	0.042	0.021**
ADDINC	−0.110	0.374
TOTDEBT	−0.105	0.031***
LIQUID	0.002	0.002
SELFEMP	−2.205	0.570***
Transaction Costs of Default Variable		
TCDEFAULT	−2.622	1.727
Interaction Terms		
*TCDEFAULT*TOTDEBT*	0.103	0.061*
*TCDEFAULT*SELFEMP*	2.657	1.191**
Mortgage Price and Economic Conditioning Variables[a]		
ARMWTERM	0.709	0.590
PFRMARMDIFF	1.716	3.148
INTGCHOR	−47.306	65.950
OWNOCCUP	0.049	0.511
APPREC	−0.003	0.054

Notes: The dependent variable is *ARMFRM*. The number of observations is 1,003. The Nagelkerke's R^2 is 0.169, the Cox and Snell's R^2 is 0.071.

[a] The six "dummy" variables indicating origination quarter (i.e., *ENTRY90Q1*, *ENTRY90Q2*, etc.) are included in the model, but not displayed in the table. None of the estimated dummy entry coefficients are statistically significant.

* Statistically significant at the 0.10 level.

** Statistically significant at the 0.05 level.

*** Statistically significant at the 0.01 level.

Exhibit 4. Estimated Odds Ratios (OR) and 95% Confidence Intervals (CI) for the Effects of Total Debt Ratio and Recent Self-Employment

Borrower Default Risk Factors	High	Low
	TCDEFAULT = 1	*TCDEFAULT* = 0
TOTDEBT		
OR	1.00	0.90
CI	0.88, 1.13	0.85, 0.96
SELFEMP		
OR	1.57	0.11
CI	0.21, 11.61	0.04, 0.34

Notes: *TOTDEBT* = total debt ratio; *SELFEMP* = recently self-employed.

the effect of *SELFEMP* is 0.11, indicating that recently self-employed (i.e., riskier) borrowers have odds of selecting ARMs that are 0.11 that of borrowers who are not recently self-employed.[13] Since the calculated endpoints of a 95% confidence interval for the odds ratio are 0.04 and 0.34, a range that does not encompass the null value of 1.0, this is a statistically significant estimate. Turning to the case where borrower transaction costs of default are high (*TCDEFAULT* =1), the odds ratio point estimate for *SELFEMP* is 1.57, with 95% confidence limit endpoints of 0.21 and 11.61. The interval surrounding this estimate encompasses the null value of 1.0, so the result is not statistically significant at the 5% level.

To summarize, when a borrower's transaction costs of default are small, recently self-employed borrowers tend to select FRMs over ARMs. However, when transaction costs are high, there is insufficient statistical evidence to conclude that borrowers prefer one product over another.

Next, consider the case of *TOTDEBT*. Again, the interest is in the effect of *TOTDEBT* on mortgage choice (*ARMFRM*), contingent on the transaction costs of default (*TCDEFAULT*). As shown in Exhibit 4, when borrower transaction costs of default are low (i.e., *TCDEFAULT* = 0), the odds ratio for the effect of *TOTDEBT* is 0.90, with 95% confidence interval endpoints of 0.85 and 0.96. Thus, each one percentage point increase in a borrower's total debt ratio reduces the odds of choosing an ARM by a factor of 0.90 (controlling for other variables in the model). Since the confidence interval does not encompass 1.0 (i.e., the null value), this odds ratio estimate is statistically significant at the 5% level. On the other hand, when transaction costs are high (*TCDEFAULT* = 1), the odds ratio is 1.00, with 95% confidence interval endpoints of 0.88 and 1.13. This confidence interval includes the null value of 1.0, so the odds ratio estimate is not statistically significant.

In summary, there is strong evidence that when a borrower's transaction costs of default are sufficiently small, increases in the total debt ratio increase the odds that the borrower will select a FRM over an ARM. On the other hand, the estimated odds ratio is not statistically significant when borrower transaction costs of default are high.

Conclusion

One of the most important decisions prospective mortgage borrowers make is whether to select a FRM or an ARM. At the same time, lenders have an interest in better understanding the consumer choice process leading to this selection, with savvier lenders better positioned to meet the demands of consumers and profit from such insight. Whereas the extant literature has sought to explain, with mixed results, the choice between ARMs and FRMs mainly by examining various borrower characteristics and mortgage price variables, this investigation empirically examined the interplay between borrower default risk and the previously unexamined issue of borrower transaction costs of default. Employing an interaction logistic regression model, in which a range of borrower default risk factors are considered, along with mortgage price and economic conditioning variables, and a measure of the transaction costs of default, evidence is found that total debt ratios and recent self-employment interact with borrower default costs in

influencing mortgage choice. Specifically, when borrower transaction costs of default are small, increases in borrower default risk decrease the odds that the borrower will choose an ARM. However, when borrower transaction costs of default are high, there is no statistically discernible relationship between increases in borrower default risk and the odds of choosing an ARM.

Given the importance and complexity of the mortgage product selection process, this investigation contributes to the literature by empirically testing whether mortgage choice is a *contingent* decision, in which borrower default risk factors such as total debt ratios and (recent) self-employment status interact with borrower transaction costs to determine the mortgage product chosen. This study represents the first empirical attempt to explicitly apply transaction cost reasoning to the mortgage choice decision.

Appendix A

Variable Operationalizations

Variable	Description
ARMFRM	Dichotomous variable equal to 1 if the loan is an ARM; 0 if a FRM.
TCDEFAULT	Dichotomous variable equal to 1 if the property is subject to non-judicial foreclosure; 0 otherwise
FICO	The primary borrower's Fair Isaac and Co. credit (FICO) score.
LTV	Loan-to-value ratio at origination, based on the lesser of sales price or appraised value. Expressed in percentage format.
ADDINC	Dichotomous variable equal to 1 if there are two or more formally designated borrowers (i.e., a principal borrower plus one or more co-borrowers) and the gross income of the first co-borrower is positive; 0 otherwise.
TOTDEBT	Monthly principal, interest, taxes, and insurance ("piti") payments plus all other monthly payment obligations divided by total (including co-borrower) gross monthly income. Expressed in percentage format.
LIQUID	The value of savings, stocks, bonds, etc. held by the borrower divided by total (including co-borrower) gross annual income. Expressed in percentage format.
SELFEMP	Dichotomous variable equal to 1 for recently self-employed borrowers (i.e., 3 or fewer years); 0 otherwise.
OWNOCCUP	Dichotomous variable equal to 1 if the property is owner-occupied; 0 otherwise.
APPREC	The average annualized house price appreciation rate over the preceding five years for the locality in which the property securing the mortgage lien is located. Appreciation rates are estimated using Freddie Mac's Conventional Mortgage Home Price Index (CMHPI).

Variable	Description
ARMWTERM	Dichotomous variable equal to 1 if the borrower qualifies for conventional financing based under prevailing adjustable-rates but not under prevailing fixed-rates; 0 otherwise. Qualification is based upon the traditional underwriting standard of a 28% PITI (principal, interest, taxes, and insurance) to income threshold. Property tax and insurance costs are available for each loan in our dataset, while prevailing market interest rates are calculated for each loan using information from Freddie Mac's Primary Mortgage Market Survey. Points are imputed into the calculation of effective market interest rates for each loan assuming the loan will terminate after 40% of the original term is complete.
PFRMARMDIFF	The difference between the prevailing market rate of interest on fixed-rate and adjustable-rate mortgage products at the time of loan origination. Prevailing market rates for all mortgage products are based upon data from Freddie Mac's Primary Mortgage Market survey.
INTGCHOR	The conditional volatility of the 10-year constant maturity treasury rate, based on an exponential GARCH specification.
ENTRY90Q1, ENTRY90Q2, ENTRY90Q3, ENTRY90Q4, ENTRY91Q1, & ENTRY91Q2	Six "dummy" variables (0 or 1) used to indicate the loan's origination quarter. The reference (omitted) dummy variable is *ENTRY89Q4*.

Appendix B

Calculating Odds Ratios and Confidence Intervals in the Case of Interaction Effects

As outlined in Kleinbaum and Klein (2002), when the logistic regression involves interaction effects, the estimated odds ratio is given by:

$$\hat{O} = e^{\hat{l}},$$

where l is a linear function (and $\hat{l}$ is the estimate of the function based upon maximum likelihood estimates) of the form:

$$l = \beta + \sum_{j=1}^{p_2} \delta_j W_j$$

and β is the coefficient to the borrower default risk ("exposure") variable (*TOTDEBT*; *SELFEMP*), δ s are the coefficients to the interactions (*TCDEFAULT*TOTDEBT*; *TCDEFAULT*SELFEMP*), W s are the effect modifiers (*TCDEFAULT* = high (1) or low (0)), and p_2 is the number of interactions.

The formula for the associated confidence interval of the odds ratio is:

$$\exp[\hat{l} \pm Z_{1-\alpha/2}\sqrt{\hat{\text{var}}(\hat{l})}],$$

where the estimated variance of $\hat{l}$ is given by:

$$\hat{\text{var}}(\hat{l}) = \hat{\text{var}}(\hat{\beta}) + \sum_{j=1}^{p_2} W_j^2 \hat{\text{var}}(\hat{\delta}_j) + 2 \sum_{j=1}^{p_2} W_j \hat{\text{cov}}(\hat{\beta}, \hat{\delta}_j) + 2 \sum_{j} \sum_{k} W_j W_k \hat{\text{cov}}(\hat{\delta}_j, \hat{\delta}_k)$$

(the vâr and côv values obtained from the estimated variance-covariance matrix).

Endnotes

[1] As reported by Fahey (2004), ''Angelo Mozilo, the chairman of Countrywide Financial, has stated that borrowers can choose from 180 mortgage loan products in his company's offerings.''

[2] Additional evidence of the linkages between interest rates and mortgage choice decisions can be found in Brueckner and Follain (1988), Brueckner (1993), Campbell (2006), and Vickery (2006).

[3] For additional studies on the effects of mobility on mortgage choice decisions see Brueckner (1993), Rosenthal and Zorn (1993), Gabriel and Rosenthal (1993), and Chan (1996).

[4] While the dataset is uniquely robust in the level of loan-specific attributes available, there is one potentially important data limitation—the potential for sample selection bias. Specifically, the loans examined in this study are exclusively loans that were actually ''booked.'' Some applicants seeking entry into the pool may have been denied a loan, although no information is available on these prospective borrowers. To the extent that incentives and/or preferences of these rejected applicants systematically differ from those of the applicants included in the sample, the generalizability of the results may be curtailed.

[5] Transaction costs of default do not have to be financial in nature. For example, in the event of a default that leads to loss of the house, a family is forced to move, with the result that the children may have to make new friends. Such a non-pecuniary externality may also be viewed as a transaction cost.

[6] According to http://www.foreclosures.com, the time to complete foreclosure proceedings (including any statutorily mandated redemption period) and obtain ''absolute title'' varies widely, from as little 60 days in states such as Louisiana, Mississippi, New Hampshire, Texas, and West Virginia to a year or more in states such as Alabama, Kansas, Maine, Minnesota, and Wisconsin.

[7] While loans with high LTV ratios are generally considered to be riskier than their low LTV counterparts, a pair of recent empirical investigations have challenged this widely held belief. First, Archer, Elmer, Harrison, and Ling (2001) argue that lenders originating high LTV loans will likely require compensating factors along other dimensions to offset this risk source. Consistent with this notion, they find no statistically significant relationship between the incidence of default and LTV ratios at origination. Second, Harrison, Noordewier, and Yavas (2004) argue that borrowers with private information about their risk type may self-select into differing mortgage products. Within their framework, high LTV loans may signal either high or low default risk, depending on additional borrower and market considerations.

[8] In practice, a relatively small fraction of mortgage loans follow their original amortization schedule from origination until their maturity date. Reasons for early termination vary widely, but are generally classified into two competing hazards: prepayment and default. Default events occur when borrowers become unable (or unwilling) to make timely payments of principal and/or interest on the loan. Prepayment occurs when the loan is paid off in full prior to maturity, which is caused by a number of factors, including refinancing the loan or selling the property. While these events are difficult to accurately

forecast, lenders need to estimate the expected duration of the loan in order to calculate the effective borrowing cost. Since a mortgage often requires the payment of points or other up-front fees at the time of loan origination, measuring the true cost of the loan requires amortizing these fees over the expected life of the product. Consistent with the literature (e.g., Lee, 2003), it is assumed here that all loans terminate after 40% of their original maturity has elapsed. Thus, a 30-year loan's points and fees are amortized over twelve years.

[9] For details on the rationale behind, and construction of, the exponential GARCH (i.e., EGARCH) metric, see Harrison et al. (2002).

[10] In all of the models discussed, *FICO*, *LTV*, *ADDINC*, *LIQUID*, *TOTEBT*, and *SELFEMP* are retained, whether or not they interact with the effect modifier *TCDEFAULT*.

[11] As Brambor, Clark, and Golder (2006) observe, ''it makes little sense to talk about the unconditional or average effect of X on Y when you have a conditional hypothesis.''

[12] The hypothesis-testing approach is employed since in their review of 72 articles (from the 13 economics journals listed in JSTOR from 1980 to 1999) that dealt with nonlinear models (e.g., logit, probit, etc.) with explicit interaction terms, Ai and Norton (2003) report that *not a single one* correctly interpreted the coefficient. The interaction effect, they emphasize, ''cannot be evaluated simply by looking at the sign, magnitude, or statistical significance of the coefficient on the interaction term when the model is nonlinear.'' See Appendix B for the appropriate formulas involved in calculating the odds ratios and their associated confidence intervals when the logistic regression involves interaction effects.

[13] The inverse odds ratio can be used (DesJardins, 2001) to facilitate interpretation of odds ratios with values less than 1.0. In this case, the inverse odds ratio is $1/0.11 = 9.1$, indicating that borrowers who have not been recently self-employed have odds of choosing an ARM that are over nine times greater than that of recently self-employed borrowers.

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David M. Harrison, Texas Tech University, Lubbock TX 79409-2101 or david.m.harrison@ttu.edu.

Thomas G. Noordewier, University of Vermont, Burlington, VT 05405 or tom.noordewier@uvm.edu.