

What homebuyers need to know about the differential risk of mortgages

Larry J. Prather^{a,*}, Che-Chun Lin^b, Ting-Heng Chu^c

^a*Department of Accounting and Finance, Southeastern Oklahoma State University, Durant, OK 74701, USA*

^b*Department of Quantitative Finance, National Tsing Hua University, Hsin-Chu 30013, Taiwan*

^c*Department of Economics and Finance, East Tennessee State University, Johnson City, TN 37614, USA*

Abstract

Because homeownership represents the largest investment many individuals make, and the credit risks of competing mortgage products are not well understood, we develop a framework to quantify absolute and relative credit risks of mortgage products. We use simulations to examine the default rates of five types of mortgage products under both a normal and stressed economy to examine relative risk differences among the competing mortgage products. Results suggest that some mortgage products have a default risk four times larger than fixed-rate loans and default probabilities of 30% in a stressed economy. As a result, homebuyers should consider the credit risk of competing mortgage products before selecting a mortgage.

JEL classification: G21; G17

Keywords: Home mortgages; Default risk; Mortgage products

1. Introduction

Choosing the best mortgage to finance a home purchase can be an overwhelming task. While homebuyers traditionally had only fixed rate mortgages (FRMs) to consider, today numerous types of mortgage loans are available to finance or refinance their home. In addition, plenty of research exists that is devoted to assisting homebuyers in making the best choice. Articles such as Herman and Lloyd (1995) explain important, and sometimes

* Corresponding author. Tel.: +1-580-745-2566; fax: +1-580-745-7485.

E-mail address: lprather@se.edu (L.J. Prather)

complex, loan terms and characteristics. Moreover, research abounds that provides guidance in choosing between FRMs and adjustable rate mortgages (ARMs) (e.g., Dhillon, Shilling, and Sirmans 1987; Templeton, Main, and Orris, 1996), the choice between ARMs with different lengths of fixed rate periods and caps (Templeton, Main, and Orris, 2002), the tradeoff between points and mortgage rates (Yang, 1992), and the choice between 15-year and 30-year loans (e.g., Dhillon, Shilling, and Sirmans, 1990; Phillips, Rosenblatt, and Vanderhoff, 1992; Janjigian, 1994; Vruwink and Gisher, 1995; Goff and Cox, 1998; Kistner, 1998, 2001; Tomlinson, 2002; Basciano, Grayson, and Walton, 2006; Baek and Bilbeisi, 2011), and the choice between monthly and bi-monthly mortgage payments (Yohannes, 1991). As an extension, Hoover (2003) and Fortin, Michelson, Smith, and Weaver (2007) provide information to assist homeowners with making the best refinancing decision. McClatchey and de la Torre (2008) even provide a four step process that can be used to compare the loan products from various lenders.

Lee and Hogarth (2000) find that 78% of people seeking a home loan compare interest rates, 76% compare the type of loan, and 54–65% compare fees. Comparing loan terms is a good start in comparing mortgages because the best mortgage choice for a given homebuyer is complex and depends on a multitude of factors such as their marginal tax rate, risk tolerance, expected length of the homeownership period, and investment opportunities. Research also details how changes in borrower characteristics do, or should, affect loan choice. However, the research above primarily focuses on the best financial outcome in terms of an extended time-value-of-money approach without considering credit risk differences among mortgage loans. However, credit risk differences are important and the importance of these differences may have increased with the introduction of numerous nontraditional mortgage products (NMPs) during the last decade. These NMPs entail creative features such as hybrid fixed-rate and adjustable-rate periods and provide various payment options for borrowers which can cause payments to increase in the future to a point where the homebuyer may no longer afford to make the payment.

Not only are NMPs a concern, but Campbell and Cocco (2003), Miles (2004, 2005), and Miles and Pillonca (2007) suggest that while ARM contracts generally enhance the affordability of a home purchase, ARMs carry higher credit risk than FRMs. Unfortunately, there is a paucity of studies that consider the impact of key economic risk factors on various types of mortgage loans. While Follain (1990) discusses sources of uncertainty such as future interest rates, housing prices, and economic conditions, few studies (e.g., Yang, Buist, and Megbolugbe, 1998; Buist and Yang, 1998) explicitly deal with important variables such as income volatility, home price changes, and interest rate changes to analyze the default risk of mortgage contracts. We attempt to fill that gap by using the simulation framework of Buist and Yang (1998) to compare various NMPs with their counterparts in the conventional mortgage market.

Our goal is to provide comparative default risk information to homebuyers and professionals that may advise clients on home purchase and financing decisions such as financial planners, and real estate professionals. To accomplish that goal, we assess different mortgage types in terms of the two drivers of default risk—the probability of negative equity (PnegQ) and the probability of a payment shortage (PSHORT). Following Yang, Buist, and Megbolugbe (1998), we analyze the probability of default as the probability of both events

occurring simultaneously. Second, we use Monte Carlo simulations with three correlated stochastic variables (mortgage interest rate, home price, and household income) to determine the default risk of various ARM and FRM contracts under normal and stressed economies. The results show that NMPs improve affordability at the cost of higher credit risk. As we show later in the article, some of these creative loans have a probability of default as much as four times larger than traditional fixed-rate mortgages. Moreover, the probability of default in a stressed economy ranges from 17% to 30% for some products. Thus, some of these products should probably be avoided.

The remainder of the article is organized as follows. Section 2 provides background information and Section 3 presents the model and details the sample of products being analyzed. Section 4 presents the results of our simulations under a variety of economic conditions. Section 5 concludes.

2. Background

2.1. Mortgage risk

The ability of the borrower to pay the monthly payment has been considered to be one of the most important credit risk factors and a borrower should not default if they can afford to pay the monthly payment. An “ability-to-pay problem” occurs when the borrower cannot afford to pay the required payment. Ability-to-pay problems are typically managed at mortgage origination by setting maximum allowable payment-to-income ratios (PTI). While PTI can be controlled at mortgage origination, PTI can change over time because of economic events that cause income to change or mortgage terms that cause future payments to change.

Another risk comes from option theory that suggests that a borrower would have an incentive to default when the unpaid mortgage principal balance (UPB) exceeds the market value of the house used as collateral. Defaults caused by negative equity are referred to as “willingness-to-pay problems.” Willingness-to-pay problems are managed at mortgage origination by setting a maximum allowable loan-to-value ratio (LTV) which is intended to mitigate negative equity situations. While initial LTV ratios can be controlled at mortgage origination, future economic conditions will influence the future home price and mortgage terms will influence the future UPB. Thus, future LTV ratios depend on both mortgage terms and future economic conditions.

Future ability-to-pay and willingness-to-pay problems are functions of mortgage characteristics and future economic conditions. While homebuyers may not be able to control future economic conditions, they need to understand that risk exists. Moreover, because mortgage terms differ, the risk of ability-to-pay and willingness-to-pay problems will differ with the mortgage that the homebuyer chooses. Therefore, it would be informative to examine the relationship between mortgage characteristics and future ability-to-pay and willingness-to-pay problems of competing mortgage contracts under normal economic conditions and under a “stressed” economy. This will provide homebuyers with some information about absolute

and relative risk differences of several different mortgage types. Homebuyers need to consider this risk as they attempt to select the best home mortgage.

2.2. Mortgage affordability

One approach to improve affordability is to encourage borrowers to use ARMs instead of FRMs. Because lenders do not face interest rate risk, ARMs can be offered at lower interest rates than FRMs. Thus, borrowers receive lower monthly payments and therefore face lower income requirements. Most recently issued ARMs include a “teaser” rate, which is a low rate for the beginning period. This innovation was also modified to include an option payment ARM which gives the borrower the option to determine the size of the monthly payment. The payment options range from a full amortization payment to a minimum payment that is not sufficient to cover the interest obligation. If the borrower chooses to make the minimum payment, the unpaid portion of the interest obligation is added to the mortgage balance, causing negative amortization. This product carries very low initial interest rates so that borrowers with limited income can qualify.

2.3. Evolution of the mortgage market

Dhillon, Shilling, and Sirmans (1987) reported that the market share of ARMs increased from 8% in 1981 to a peak of 65% in 1984. By 2005, ARMs accounted for 50% of mortgages originated and currently, ARMs account for approximately 10% of originations. The recent decrease is presumably because of low rates on fixed rate mortgages and high mortgage default rates reported by the media. We have also seen the rise of various specialized ARM products such as 2/28 and 3/27 hybrid ARMs, negative amortization mortgages, option payment ARMs, and 3/1 or 5/1 ARMs with a cap structure. These NMPs pose a challenge in terms of assessing their risk. Because of the newness of those products, there is lack of performance data that prevents empirically gauging the extent of the risks posed by these products in different stages of the economic cycle.

Characteristics of 2/28 and 3/27 mortgages make them difficult to properly value and they can be extremely risky. These hybrid mortgages feature a fixed rate for two or three years, respectively. After the fixed period, the interest rate typically resets semiannually afterward. This feature creates a potential ability-to-pay problem. This is particularly important because these types of loans were designed to provide borrowers with marginal credit ratings time to improve their credit to refinance into a less risky loan.

Several studies link mortgage choice to macroeconomic outcomes (e.g., Campbell and Cocco, 2003; Miles, 2004; Vickery, 2007; Wyman, 2005). ARM contracts create an income risk for a borrower because interest rate changes can cause significant payment shocks in an increasing rate environment. This can increase mortgage default risk. The initial teaser rates in ARM contracts may be viewed as attractive to borrowers at the initial stage, but they can increase the likelihood of payment shock and default risk.

The research most relevant to this article examines mortgage choice in terms of loan termination and default-prepayment risks (e.g., Cunningham and Capone, 1990; Stanton and Wallace, 1995; Ambrose and LaCour-Little, 2001; Calhoun and Deng, 2002; Ambrose,

LaCour-Little, and Huszar, 2005). These studies indicate that hybrid ARMs experience relatively high default rates, which would be an expected outcome with a payment shock at the time of rate adjustment. The most recent extension in this area is LaCour-Little and Yang's (2010) finding that deferred amortization contracts are more prevalent in booming housing markets. Moreover, those mortgages default more often, particularly among lower-income borrowers with aggressive consumption levels.

3. Selected mortgage products and the simulation parameters

3.1. Mortgage characteristics and differential default risk

To provide a cross-section of mortgage products that represent mortgages that consumers must choose among, we investigate five competing types of mortgage products. These five types of mortgages present a representative sample of mortgages that will have different payments over time because of differential initial interest rates, differential future interest rates during the tenure of the loan, and differential payment terms that are dictated by the type of the loan. This is important because these factors will influence the default risk that the homebuyer will incur during the life of the loan. The five mortgage types we selected are: (1) 30-year fully amortized fixed rate mortgages (FRMs), (2) 30-year fully amortized adjustable rate mortgages (ARMs) with an annual reset frequency and no cap, (3) 30-year fully amortized ARMs with an annual reset frequency and a 5/1/1 cap, (4) 30-year hybrid 2/28 ARMs with an assumed initial fixed rate of 3% for first two years, and an interest rate that will reset at the benchmark index rate plus 2.75% and, (5) 30-year option payment ARMs where a minimum payment is made in the first five years that results in negative amortization during the minimum payment period. The initial contract rate for the option payment ARM is 3% and the margin is 2.75%. The rate will adjust and principal amortization will begin at the end of fifth year and there is a 7.5% annual payment cap.

These simulated economic paths are developed for the five types of mortgage contracts being analyzed. The parameters of the mortgage products are:

- Initial 30 year 5/1/1 ARM characteristics: LTV = 95, contract rate = 7%, initial interest rate = 3%, periodic cap = 1%, lifetime cap = 5%, adjustment interval = 12 months, assumed interest rate premium = -0.3%, $\alpha = 0.25$, initial payment-to-income ratio = 35%, threshold payment-to-income ratio = 40%;
- Initial Option ARM characteristics: initial contract rate = 3%, annual cap = 7.5%, margin = 2.75%, loan rate recast period = 60 months, minimal payment reset frequency = 12 months; and
- Initial 2/28 ARM characteristics: initial contract rate = 3%, loan rate reset period = 24 months, loan reset rate = 2.75% plus benchmark index rate.

Choosing mortgage types that have differential payments over time is important because finance literature suggests that mortgage defaults are generally caused by ability-to-pay problems and/or willingness-to-pay problems. An ability-to-pay problem occurs when the borrower lacks sufficient income to make the monthly mortgage payment. One facet of an

ability to pay problem is the size of the payment at any point in time. Thus, because the required payment varies over time with the characteristics of a given loan, ability-to-pay problems will differ for our selected loan products.

Willingness-to-pay problems refer to situations where the value of the mortgaged house falls below the unpaid principle balance (UPB) to the extent that the borrower has the incentive to quit making payments and let the lender take ownership of the collateral house. Willingness-to-pay problems can differ among our selected loan products as well because the amortization of principle can differ, causing the UPB to differ among loan products at different points of time during the tenure of the loan.

Yang, Buist, and Megbolugbe (1998) and Elmer and Seelip (1999) argued that willingness-to-pay problems are a necessary but not a sufficient condition to trigger mortgage defaults. Given the severe consequences of default, most borrowers would not default unless they are subject to both ability-to-pay and willingness-to-pay problems. Therefore, we follow the analytical framework of Buist and Yang (1998) to investigate the default risk embedded in various mortgage product types. Because loan characteristics affect ability-to-pay and willingness-to-pay problems, homebuyers need to be aware of the absolute and relative credit risk of various mortgage products.

3.2. Simulating default risk for selected mortgage products

To examine willingness-to-pay problems, we use a framework similar to Calhoun and Deng (2002) and Yang, Lin, and Cho (2011) who define the probability of negative equity (PnegQ) as the probability that the UPB of the mortgage is greater than the value of the collateral house (H).

To examine ability-to-pay problems, we follow the lead of Lin et al. (2011) and Lin et al. (2013) who use the probability of a PSHORT occurring. Thus, we define PSHORT as the probability that the borrower's income will be insufficient to support the borrower's minimum living expenses and mortgage payments. When normalized, PSHORT is closely related to the current payment-to-income ratio of a mortgage. As the mortgage payment becomes larger, ability-to-pay problems may occur. Similar to Buist and Yang (1998), we assume that default occurs if and only if both events occur simultaneously.

PnegQ and PSHORT are determined by three stochastic state variables; (1) the mortgage interest rate, (2) the home price growth rate, and (3) the household income growth rate (or their intertemporal changes designated as $[r, (dH/H), (dY/Y)]$, respectively). We assume these three risk factors r, H, Y follow stochastic processes.

The interest rate, Eq. (1), follows a Cox-Ingersoll-Ross (1985) mean-reverting square root process, where α is the mean-reverting speed, μ_r is the long term mean reverting level, and σ_r is the volatility. It is a macroeconomic variable that affects all mortgage loans and involves no idiosyncratic risk.

$$dr = \alpha(\mu_r - r)dt + \sigma_r \sqrt{r}dz, \quad (1)$$

Following Yang, Lin, and Cho (2011), we assume that the house price growth rate follows a two factor process (Eq. [2]). The first factor, h_1 , captures the variability of the local

market's house price index appreciation rate (HPA) and H_1 follows a geometric Brownian motion (log-normal process) with mean μ_{H_1} and volatility σ_{H_1} . The second factor, h_2 , captures the dispersion of individual house appreciation rates from local HPA and H_2 follows a geometric Brownian motion with mean zero and volatility σ_{H_2} .

$$\begin{aligned}\frac{dH}{H} &= \frac{dH_1}{H_1} + \frac{dH_2}{H_2} = h_1 + h_2 \\ \frac{dH_1}{H_1} &= \mu_{H_1}dt + \sigma_{H_1}dz_{H_1}; \quad \frac{dH_2}{H_2} = \sigma_{H_2}dz_{H_2}\end{aligned}\quad (2)$$

Eq. (3) presents the household income growth rates to capture the variability of the local market's income growth rate (y_1) and the dispersion of a particular household's income growth rate from the local market average (y_2). The Y_1 follows a geometric Brownian motion (log-normal process) with mean μ_{Y_1} and volatility σ_{Y_1} and the Y_2 follows a geometric Brownian motion with mean zero and volatility σ_{Y_2} .

$$\begin{aligned}\frac{dY}{Y} &= \frac{dY_1}{Y_1} + \frac{dY_2}{Y_2} = y_1 + y_2 \\ \frac{dY_1}{Y_1} &= \mu_{Y_1}dt + \sigma_{Y_1}dz_{Y_1}; \quad \frac{dY_2}{Y_2} = \sigma_{Y_2}dz_{Y_2}\end{aligned}\quad (3)$$

$z_r, z_{H_1}, z_{Y_1}, z_{H_2}, z_{Y_2}$ are five standard Weiner processes with the following correlation matrix:

$$\Sigma = \begin{bmatrix} 1 & \rho_{r,H_1} & \rho_{r,Y_1} & 0 & 0 \\ \rho_{r,H_1} & 1 & \rho_{H_1,Y_1} & 0 & 0 \\ \rho_{r,Y_1} & \rho_{H_1,Y_1} & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & \rho_{H_2,Y_2} \\ 0 & 0 & 0 & \rho_{H_2,Y_2} & 1 \end{bmatrix}. \quad (4)$$

The matrix in Eq. (4) assumes that correlations exist among the systematic risks (the interest rate, the local HPA, and the average household income growth rate in the area (z_r, z_{H_1} , and z_{Y_1})), respectively. The risks z_{H_2} and z_{Y_2} are independent from the systematic risks. However, a correlation exists between the dispersion of a single house's appreciation rate from the local HPA and the dispersion of a particular household's income growth rate from the local average income growth rate. Intuitively, they are positively correlated because a lower income household is more likely to undermaintain the house, causing the house to suffer above average physical deterioration. As a result, the appreciation rate of the house would be lower than other houses in the same local market.

Under a discrete time framework, the three stochastic risk factors can be rewritten as the following orthogonal processes (see Buist and Yang (1998)):

$$\Delta r_t = (\alpha + q)(\mu_r - r_{t-1}) + \xi_r \sigma_r \sqrt{r_{t-1}} \quad (5)$$

$$\Delta H_t = \mu_{H_1} + \xi_{H_1} \sigma_{H_1} + \xi_{H_2} \sigma_{H_2} \quad (6)$$

$$\Delta Y_t = \mu_{Y_1} + \xi_{Y_1} \sigma_{Y_1} + \xi_{Y_2} \sigma_{Y_2} \quad (7)$$

where q is the interest rate risk premium and the correlated shocks (ξ) can be rewritten in an orthogonalized system as:

$$\xi_r = \eta_r \quad (8)$$

$$\xi_{H_1} = \rho_{r,H_1} \eta_r + \sqrt{1 - \rho_{r,H_1}^2} \eta_{H_1} \quad (9)$$

$$\xi_{Y_1} = \rho_{r,H_1} \eta_r + \frac{(\rho_{H_1,Y_1} - \rho_{r,H_1} \rho_{r,Y_1})}{\sqrt{1 - \rho_{r,H_1}^2}} \eta_{H_1} + \frac{\sqrt{1 - \rho_{r,Y_1}^2} \sqrt{1 - \rho_{r,H_1}^2}}{(\rho_{H_1,Y_1} - \rho_{r,H_1} \rho_{r,Y_1})} \eta_{Y_1} \quad (10)$$

$$\xi_{H_2} = \eta_{H_2} \quad (11)$$

$$\xi_{Y_2} = \rho_{H_2,Y_2} \eta_{H_2} + \sqrt{1 - \rho_{H_2,Y_2}^2} \eta_{Y_2} \quad (12)$$

and η 's represents an independent random standard normal variable.

Parameters used in our simulations are described as follows (Buist and Yang, 1998¹; and Yang, Lin, and Cho, 2011²; provide justification for specific values):

- Long-term means and volatilities: $\mu_r = 0.065$, $\sigma_r = 0.15$; $\mu_{H_1} = 0.05$, $\sigma_{H_1} = 0.06$, $\sigma_{H_2} = 0.08$; $\mu_{Y_1} = 0.035$, $\sigma_{Y_1} = 0.05$, $\sigma_{Y_2} = 0.07$;
- Pair-wise correlations: $\rho_{r,H_1} = 0.4$, $\rho_{r,Y_1} = 0.7$, $\rho_{H_1,Y_1} = 0.6$, and $\rho_{H_2,Y_2} = 0.1$.

The assumptions and estimates provide initial values for our model's parameters and enable us to construct future economic shocks using Monte Carlo simulation. The parameter values represented as $[\mu_{H_1}, \sigma_{H_1}, \sigma_{H_2}]$ for the house appreciation rates were imputed based on the annualized estimates of Yang, Lin, and Cho (2011). They estimate the quarterly μ_{H_1} , σ_{H_1} , σ_{H_2} to be 0.0139, 0.0303, and 0.0409, respectively.

As for the parameter values represented as $[\mu_{Y_1}, \sigma_{Y_1}, \sigma_{Y_2}]$ for the household income growth rate, μ_{Y_1} and σ_{Y_1} can be observed from the market, but σ_{Y_2} is unobserved and thus an assumed value must be used. Similar to Yang, Lin, and Cho (2011), we compute the parameter values for the household income growth rate and its variability using data from state household income, published by the U.S. Census Bureau (2008).

We simulate the correlated state variables, as specified in Eqs. (5) through (7), with 10,000 paths. We define a stressed economy in terms of changes in home price growth rates, household income growth rates, and mortgage interest rates; and we compare the results from a normal economy to those of the stressed economy. For a stressed economy, we use shock assumptions on interest rates, home prices and household income. The interest rate shock requires testing an increase in the mean growth rate of interest rates by their own standard deviation during a two-year window after origination.³ Likewise, home price and household income shocks are modeled as a reduction in their respective mean growth rates by their standard deviations during a two-year window after origination. The shocks of each series will revert to their respective normal-economy level after two years from origination and remain constant throughout the loan life.

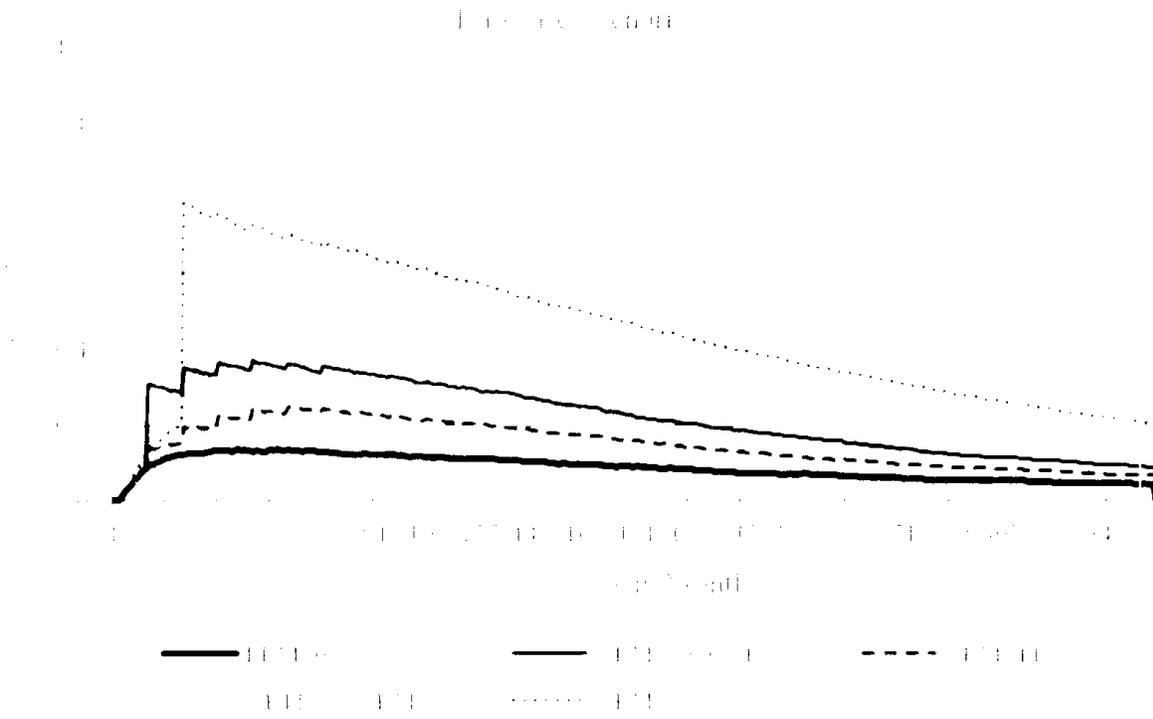


Fig. 1. Probability of a payment shortage (normal economy). The output is a plot of the probability that a homebuyer will have a payment shortage (PSHORT) between loan origination and loan payoff for our sample of loans.

These simulated economic paths are developed for the five types of mortgage contracts being analyzed and Figs. 1 through 4 show the key results in terms of the estimated PSHORT and PD (probability of default) over the loan lives.

4. Results

4.1. Differential ability-to-pay problems

Differential ability-to-pay problems are illustrated in Figs. 1 and 2 that present the probability of a PSHORT under normal and stressed economies, respectively. Fig. 1 reveals that the loan products have the same PSHORT in the first year because we assume annual rate adjustments. Thus, homebuyers that are certain that they will flip the house in less than one year would not need to worry about differential ability-to-pay problems. However, after the initial period, ARMs begin showing discrete jumps in PSHORT. The PSHORT pattern reveals that FRMs exhibit the lowest PSHORT, followed by ARMs with a 5/1/1 cap structure, and ARMs with no caps. Thus, these various types of mortgages exhibit differential risk to borrowers in terms of the borrowers' future ability to pay. While the amount of risk a borrower chooses to take is a personal decision that depends of the borrowers degree of risk aversion, the risk of an ability-to-pay problem in the future for a 5/1/1 ARM is about 1.5 time larger than for a FRM. An ARM without a cap has a risk of an ability-to-pay problem in the future of about twice that of a FRM.

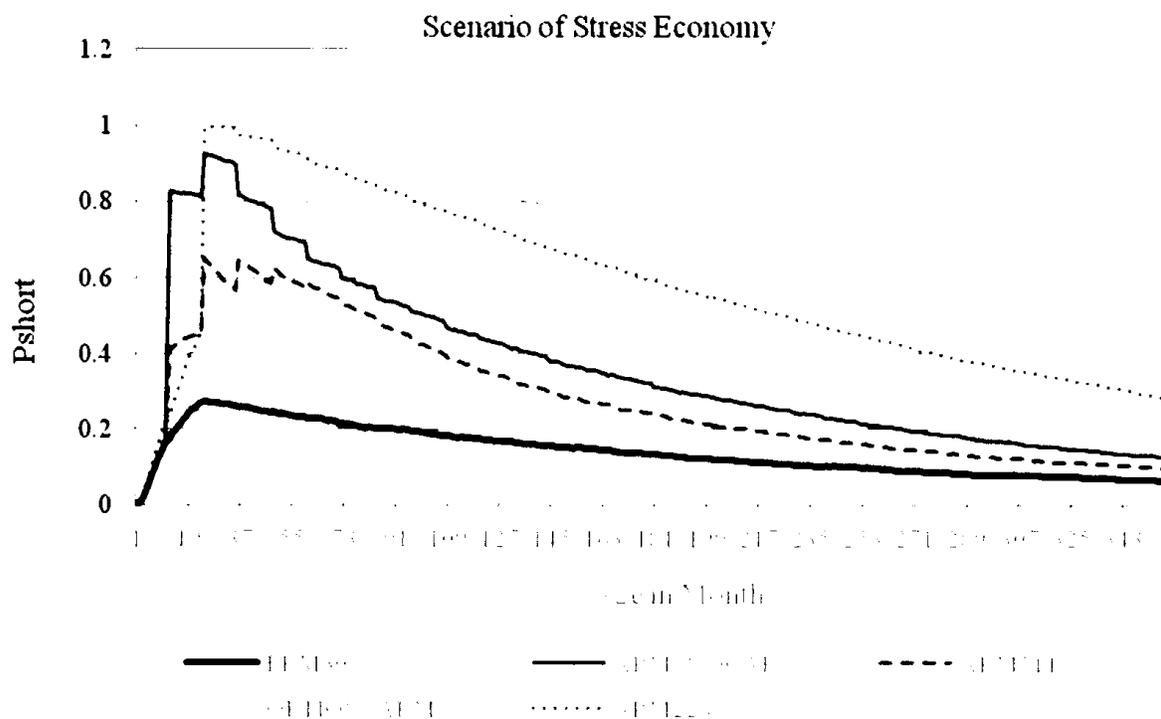


Fig. 2. Probability of a payment shortage (stressed economy). The output is a plot of the probability that a homebuyer will have a payment shortage (PSHORT) between loan origination and loan payoff for our sample of loans.

PSHORT trends of option ARMs and 2/28 ARM products reveal that they exhibit discrete jumps at the rate reset points (second year). However, a more alarming feature is that the PSHORT of these products is more than twice as large as the PSHORT for any of the other products that we examined.

Borrowers need to realize that the relative risk of these products is extremely high, even in a normal economy. Perhaps a homebuyer should ask the question “if my income was insufficient to support my lifestyle and make my mortgage payments, where could I come up with the extra money, and how long could I tap this source of funds?” One possible source of funding would be a large investment portfolio. Another may be the curtailment of a lavish lifestyle or an expensive hobby. Perhaps family or friends would assist. While each borrower’s situation is unique, borrowers need to consider this question.

At this point, it is tempting to say that the results we present are not surprising. After all, FRMs should be the least risky because the payment is fixed for life (no payment shock). Furthermore, ARMs with a 5/1/1 cap structure should be less risky than ARMs with no caps because the payment shock is limited by the product design. The probability of a payment shortage for a 5/1/1/ ARM peaks at slightly above 20% while the probability of a payment shortage peaks at just below 40% for ARMs with no cap. The risk of option ARMs is that the borrower may choose to make payments that are less than fully amortizing which increases the probability of negative equity. This also complicates refinancing in an increasing interest rate environment because the required monthly payments would increase. Loans with teaser rates such as option ARMs and 2/28 ARMs are more risky because interest

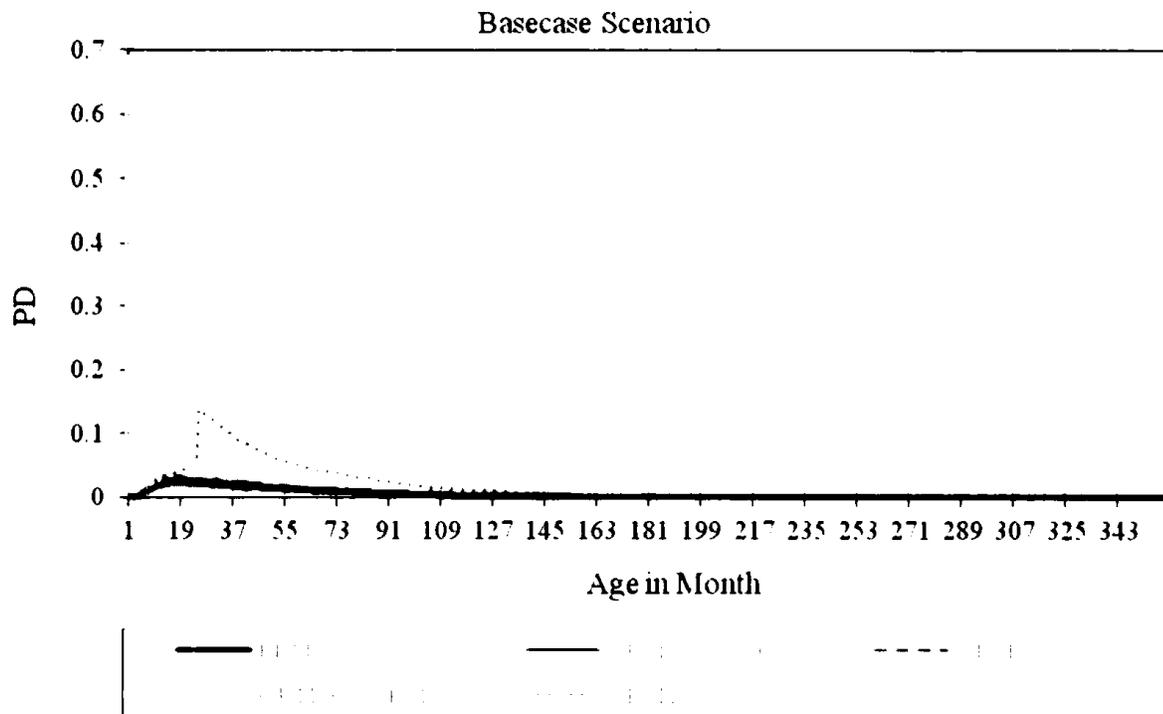


Fig. 3. Probability of default (PD) (normal economy). The output is a plot of the probability that a homebuyer will default between loan origination and loan payoff for our sample of loans.

rates can increase causing a future payment shock. However, what we find surprising is the high PSHORT for many of these loans and the vast differences in PSHORT among them in a normal economy. The probability of a payment shortage approaches 70% in some cases!

Unsurprisingly, a stressed economy increases PSHORT for all mortgage products. However, the magnitude of increase in PSHORT for most products is alarming. For example, 5/1/1 ARMs with a cap structure show a PSHORT that is 3.3 times higher than in a normal economy, ARMs without a cap structure have a PSHORT that is 2.8 times higher, FRMs have a PSHORT that is 2.3 times higher, and option ARMs have a PSHORT that is 1.8 times higher. Because of the already high PSHORT for 2/28 ARMs, the increase in PSHORT is small in percentage terms; however, in terms of absolute magnitude, the PSHORT is nearly 100%! Not only did the PSHORT increase significantly, the relative difference in PSHORT for the various mortgage products become clear. A PSHORT above 20% for FRM is a scary enough proposition, but even modest 5/1/1/ ARMs have a PSHORT of around 60%. A buyer should consider the potential impact on their lifestyle and the lifestyle of their family before committing to one of these risky loans. Furthermore, the buyer should ask themselves where they could come up with the extra money that would be required to make mortgage payments if they faced ability-to-pay problems. Are friends and relatives going to be willing and able to help or are cash reserves sufficient to cover any short fall? If not, where will the money come from?

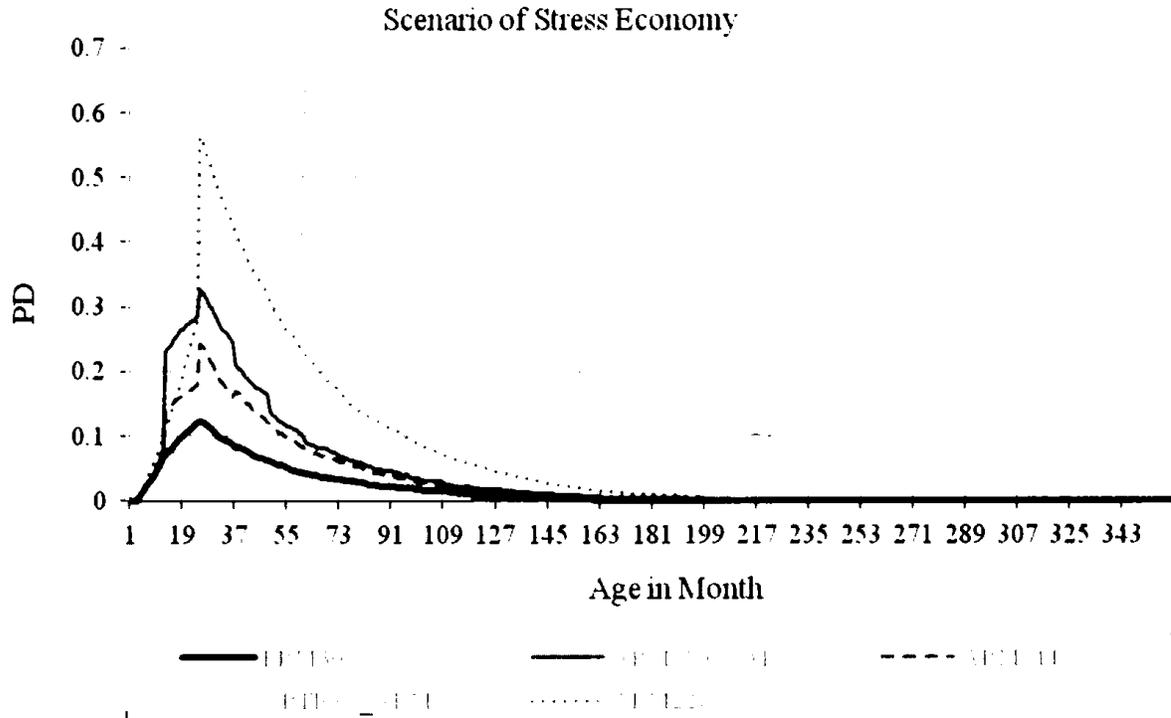


Fig. 4. Probability of default (PD) (stressed economy). The output is a plot of the probability that a homebuyer will default between loan origination and loan payoff for our sample of loans.

4.2. Differential probability of default

The probability of default (PD) is triggered by two events, negative equity and ability-to-pay problems. As illustrated in Fig. 3, the normal economy PD trends for most loan products peak at similar levels after two years. Therefore, borrowers that will retire their loan within two years have tremendous flexibility. However, after that period, 2/28 and option ARMs exhibit a higher likelihood of default than other products. This outcome for 2/28 ARMs is because of the large payment shock; whereas, for option ARMs, it is primarily caused by the negative amortization feature of that product (the current UPB is most likely to exceed the UPB at loan origination). ARMs without a cap structure consistently show a higher PD than their counterparts with a cap structure. The PD value is less than 10%, except for 2/28 and option ARMs. Judging from the PD estimates, option ARMs are the riskiest products, followed by 2/28 ARMs and 5/1/1 ARMs. The PD values for option ARMs peak at nearly 15% while 2/28 ARMs peak around 14%. While the relative PD ranking was expected, the magnitude of the PDs, and PD differentials, during a normal economy was surprising. Again, buyers need to ask themselves how much risk they are willing to take. The default risk of FRMs, 5/1/1 ARMs, and ARMs with no cap are significantly lower than the risk of option ARMs and 2/28 ARMs.

Compared with normal-economy outcomes, PD values under a stressed economy exhibit a significant increase. The PD for 2/28 ARMs peak in the second year at nearly a 60% probability of default. The PD for option ARMs peaks around the fifth year above 60% compared with 15% under the nonstressed economy. Other loan products also show higher PD values under the stressed economy than under the baseline economy. The risk-ranking

Table 1 Probability of default of mortgage products

Product	Probability of default (normal economy)	Probability of default multiplier (normal economy)	Probability of default (stressed economy)	Probability of default multiplier (stressed economy)
FRM30	1.54%	1	7.03%	1
ARM_NOCAP	2.08%	1.35	17.47%	2.49
ARM511	1.58%	1.03	12.64%	1.80
OPTION ARM	6.06%	3.94	30.00%	4.27
ARM228	6.23%	4.05	27.10%	3.85

The first column lists the mortgage products we simulated and columns two and four present the probability of default for a normal economy and a stressed economy, respectively. To compare relative risks, columns three and five provide probability of default multipliers for each of the mortgage products. The probability of default multipliers are computed by dividing the probability of default for a given mortgage product by the probability of default of the FRM.

from highest to lowest is option ARMs, 2/28 ARMs, ARM with no caps, 5/1/1 ARMs, and FRMs. Again, while the relative PDs were not surprising, the differences in the magnitudes of the PDs between the stressed and nonstressed scenarios were surprisingly large. As before, homebuyers need to ask themselves how much risk are they willing to take and they also consider how a foreclosure would affect their life. There are no absolutely right answers because the individuals risk aversion come into play. However, it is clear that risk is an important consideration.

Table 1 presents the average cumulative PD during the first five years for individual mortgages. The PD for a normal economy ranges from 1.54% for FRMs to 6.23% for 2/28 ARMS. To more easily examine the relative default risk among different mortgage types we created a PD multiplier. The probability of default multipliers are computed by dividing the probability of default for a given mortgage product by the probability of default of the FRM. Formally,

$$\text{PD multiplier} = \text{PD of product of interest} / \text{PD of base product} \quad (13)$$

In essence, the PD multiplier normalizes the PD for easy comparison. The base PD multiplier shows that 2/28 and option ARMs are about 4.1 and 3.9 times riskier than a standard FRM, respectively. However, the base PD of a 5/1/1/ ARM is only marginally higher than that of an otherwise similar FRM. While even the most risky products have only a 6% PD in a normal economy, a borrower needs to carefully think about the magnitude of damage to their financial future if they default.

The PD in a stressed economy increases dramatically. Even the PD of safe FRMs increases to 7% while the PD of option arms increases to 30%. The stressed PD Multiplier shows that the dispersion of PDs among loan products increases under the stressed economy. An ARM with no cap has a PD that is about 2.5 times that of a FRM. This evidence suggests that a large default risk differential exists among competing mortgage products and that risk is exacerbated by economic scenarios that typify a stressed economy. Financial professionals and homebuyers can use the PD information we provide in Table 1 to assess the absolute and relative riskiness of any combination of loan products that we simulated for their decision

making process. However, the choice of the degree of risk that particular buyer is comfortable taking is a personal decision.

5. Conclusion

Buying a home is often the largest investment that a person makes during their lifetime, so the choice of a home and how to finance that home can have significant and long-lasting financial implications for the purchaser. Home purchases can also have important emotional elements because the home buyer may find the “perfect” house and want the deal to work out so badly that they will go to great lengths to make the deal work. Unfortunately, this can lead to suboptimal financial decisions. Not only does a buyer face overpaying for a home, the buyer risks making a poor choice concerning the type of mortgage used to finance the home. For example, a buyer may choose a seemingly “affordable” loan type that contains potentially negative characteristics without due regard for potential risk. Unfortunately, this may result in either an ability-to-pay problem that will adversely affect the buyer’s future lifestyle or worse yet a default that will have more dramatic and long lasting affects on the borrower.

Selecting a mortgage can be a difficult task. While it is important to compare the interest rates and payment terms of competing loan types, it is also important to consider how various loan types influence the probability of default. Finance theory is clear that financial decisions involve two central elements, risk and return. This is as true with financing a home as it is in selecting a mutual fund or building an investment portfolio. Therefore, assessing the current “affordability” of mortgage options without considering the potential risk of those options can be a costly mistake. Unfortunately, little information is available to home buyers to assist them in assessing the risk of default of various types of home loans.

To assist home buyers in understanding the default risks of various types of home loans, we document the relative credit risks of five types of mortgage products. We find that significant risk differences exist among competing products that suggests that homebuyers and homeowners should consider the default risks of these products when selecting a loan to finance or refinance their home. While we are not able to provide guidance for a particular individual or situation, we can say that the homebuyer needs to critically examine the risk of ability-to-pay and willingness-to-pay problems. After that examination, they need to ask themselves what they would do if they faced an income shortage, if they owed more on the house than it was worth, or both. Finally, they need to find a loan that they are personally comfortable with in terms of absolute and relative default risk. The simulated default risk is provided in Table 1 to help homebuyers assess risk differences.

Notes

- 1 Those to have estimated interest rate parameters over the past few years include Buist and Yang (1998). Of course, 30-year government bond yields and long-term interest rates have fallen to between 3.5% and 4%. However, currently r_0 may have reached as low as 1%. Moreover, when we expect that r_0 , μ_r simultaneously drop, it follows

that the FRMs contract rate will also be set lower. When monitoring U.S. interest rate trends, it appears that only long-term interest rates are falling, so $\alpha = 0.25$, $\sigma_r = 0.15$ is probable. Therefore, we believe that the interest rate parameters are suitable.

- 2 With regard to housing price fluctuations, Yang, Lin, and Cho (2011), report that in the United States, from 1991–2010, annual house prices grew at an average rate of 3.3%. With regard to σ_{H_2} , as no individual house price data set exists, only estimated data can be used. Often, σ_{H_2} will reflect individual home repairs; therefore, building, decorating, and other factors that may lead to discrepancies. If the sample is expanded, for example, if h_1 were to be the state housing price growth rate, σ_{H_2} should also reflect the state's urban-rural gap caused by the deviation of the individual housing price growth rate from the state housing price growth rate. In certain counties, the annual housing price growth rate has almost reached 30%, in others, housing prices have virtually stagnated. As a result, σ_{H_2} is thought to be greater than σ_{H_1} ; therefore, it follows that $\sigma_{h_1} = 0.06$, $\sigma_{h_2} = 0.08$, $\sigma_{H_1}^2 = 0.06^2 + 0.08^2 = 0.1^2$ representing that 36% ($\sigma_{H_1}^2 / (\sigma_{H_1}^2 + \sigma_{H_2}^2)$) of housing price variations originate from systematic factors, and 64% come from individual factors. With regard to income growth, U.S. economic growth over the past 10 years has averaged around 3%. The calculated average income growth rate is 3.5%. Of course, income growth rate variations from individual factors should be greater, and therefore σ_{y_1} , σ_{y_2} and $\sigma_{Y_1}^2 / (\sigma_{Y_1}^2 + \sigma_{Y_2}^2) \approx (1/3)$ is considered appropriate. As for the setting of the correlation coefficient, with an overheated housing market or economy, the U.S. Federal Reserve will likely raise interest rates to curb inflation. Therefore, it is reasonable to set the correlation coefficient to 0.6 to 0.7. The growth rate H_2 and Y_2 should be positively correlated, and a single correlation coefficient should not be high.
- 3 According to Ambrose et al. (2007), rating agencies impose stress tests that include a 10-year simulation where a stressed economic environment occurs during the first four years. An S&P model that has been in use for two years in Canada serves as another type of stress test. We use a process similar to the one used in Canada, a two-year shock after origination, for our simulation framework.

Acknowledgments

The research support from the National Science Council of Taiwan (NSC102-2410-H-007-046 for C. C. Lin) is gratefully acknowledged. Larry Prather acknowledges research support from Southwestern Oklahoma State University's organized research program. All errors are our own.

References

- Ambrose, B., Boyle, P., Cassidy, H., & Yang, T. (2007). *Mortgage Insurance: An Evaluation of Methods of Determining Capital Requirements*. The White Paper by Integrated Financial Engineering Inc. (IFE Group).
- Ambrose, B., & LaCourre-Little, M. (2001). Prepayment risk in adjustable rate mortgages subject to initial year discounts: Some new evidence. *Real Estate Economics*, 29, 305–327.

- Ambrose, B., LaCour-Little, M., & Huszar, Z. (2005). A note on hybrid mortgages. *Real Estate Economics*, 33, 765–782.
- Baek, C., & Bilbeisi, K. (2011). Should home buyers choose a short- or long-term mortgage? *The CPA Journal*, June, 56–61.
- Basciano, P., Grayson, J., & Walton, J. (2006). Is a 30-year mortgage preferable to a 15-year mortgage. *Journal of Financial Counseling and Planning*, 17, 14–21.
- Buist, H., & Yang, T. (1998). Pricing the competing risks of mortgage default and prepayment in metropolitan economies. *Managerial Finance*, 28, 110–128.
- Calhoun, C., & Deng, Y. (2002). A dynamic analysis of fixed- and adjustable-rate mortgage terminations. *Journal of Real Estate Finance and Economics*, 24, 9–23.
- Campbell, J., & Cocco, J. (2003). *Household Risk Management and Optimal Mortgage Choice*. National Bureau of Economic Research, Inc. NBER Working Paper: 9759.
- Cox, J., Ingersol, J., Jr., & Ross, S. (1985). An intertemporal general equilibrium model of asset prices. *Econometrica*, 53, 363–384.
- Cunningham, D., & Capone, C. (1990). The relative termination experience of adjustable to fixed-rate mortgages. *Journal of Finance*, 45, 1687–1703.
- Dhillon, U., Shilling, J., & Srimans, C. (1987). Choosing between fixed and adjustable rate mortgages: A note. *Journal of Money, Credit, and Banking*, 19, 259–267.
- Dhillon, U., Shilling, J., & Srimans, C. (1990). The mortgage maturity decision: The choice between 15-year and 30-year FRMs. *Southern Economic Journal*, 56, 1103–1116.
- Elmer, P., & Seelip, S. (1999). Insolvency, trigger events, and consumer risk posture in the theory of single-family mortgage default. *Journal of Housing Research*, 10, 1–25.
- Follain, J. (1990). Mortgage choices. *Journal of the American Real Estate and Urban Economics Association*, 18, 125–144.
- Fortin, R., Michelson, S., Smith, S., & Weaver, W. (2007). Mortgage refinancing: the interaction of break even period, taxes, NPV, and IRR. *Financial Services Review*, 16, 197–209.
- Goff, D., & Cox, D. (1998). 15-year versus 30-year mortgages: Which is the better option? *Journal of Financial Planning*, 11, 88–95.
- Herman, G., & Lloyd, J. (1995). A home for your family choosing the best mortgage. *North Carolina Extension Service, North Carolina State University College of Agriculture and Life Sciences*, July.
- Hoover, G. (2003). The mortgage refinance decision: An equation-based model. *Financial Services Review*, 12, 319–337.
- Janjigian, V. (1994). Choosing the term on a fixed-rate home mortgage: A cash flow perspective. *Financial Practice and Education, Spring/Summer*, 167–168.
- Kistner, W. (1998). Home mortgage loan term options. *Healthcare Financial Management, October*, 86–88.
- Kistner, W. (2001). Choosing the right mortgage. *Healthcare Financial Management, November*, 80–81.
- LaCour-Little, M., & Yang, J. (2010). Pay me now or pay me later: Alternative mortgage products and the mortgage crises. *Real Estate Economics*, 38, 687–732.
- Lee, J., & Hogarth, J. (2000). Consumer information search for home mortgages: Who, what, how much, and what else? *Financial Services Review*, 9, 277–293.
- Lin, C., Chu, T., & Prather, L. (2011). Default risk of exotic mortgage products. *Journal of International Finance and Economics*, 11, 161–170.
- Lin, C., Prather, L., Chu, T., & Tsay, J. (2013). Differential default risk among traditional and non-traditional mortgage products and capital adequacy standards. *International Review of Financial Analysis*, 27, 115–122.
- McClatchey, C., & de la Torre, C. (2008). Your mortgage loan: fairly priced, ... or not? *Financial Services Review*, 17, 237–256.
- Miles, D. (2004). *The UK Mortgage Market: Final Report and Recommendations*. Imperial College of London (Report Submitted to Chancellor of Treasury).
- Miles, D. (2005). Incentives information and efficiency in the UK mortgage market. *The Economic Journal*, 115, c82–c98.

- Miles, D., & Pillonca, V. (2007). *Housing: Europe vs. the US – Sustainability and Prospects*. Berlin: Morgan Stanley.
- Phillips, R., Rosenblatt, E., & Vanderhoff, J. (1992). The effect of relative pricing on the fixed-rate mortgage term decision. *Journal of Real Estate Research*, 7, 187–194.
- Stanton, R., & Wallace, N. (1995). ARM wrestling: Valuing adjustable rate mortgages indexed to the eleventh district cost of funds. *Real Estate Economics*, 23, 311–345.
- Templeton, W., Main, R., & Orris, J. (1996). A simulation approach in the choice between fixed and adjustable rate mortgages. *Financial Services Review*, 5, 101–117.
- Templeton, W., Main, R., & Orris, J. (2002). An investigation of adjustable-rate mortgage pricing features. *Financial Services Review*, 11, 367–379.
- Tomlinson, J. (2002). Advising investment clients about mortgage debt. *Journal of Financial Planning*, 15, 100–108.
- Wyman, M. (2005). *Risk and Funding in European Residential Mortgage—Responding to Changes in Mortgage Demand*. London, England: Mortgage Insurance Trade Association.
- United States Census Bureau. (2008). *Median Household Income by State*. www.census.gov. U.S. Census Bureau.
- Vickery, J. (2007). *Interest Rates and Consumer Choice in the Residential Mortgage Market: A Summary* (pp. 326–335). Proceedings, Federal Reserve Bank of Chicago, Chicago, IL.
- Vruwink, D., & Gisher, D. (1995). The effects of income tax rates and interest rates in choosing between 15- and 30-year mortgages. *The CPA Journal*, November, 72–75.
- Yang, T. (1992). Self selection in the fixed-rate-mortgage market. *Journal of the American Real Estate and Urban Economics Association*, 20, 359–391.
- Yang, T., Buist, H., & Megbolugbe, I. (1998). An analysis of ex-ante probabilities of mortgage prepayment and default. *Real Estate Economics*, 26, 651–676.
- Yang, T., Lin, C., & Cho, M. (2011). Collateral risk in residential mortgage defaults. *Journal of Real Estate Finance Economics*, 42, 115–142.
- Yohannes, A. (1991). Comparing mortgages with different payment frequencies. *Financial Services Review*, 1, 131–142.