Reforming Housing Finance: Perspectives from Denmark

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Abstract

This paper investigates the effect of adding a distinct feature of the Danish mortgage market to the market in the United States. This feature, a buyback option, enables mortgagors to buy back their share of the mortgage-backed security at market price. Extending a standard referenced pricing model, the findings indicate that the introduction of the buyback option reduces the credit spread required by the financial intermediary by 23%, potentially reducing the contingent liability of the U.S. government. Furthermore, the buyback option protects households against the risk of being locked in after an increase in interest rates. This could be of particular benefit to low-to-middle income households.

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Introduction

There is an ongoing controversy regarding the costs and benefits of Fannie Mae and Freddie Mac. The controversy has many aspects, but it mainly evolves around the fact that, in spite of any legal basis, investors treat debt and mortgage-backed securities issued by Fannie Mae and Freddie Mac (F&F) as if the United States government guarantees them. It is a fact, however, that they enjoy certain benefits and have certain restrictions due to their close relationship with the federal government, a summary for this relationship being that they are "government sponsored enterprises" or GSEs.

The controversy concerns a range of aspects of the GSEs of which two are of particular interest in this paper. First, it is argued in the literature that the GSEs pose a contingent liability for the U.S. government (*e.g.*, White, 2003; and Frame and White, 2004. According to Frame and White (2004), the liability constitutes approximately USD 288 billion over a 25-year period. On the other hand, Roll (2003) argues that the retained mortgage portfolios of F&F provide a range of benefits to the homeowners in general. Second, some critics argue that in spite of their charters, the GSEs do not improve home ownership for low-to-middle income

(LMI) households. This is, for example, the case in White (2003) and Passmore (2003), while Blinder, Flannery and Kamihachi (2004) criticize the approach in Passmore (2003) and generally find larger benefits of the implicit subsidy. Further, Bostic and Surette (2001) find that from 1989 to 1998, home ownership increased from 63% to 66.2%. The increase occurs while there is a general decline in disparity between different groups. The authors attribute this to a change in the mortgage markets, and see this as an indication that regulation works. In short, there is considerable disagreement concerning the risks posed by the GSEs to the taxpayers and how good a job the GSEs have done at promoting home ownership for the LMI households.

This paper contributes to the literature by addressing the possibility of a contingent liability of the U.S. government and the benefit to LMI households. It examines the effects of introducing a distinct feature from the Danish mortgage market into the U.S. mortgage market, which serves to reduce the contingent liability of the U.S. government and improve the conditions of LMI households. The distinct feature that will be introduced is the *buyback option*. This option enables the mortgagor, in *addition* to the standard prepayment option, to buy back the mortgage at the prevailing bond price. This will have a number of positive effects. First, the paper argues and supports with calculations that the credit risk of the GSEs could be decreased if mortgagors could buy back their loans at the market price. Second, having a buyback option protects the mortgagor from the lock-in effect and could thereby encourage LMI households, which are particularly exposed to lock-in effects, to become homeowners. Third, from a macro economic perspective, introducing the buyback option could increase the mobility of the labor force in general, as it would make it easier for people to move if their the loan could be terminated at its current value.

This paper highlights a particular difference between the U.S. and the Danish mortgage markets, which are generally very similar. As is the case for the U.S., the Danish market for mortgage-backed bonds is very large. The total volume of outstanding mortgage debt totaled 101% of GDP in 2003, compared to 81% in the U.S. In Europe, the Danish market is the second largest, which is exceeded only by Germany.

Four large mortgage credit institutions (MCIs) who originate, securitize and service the loans dominate the Danish mortgage market. Founded as a cooperative system, the institutions are today private but highly regulated. For example, the MCIs are not allowed to retain any prepayment risk themselves. Despite being private companies, there is, like in the U.S., a widespread belief that the government will never allow the MCIs to default. As in the U.S., the Danish MCIs guarantee the loans such that in the event of default by mortgagors, the investor receives face value. The MCIs are required by law to follow the so-called 'balance principle,' which requires that all lending activities must be funded by issuing bonds with exactly matching cash flows. In that sense, Danish mortgage-backed bonds are genuine pass-through securities where the payments from an individual mortgagor can be traced into a pool and on to the bond for which the mortgage serves as collateral.

The balance principle and generally tight regulation ensure a very stable market, which since its creation in 1797 has not experienced a single default in a bond series. According to Moody's (2002), ''Danish mortgage bonds are very strong and very low-risk financial instruments'' with ratings between Aaa and Aa2. As in the U.S., the dominant type of loan is a callable fixed coupon annuity; in Denmark typically with 30 years of maturity. However, in addition to being able to prepay the loan penalty-free, a Danish mortgagor is able to cancel the loan simply by going to the secondary market and buying back an equivalent amount of bonds in the series in which the loan was originally issued. For a more thorough description of the Danish mortgage market, see for example BIS (2004) and Batten, Fetherston and Szilagyi (2004).

A numerical example will be helpful in highlighting the differences and similarities. Suppose the borrower needs USD 300,000 to finance the purchase of a house. In the U.S., a mortgage bank would originate a 30-year fixed-rate callable mortgage. This mortgage would be sold to a GSE, Fannie Mae for example, who would pool this particular mortgage together with similar mortgages and then issue a bond backed with the cash flow of the mortgage, a mortgage-backed bond. The GSE would guarantee the payments, such that in the event of default, the investor receives face value while prepayments are passed through. In Denmark, the link with the mortgage bank would be skipped and the mortgagor would go straight to the MCI, which would give the mortgagor USD 300,000 and finance this by issuing an equivalent amount in an existing bond series.

Suppose that time passes and the remaining face value is now USD 200,000. Suppose also that interest rates increase such that the bond trades below face value. In the U.S., if the mortgagor needs to move from the house, the face value of USD 200,000 has to be paid back. This happens even if the bond, which serves to finance the mortgage, trades in the secondary market for only USD 180,000. In Denmark, however, the loan at a price of USD 180,000 would be bought back in the secondary market and the loan would simply be cancelled. This means that the Danish mortgagor saves USD 20,000 compared to the U.S. case. On the other hand, if interest rates had gone down, the loan could have been prepaid at par in both countries with the same financial gain.

Should the house price at the time of termination be below face value of the loan, it would be cheaper in the U.S. to simply default on the loan. However, if the buyback option was present, the bond value could be below face value such that buying back the loan in the market would be cheaper than defaulting. This means that default would be used less and it would generally reduce the credit risk inherent in the mortgage pool.

However, everything comes at a price, so having the buyback option would cost the mortgagor money. There are two questions to be answered: How much would it cost to have a buyback option in the U.S.? To what extent would it reduce the credit risk of the mortgages? To provide answers to these questions, the paper analyzes the introduction of the buyback option in a theoretical bond-pricing model in the spirit of Schwartz and Torous (1992) and Kau, Keenan, Muller and Epperson (1992). These models assume stochastic house prices and interest rates and are able to capture a number of stylized facts of the mortgage market. Within a model of this type, the effects of introducing the buyback option can be examined.

The findings are as follows. Focusing on par rates, the spread required by the GSE to insure the investor from mortgage default, the insurance spread, is at the outset equal to 19.5 bp, very much in line with the estimates of Jaffee (2003). Introducing the buyback option decreases the insurance spread from 19.5 bp to 15 bp, a relative decrease of roughly 23%. This relative decrease is stable across a range of initial loan-to-value (LTV) ratios and, more importantly, stable across changing economic environments. The model implies that introducing the buyback option increases the fair coupon rate by 50 bp.

Keep in mind that a risk-neutral pricing framework is employed. This means that the changes in par rates and insurance spreads reflect a real change in value. In light of this, the reduced insurance spread implies that the mortgages are rendered less credit risky. This is because that when facing non-financial termination, the option to buy back the loan at market value makes defaults less likely. The price for avoiding the lock-in problem for the mortgagor is 50 bp, which may seem relatively high. This simply reflects that with the choices of economic environment and specifications of prepayment and default behavior in the model, it is very likely that the buyback option will be used and hence it has a lot of value.

The decreased insurance spread implies a reduction in the credit risk of the mortgages. This means that the GSEs are less exposed to credit risk. To the extent that the U.S. government in fact has a contingent liability, this liability could be reduced by introducing a buyback option.

The findings indicate that introducing the buyback option could benefit LMI households in two ways. First, one would expect these families to be most prone to the risk of unemployment and as such, it is vital for them to be mobile and able to cancel the mortgage at a fair value. The buyback option will make it easier for the mortgagor to move, given that the loan can always be cancelled at the prevailing market price instead of being forced to prepay at the (presumably) higher face value. Second, the stability of the decrease in insurance spread across all LTV ratios means that LMI households, who tend to be wealth and liquidity constrained and need a high LTV loan, would have a better chance at obtaining a loan since the default risk would be lower.

Obviously, the increased coupon rate needed to obtain the buyback option could inhibit LMI households from becoming homeowners themselves. Therefore, the real-world effect would be an empirical issue, depending on the preferences of the U.S. households in general.

The remainder of the paper is organized as follows. First, the general model is introduced. This includes a description of the standard valuation methodology, a discussion of the actions of the mortgagor and a parameterization of these. The following section describes how the model is implemented and how the buyback option can be incorporated into the modeling framework. Numerical results are discussed next. The paper closes with a short conclusion.

The Model

The model is in the spirit of Kau et al. (1992) and Schwartz and Torous (1992). The economy is characterized by two state variables: the current house value H and the short rate r. The value of any claim, mortgage or bond, is assumed to be a function of the current values of H and r. By using standard risk neutral pricing techniques, a two-dimensional PDE, which can be solved numerically, can be derived. A distinct separation is made between the mortgage, following Schwartz and Torous, which the mortgagor uses to finance the purchase of a house, and the bond, which is actually sold.

Assume a mortgagor seeks to finance the purchase of a house with value H. This is done by borrowing the money from an agency and the loan is paid back as a continuous annuity. To finance the loan, the agency issues another security, a bond, and sells it to investors. As the mortgagor pays down the loan, the payments, minus a spread, are passed on to the investor. In case of prepayments by the mortgagor, the investor receives the face value of the loan. However, if the mortgagor defaults on payments, the investor is fully insured so the agency retains the house while the investor receives the face value. The agency is compensated for this credit risk through the part of the interest payments retained—the insurance spread. This means that whether there is default or prepayment, the investor always receives face value.

In the general valuation, the 'reduced form' stance of the investor and the agency who has invested in a pool of mortgages (bonds for the point of view of the investor) is taken. The agency and the investor do not know when the mortgagors default or prepay but they attach probabilities to each action, depending on the economic environment, and value the resulting cash flow accordingly.

At origination of the contract, the house is more valuable than the mortgage, which implicitly means that unless the house is worth exactly the same as the loan, the mortgagor puts an amount of money up front to finance the purchase. These effects are not taken into account in this paper; it focuses solely on the actions of the mortgagor after the loan has been taken.

With the superficial description of the model in place, a brief summary is given of the differences between the proposed model and that proposed by Schwartz and Torous (1992). Schwartz and Torous model the prepayment activity as a baseline prepayment in case of no financial incentives multiplied by a function that captures financially motivated prepayments. The model proposed in this paper undertakes a complete separation by modeling financial and non-financial prepayment individually. Furthermore, the implicit assumption in Schwartz and

Torous that the mortgagor prepays the loan according to how much higher the value of the mortgage is compared to the face value is removed. Instead, the required gain approach proposed by Jakobsen (1992) is used, which has its foundation in the present value of the scheduled cash flow compared to a refinancing alternative issued at par. This is a more intuitive approach given the observed lack of rationality in prepayment activity.

Additionally, a less strict structure is imposed on the prepayment behavior as a function of the value of the house. In Schwartz and Torous (1992), a prepayment function of Green and Shoven (1986) is used. Everything else being equal, this prepayment function implies that prepayment rates are lower the more valuable the mortgaged house is. One could think that the opposite would happen: the more equity in the house, the more likely it is that the mortgagor prepays. In the model, the house price in the prepayment function is used to ensure that when there is negative equity in a house, prepayments are severely restricted.

Thus, at a given point in time, the number of how many mortgagors are going to prepay or default can be calculated. However, as Schwartz and Torous (1992) briefly consider, it may very well be that if interest rates are sufficiently low and the loan-to-value ratio is high, some mortgagors default while other mortgagors prepay. In doing so, it is implicitly assumed that mortgagors who prepay under such circumstances have other sources of wealth. Within the model, the specification ensures that only mortgagors with very limited amounts of negative equity in their house will refinance under these circumstances.

In the next section, the general valuation methodology is introduced followed by an introduction to the notation, a description of the actions of the mortgagor and finally the specific parameterization of these actions.

Valuation Methodology

As described above, the two state variables of the economy are assumed to be the current house price H and the current short interest rate r. They are assumed to evolve according to the following stochastic processes:

$$\frac{dH}{H} = (\alpha - s)dt + \sigma_H dz_H. \tag{1}$$

$$dr = \gamma(\theta - r)dt + \sigma_r \sqrt{r}\, dz_r. \tag{2}$$

Where z_H and z_r are Brownian motions under the empirical probability measure and ρ is the instantaneous correlation between these.

The process for the interest rate is a standard CIR [Cox, Ingersoll and Ross (1985)] process where the short-term interest rate is assumed to mean revert with the rate

γ to its long-term level θ. The square of the volatility is proportional to the current interest rate and for suitable choices of the parameters, as in this paper, interest rates never reach zero.

The process for the house price is a standard geometric Brownian motion. With the usual interpretation, α is the instantaneous return from owning the house and σ_H is the instantaneous volatility. It is assumed that the service flow required to maintain the house, which is constant and proportional to H, is paid continuously at the rate s. From the analogy to stock prices, the holder of a claim dependent on the house price has no right to the service flow; and hence, the return from the viewpoint of the holder of the claim is $\alpha - s$ and not simply α.

The model assumes that there is no arbitrage in the economy and that Q is an equivalent martingale measure associated with the numeraire $\exp(\int_0^t r_s ds)$. Following Duffie (1996), the assumption of no arbitrage implies the existence of the measure Q under which all discounted claims are martingales.

Consider a claim X, which is assumed to be a function of the two state variables $X(t) = X(t,H,r)$. Given the absence of arbitrage, the claim can be valued under the Q measure as the expected discounted cash flow:

$$X(r,H,t) = \mathrm{E}_t^{\mathrm{Q}}[\textstyle\int_t^T \exp(-\int_t^S r_u du)x(r,H,s)ds + e - \int_t^T r_s ds\, X(r,H,T)]. \tag{3}$$

Where $x(r,H,t)$ is the continuous dividend rate of the claim and $X(r,H,T)$ is the terminal payment. Applying the standard Feynman-Kac relationship (*e.g.*, Duffie, 1996), X must also be a solution to the following two-dimensional partial differential equation, PDE.

$$X_t - rX + (r - s)X_H + (\gamma(\theta - r) + \lambda r)X_r + \tfrac{1}{2} H^2\sigma_H^2 X_{HH} + \tfrac{1}{2} r\sigma_r^2 X_{rr} + \sigma_r\sigma_H\rho H\sqrt{r}\, X_{Hr} + x(r,H,t) = 0, \tag{4}$$

where subscripts denote partial derivatives with respect to the argument.

This equation is the fundamental PDE and together with a boundary condition on X, Equation (4) completely specifies the value of the claim X.

Notation

The characteristics of the mortgage contract, which is assumed to be an annuity, are defined by:

c = The continuously compounded coupon paid by the mortgagor;
p = The continuously compounded coupon paid to the investor;
i = The insurance spread, $i = c - p$;
T = The maturity of the bond;
C = The continuous rate of payment; and
$F(t)$ = The face value of the loan at time t.

Given an initial face value of $F(0)$, C and $F(t)$ are given by:

$$C = c \frac{F(0)}{1 - \exp(-cT)} \tag{5}$$

$$F(t) = F(0) \frac{1 - \exp(-c(T-t))}{1 - \exp(-cT)} \tag{6}$$

Further:

$S(r,t)$ = The present value of the remaining scheduled cash flow;
$M(r,H,t)$ = The value of the risky mortgage; and
$P(r,H,t)$ = The value of the bond.

H and r are the house price and the short interest rate prevailing at time t. Here $S(r,t)$ is the discounted value of the remaining promised payments if there are no prepayments or defaults. The discounting is done with respect to the discount function implied by the process for the short rate in Equation (2).

Further, the loan-to-value (LTV) ratio is defined here as the ratio of market value of the loan to the market value of the house, that is:

$$LTV = \frac{M}{H}. \tag{7}$$

In the notation of Capozza, Kazarian and Thomson (1998), this is the MCLTV. However, the notation is limited as only one type of LTV is used in the present context.

Actions of the Mortgagor

Suppose the value of a house is H at a fixed point in time and the current short rate is r. The face value of the loan is F, S is the value of the scheduled payments and M is the mortgage contract.

The mortgagor has three possible financially motivated actions. Suppose first that the value of the house is sufficiently high so that defaulting is not considered. If r is sufficiently high, then $S < F$ and the mortgagor has no financial incentive to prepay. Therefore, the mortgagor will not take any action at the given time for the given values of H and r. However, if r is sufficiently low, the value of the remaining payments S will be high compared to face value so prepayment becomes a valid option. Further, the higher S is compared to F or equivalently the lower the current interest rate is compared to the coupon of the loan c, the larger prepayments will be.

Suppose instead that the value of the house is very low such that $H < M$. If the LTV > 1, it effectively means that the house investment has negative equity. However, it should not be expected that all mortgagors immediately default just because the house value is lower than the value of the mortgage. For reasonable values of LTV, it is likely the mortgagor does nothing since selling the house will incur a loss. Note, however, there is technically nothing wrong with prepaying in these instances. All that is needed is that the mortgagor who chooses to prepay has other sources of wealth that can be used at termination. However, for very high LTV ratios, the mortgagors are expected to default on their payments simply because it is not feasible to pay off a loan where the collateral is of very little value.

It is also important to consider what is expected to happen when a mortgagor decides to terminate the loan prematurely. In line with Kau et al. (1992), it is assumed here that the mortgagor decides to prepay or default according to what is cheapest. In default, the house of value H is lost while the cost in prepayment is $F(1 + cost)$. Therefore, for $H < F\,(1 + cost)$, the mortgagor defaults on the loan and for $H > F\,(1 + cost)$, the mortgagor prepays the loan. Note that a fixed percentage cost of face value is assumed when prepaying.

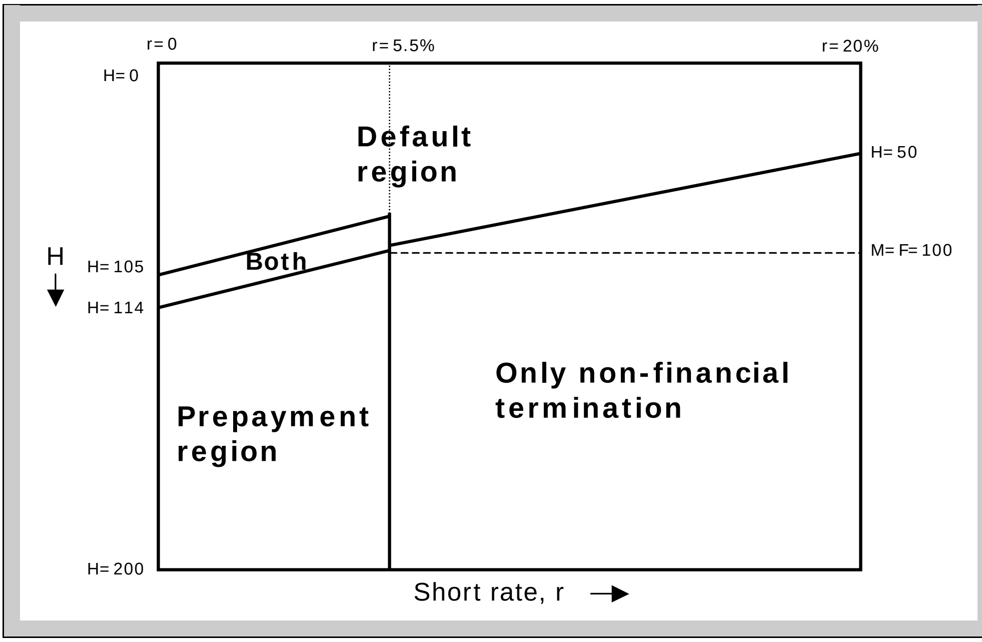
However, when $H > F\,(1 + cost)$, there will be interest rates such that $H > F\,(1 + cost) > M$ (*i.e.*, when the mortgagor prepays, the investor earns $F - M$). As explained in the introduction, this is one of the points of consideration in this paper.

It is instructive for the subsequent discussion to gain an understanding of what actions the agent chooses under different combinations of house price and interest rate. To illustrate this, Exhibit 1 has been included.

Default

Let δ denote the annualized default rate. In line with the literature in this field, assume that as long as $LTV \leq 1$ and $(H \geq M)$, there will be no financially motivated default. This essentially means that only the type of default caused by owning a house is considered, which is worth considerably less than the mortgage.

Exhibit 1 | Circumstances for Prepayments and Defaults for a 30-year Loan



This figure shows under which circumstances prepayments and defaults occur for a 30-year loan as specified with the parameters of Exhibit 3 in the section of numerical results. The focus is on a house worth 120 being financed with a loan with a coupon set such that it trades at face value of 100. With the specific choices of parameters, prepayments occur for short rates below roughly 5.5%, which is close to the initial short rate of 5.7%. If the house price is low, defaults occur but for higher interest rates there are fewer states with default. For low interest rates and higher house prices, prepayments occur while for high interest rates and house prices, there will be neither default nor prepayment. Non-financial termination occurs for any combination of house price and interest rate.

Thus, defaults caused by the inability of a mortgagor to honor the scheduled payments are not captured, for example. For $H < M$, the specification of Schwartz and Torous (1992) is used as follows for $\eta > 0$:

$$\delta(r,H,t) = \frac{M(r,H,t) - H(t)}{H(t)} \exp\left(\eta \frac{M(r,H,t) - H(t)}{H(t)}\right). \qquad (8)$$

Note that $\frac{M - H}{H} = LTV - 1$, so Equation (8) is in fact in terms of LTV. This equation has the desired properties: for $M = H$, there is no default and the default rate is increasing in LTV.

Prepayment

To model prepayments, a form of the required gain model is applied as proposed by Jakobsen (1992). For this, define the gain from prepaying as:

$$G(r,t) = \frac{S(r,t) - F(t)(1 + cost)}{S(r,t)}. \tag{9}$$

Where *cost* is a percentage cost from prepaying. $G(r,t)$ thus compares the value of a loan issued at par $F(t)$ to the present value of the remaining scheduled cash flow. Based on this measure of prepayment gain, the percentage rate at which mortgagors would like to terminate their loans is assumed to be:

$$\tilde{\pi}(r,t) = \Phi\left(\frac{G(r,t) - \mu_{gain}}{\sigma_{gain}}\right), \tag{10}$$

where Φ is the cumulative distribution function of the normal distribution truncated from below at zero. This means that in one aspect, the mortgagor is rational; if the immediate gain from prepaying is not positive, there will be no prepayment.

The specification in Equation (10) is not complete. Since $\tilde{\pi}$ does not depend on the house value, prepayments will be made irrespective of the value of the house. One would expect that when there is negative equity in a house (LTV $>$ 1), prepayments are very unlikely and when prepayments do happen, it must be because the mortgagors in question deplete other sources of wealth when refinancing. To accommodate this, the prepayment function in Equation (10) is augmented, such that for an LTV above a certain threshold (negative equity), there will be no prepayments, but for ratios lower than this threshold, the prepayment rate will be completely specified by Equation (10).

To achieve this, let LTV_{max} denote the threshold value such that $\pi = 0$ for LTV $> LTV_{max}$. Then let:

$$\pi(r,H,t) = \tilde{\pi}(r,t)\Psi\left(\frac{M(r,H,t)}{H(t)}\right), \tag{11}$$

where Ψ has the property of being zero for an LTV above LTV_{max} and quickly increase to 1 for a decreasing LTV. Specifically, Ψ is the cumulative distribution function of the truncated normal distribution, truncated from above at LTV_{max} with a sufficiently low standard deviation. This means that when the LTV is above LTV_{max}, there are no prepayments; while as the LTV decreases, the prepayment activity approaches the specification of Equation (10).

Non-financial Termination

In contrast to Schwartz and Torous (1992), the rate of non-financial termination is modeled here as a separate entity. But in line with their model, the Public Securities Association's (PSA) standard prepayment model is used as a measure of the rate of non-financial termination. In line with Kau et al. (1992), it is assumed that mortgagors terminate according to a PSA schedule of 100%. This means that the rate of non-financial termination is assumed to be 6% yearly after the 30th month of issuance of the bond. Prior to that, the rate of non-financial termination is assumed to increase linearly from zero at origination.

Implementation

Essentially, with Equation (4), all that needs to be specified for implementation are the functions $x(r,H,t)$ and $X(r,H,T)$. That is, the payout rate of the asset and the terminal condition. There are three separate entities to value with the PDE: the mortgage value (M), the bond (P) and the scheduled cash flow (S).

Since the loan is fully amortized, the terminal conditions are:

$$M(r,H,T) = P(r,H,T) = S(r,H,T) = 0. \tag{12}$$

The continuous payout rates, however, differ significantly. They are identical to those of Schwartz and Torous (1992) and are introduced in turn.

For the mortgage:

$$\begin{aligned} x_M(r,H,t) = {} & C + \pi(r,H,t)[F(t) - M(r,H,t)] \\ & + \delta(r,H,t)[H(t) - M(r,H,t)]. \end{aligned} \tag{13}$$

Equation (13) is perhaps more illustrative than the description earlier. The change in value of M is caused first by the continuous payment C. The loan is prepaid at the rate π where the agency loses the mortgage and instead receives the face value F. The loan is defaulted on with the rate δ where the agency again loses the mortgage but retains the house at value $H(t)$.

Further, for the bond:

$$x_P(r,H,t) = C - F(t)(c - p) + [\delta(r,H,t) + \pi(r,H,t)][F(t) - P(r,H,t)]. \tag{14}$$

That is, the payment C is made but the investor only gets the interest p and the difference $i = c - p$ is retained by the agency. Due to the default insurance, the investor receives the face value in case of either default or prepayment.

Finally, the scheduled payments of the mortgagor is an annuity and the simple payout rate is:

$$x_S(r,H,t) = C. \tag{15}$$

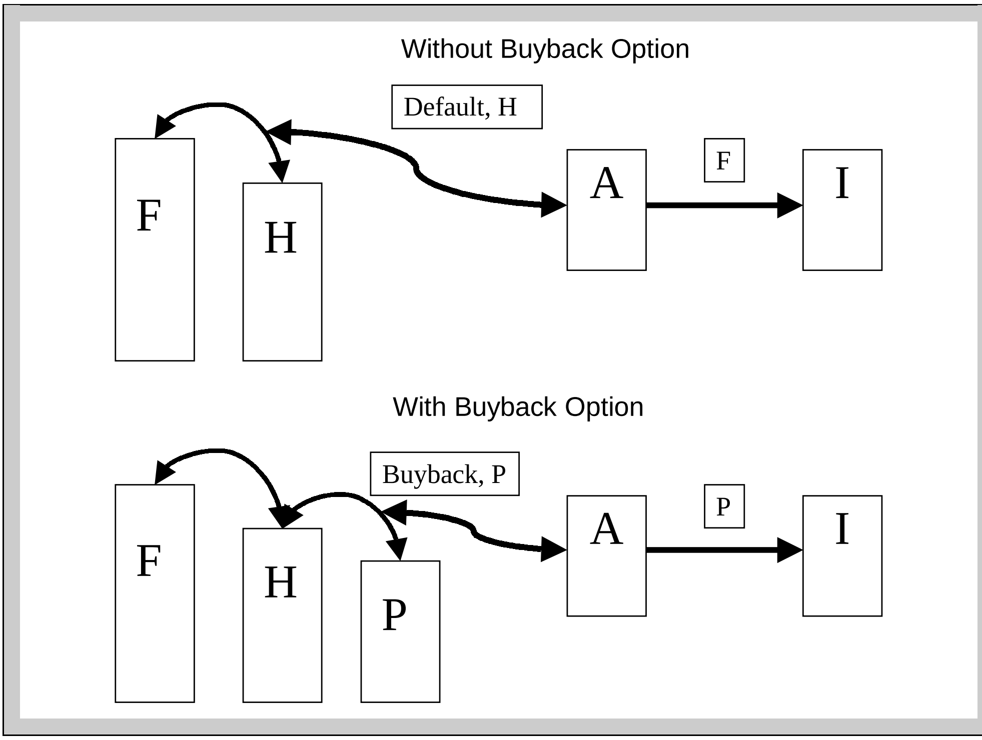
With the specification of the payout rates, a solution can be calculated. The PDE in Equation (4) is solved by an Alternate Difference Implicit (ADI) scheme with fine enough steps to give an accurate approximation to the continuous nature of the actions assumed in the model. Note that the three claims have to be valued simultaneously since they are interdependent due to the mutual dependence on the prepayment and default rates, which in turn depend on the value of the mortgage and the scheduled cash flow.

The Buyback Option

The buyback option can be used in two circumstances: in the case of non-financial termination and in the case of financially motivated termination. The most important use of the buyback option is for non-financial termination. In case a mortgagor has to move and thus needs to terminate the loan, the cheapest way to do so should be found. As discussed earlier, if $H < F \cdot (1 + cost)$ such that it is cheaper to give up the house of value H rather than prepaying at a price F $(1 + cost)$, the mortgagor defaults. However, if the interest rates are relatively high, it may very well be that the value of the bond backed by the mortgage is low such that $P < H$. In the presence of a buyback option, the mortgagor could choose to buy back the bond in the secondary market and effectively cancel the loan. This means that instead of defaulting, the mortgagor pays the market value of the loan. The effect from the buyback option in this case is illustrated in Exhibit 2.

There are three effects of introducing the buyback option in this case. First, instead of having to default, the mortgagor can simply buy back the loan at what it is worth. Second, because there is no default, the agency will not have to pay the difference between the house value and the face value to the investor. Third,

Exhibit 2 | How the Buyback Option Changes the Behavior in Non-financial Mortgage Termination



This figure illustrates how the introduction of the buyback option changes the behavior in non-financial termination. In the top portion of the figure, the mortgagor does not have a buyback option. In case the loan has to be terminated and the house is worth less than face value as depicted, then it is cheaper to default on the loan. The agency then has to pay face value to the investor and incurs a loss of $F - H$. Suppose instead that the mortgagor has a buyback option as shown in the bottom portion of the figure. If the value of the bond is below both the house and face value, then it is better to buy the loan back in the secondary market rather than prepaying or defaulting. In doing so, the loan is cancelled and the bond investor simply receives the value of the bond, P.

instead of receiving face value, which is higher than the market value of the bond in this case, the investor is simply paid the market value.

In another instance of non-financial termination, it may be that $H > F\,(1 + cost)$ such that it is more viable to prepay the loan rather than default. In this case, it may be that $P < F$ such that the bond trades below par. If the mortgagor had a buyback option, it could be possible not to prepay, but to pay the cheaper market value of the loan P. The net effect from this is that first, the mortgagor saves money and second, the investor does not receive a profit of $F - P$.

With the insights from the discussion above, how the buyback option is put into action can be formalized. Let:

$$D = \min\{F \cdot (1 + cost), H, P \cdot (1 + cost)\} \quad (16)$$

be the smallest of the expenses of prepaying, defaulting or using the buyback option respectively. In the case of prepayment, the mortgagor pays F (1 + $cost$). In the case of default, the mortgagor pays H. And finally, in case of exercising the buyback option, the mortgagor pays P (1 + $cost$). Note that the cost of exercising the prepayment and buyback options are assumed to be the same. In essence, if F (1 + $cost$) = D, there will be prepayment; if $H = D$, there will be default; and finally, if P(1 + $cost$) = D, there will be neither prepayment nor default and the bonds will simply be bought back into the market.

The other, less important, use of the buyback option is for the case of financially motivated termination. Within the model, there will be a positive rate of prepayment whenever there is a positive gain from doing so [see Equation (10)]. However, it may be the case that even if the gain from canceling the loan is positive, the market value of the security is below par due to the embedded options. In this model, this can be the case if the house price is below the face value of the bond causing defaults to be likely. Then, even though it is financially advantageous to cancel the loan, the mortgagor still has to pay the face value rather than just the value of the loan. In the presence of the buyback option, however, the mortgagor can simply choose to buy back the bond at the prevailing market price and as such the agency or the investor will not see a prepayment take place. The prepayment function is thus modified to the following:

$$\hat{\pi}(r,H,t) = \tilde{\pi}(r,t)\Psi\left(\frac{M(r,H,t)}{H(t)}\right)1_{\{P(r,H,t)>F(t)\}} \quad (17)$$

i.e., no prepayments take place when the value of the bond is below face value.

Finally, the actions of the agency have to be modified with the introduction of the buyback option. Facing default, without the buyback option, the agency has to restore the face value of the debt to the investor, retaining the house. However, with the introduction of the buyback option. it is reasonable that the agency can choose whether the compensation in case of default comes in the form of prepayment, restoring the face value, or buyback, simply repurchasing the bonds from the investor at the prevailing market prices. This further reduces the liabilities of the agency.

With these changes, the dividend payout rate to the bond defined in Equation (14) has to be modified to the following:

$$\hat{x}_P(r,H,t) = C - F(t)(c - p) + [\delta(r,H,t)1_{\{P(r,H,t)>F(t)\}} + \pi(r,H,t)][F(t) - P(r,H,t)]. \tag{18}$$

Thus, the only change is in the indicator variable, which has been multiplied onto the default rate. Only in the event of default, where the bond is worth more than the face value, will the investor see any effect from defaults.

Note that with the introduction of the buyback option, the complexity of the valuation problem is increased: when determining the optimal termination strategy, default, buyback or prepayment, the market value of the bond has to be taken into account. The same is the case for financially motivated prepayment, which now also depends on the market value of the bond.

Numerical Results

For ease of overview, all parameter values along with a short explanation are given in Exhibit 3. A few comments are warranted. The default rate and the parameters of the house price process are taken from the specification of Schwartz and Torous (1992), while the interest rate parameters are taken from Downing, Stanton and

Exhibit 3 | Study Parameters

Parameter	Value	Explanation
T	30	Maturity of loan
γ	0.13131	Mean reversion rate of interest rate process
θ	0.05740	Long-term level of interest rate process
σ_r	0.06035	Volatility of interest rate process
λ	−0.07577	Market price of interest rate risk
s	0.065	Service flow required to maintain house
σ_H	0.10	House return volatility
ρ	0	Correlation between interest and house return processes
η	4.58	Default rate parameter
μ_{gain}	0.3	Mean required gain of prepayment model
σ_{gain}	0.2	Standard deviation of the prepayment model
cost	2%	Cost of using prepayment (and buyback) option
LTV_{max}	120%	Upper limit for prepayment

Wallace (2001) to better reflect the current economic conditions. The mean and standard deviation of the required gain are admittedly ad hoc but chosen to give an annualized prepayment rate of 10% for a prepayment gain of 10% and a prepayment rate of 26% for a prepayment gain of 20%. The short rate is assumed to start at its long-term level, $r_0 = 0.0574$. Finally, innovations to interest rates and house prices are assumed to be uncorrelated as is argued for in, for example, Capozza, Kazarian and Thomson (1998).

It is important to understand how the effects from introducing the buyback option can be measured. With a starting point in a loan without a buyback option, the value of the loan will decrease with the introduction of one more option. Assuming that the mortgagor needs to buy the house at a fixed LTV, the mortgagor will need to borrow more and in turn increase the payments and the likelihood of default etc. As such, this will make it quite complicated to present an unbiased analysis of the effects.

Instead, par coupon rates are used in the spirit of Schwartz and Torous (1992). The par rate c^* is the coupon rate that the mortgagor has to pay in order for the loan to be issued at par. The par rate p^* is the coupon rate the agency has to promise the investors for the value of the bond to be issued at par. In the case of the no buyback option, simply solve for c^* and holding this fixed, solve for p^*. However, as seen above, with the introduction of the buyback option, the value of the mortgage also depends on the value of the bond, for c^* and p^* must be solved simultaneously using the following equations:

$$F = M(r,H,T,c^*,p^*). \tag{19}$$

$$F = P(r,H,T,c^*,p^*). \tag{20}$$

Evidently, this has to be done numerically and the specific method applied is to minimize, for given initial short rate and house price, the following quantity:

$$\begin{aligned} O(r,H,T,c^*,p^*) = {} & \mathrm{O}(F - M(r,H,T,c^*,p^*))^2 \\ & + (F - P(r,H,T,c^*,p^*))^2. \end{aligned} \tag{21}$$

The solution procedure always converges, albeit rather slowly, for any given precision.

For a given short rate and house price, the coupon rate can be charged to the mortgagor and also offered to the investor so that both assets trade at par. The quantity $i^* = c^* - p^*$ is the insurance spread. Exhibit 4 illustrates the par rates for the normal security and for the case with a buyback option for varying initial house prices and a face value of 100.

Focusing on the case without a buyback option, c^*, unsurprisingly, decreases as the house price increases, effectively as the mortgagor borrows less money and the creditworthiness increases. This is to be expected since a low house price means that defaults are more likely, which requires compensation in the form of a higher promised payment.

It can be seen that p^* is very stable across house prices due to the presence of the protection against the default of the mortgagor. For low house values, p^* is significantly below c^*, which is caused by the embedded compensation of default. For increasing house prices, the difference between p^* and c^* disappears. This is also seen in the insurance spread i^*, which is high for low house values caused by the presence of default risk, and goes to zero for increasing house values.

Further, for a house price of 120, an LTV of 83%, 19.5 basis points (bp) is retained as a compensation for the credit protection. Interestingly, the insurance spread at an LTV of 83% coincides perfectly, without tweaking any parameters, with the findings of Jaffee (2003) who estimates the insurance fee paid by the investors to be 19 bp. Therefore, as a starting point, the model appears to be yielding credible results.

For the case with the buyback option, the findings indicate the same stylized behavior albeit at different levels. Focusing on the insurance spread, i^*, it is consistently lower. For a house price of 120, the insurance spread drops from 19.5 bp to 14.9 bp. This decrease corresponds to a relative decrease of 23.6% and this is stable for a range of different house prices, as can be seen from the Exhibit 4. Thus, introducing the buyback option consistently lowers the portion of coupon

Exhibit 4 | Par Coupon Rates and Insurance Spread

	Normal				Buyback				Relative
H	c^*	p^*	i^*	i^*/c^*	c^*	p^*	i^*	i^*/c^*	Decrease
100	8.10	7.34	0.759	9.37	8.48	7.93	0.552	6.51	27.3
110	7.71	7.35	0.366	4.75	8.18	7.90	0.275	3.36	25.0
120	7.54	7.34	0.195	2.59	8.04	7.89	0.149	1.86	23.6
130	7.45	7.34	0.110	1.48	7.97	7.89	0.085	1.07	22.6
140	7.40	7.33	0.065	0.87	7.93	7.88	0.051	0.64	21.9
150	7.37	7.33	0.039	0.53	7.91	7.88	0.031	0.39	21.4

Notes: This table shows par coupon rates and insurance spread in percent for a security of face value equal to 100 with and without a buyback option for a fixed short rate of 5.74% and varying house price levels. Additionally, the fraction of coupon payments, i^*/c^* retained by the agency is shown, as well as the relative decrease in the insurance spread when introducing the buyback option.

payments retained by the agency as payment for the credit protection offered to the investor.

Focusing on a house price of 120, it is not surprising that with the buyback option, the mortgagor has to agree to a higher coupon payment, here 50 bp, in order to get the loan at par. This is because that with the buyback option, there will no longer be any sub-optimal behavior from the part of the mortgagor in terms of prepaying the loan even if the value of the loan is under par. Since this is a loss for the investor, the promised payment has to be higher. However, at the same time, there will no longer be a range of 'unnecessary' defaults in states with low mortgage and house prices where the agency loses the difference between the house price and the face value. This again causes the insurance spread to decrease. In short: the fair coupon rates increase because the investor can no longer make profits from non-financial termination and the fair credit spread decreases because there are fewer defaults as a result of non-financial termination where the mortgagor cannot buy back the loan at par. From the viewpoint of the mortgagor, payments are higher because it is now possible to cancel the loan at market value and this is worth precisely 50 bp.

It is of interest to examine the fair insurance spread under different economic environments. Exhibit 5 illustrates fair coupon rates and insurance spreads with

Exhibit 5 | Par Coupon Rates and Insurance Spread: Base Level of 6.035%

	0.03		0.06035		0.12	
	c^*	i^*	c^*	i^*	c^*	i^*
Panel A: Normal						
100	8.00	0.620	8.10	0.759	8.50	1.178
110	7.70	0.274	7.71	0.366	8.01	0.628
120	7.57	0.133	7.54	0.195	7.80	0.355
150	7.47	0.020	7.37	0.039	7.61	0.078
Panel B: Buyback						
100	8.33	0.372	8.48	0.552	9.01	0.971
110	8.12	0.163	8.18	0.275	8.62	0.546
120	8.03	0.080	8.04	0.149	8.45	0.311
150	7.96	0.013	7.91	0.031	8.33	0.065

Notes: This table shows par coupon rates and insurance spreads in percent for a security with a face value equal to 100 with and without a buyback option for a fixed short rate of 5.74% and for varying house price levels. The interest rate volatility parameter σ_r is varied around the base level of 6.035%.

and without a buyback option for varying house prices and levels of the interest rate volatility, σ_r. Across different values of σ_r, introducing the buyback option reduces the fair insurance spread, even though the benefits decrease as the interest rate volatility increases significantly. This comes as no surprise since the mortgagor is endowed with one more option. As is well known from the option pricing literature, option values increase with volatility so bond values decrease, raising the fair coupon rates.

A parameter of crucial importance is the house return volatility σ_H since more a volatile house price increases the default risk of the mortgage. Exhibit 6 presents an analysis of the effect on fair coupon rates and insurance spreads for three levels of σ_H. As was the case for varying interest rate volatility, the findings indicate that the buyback option consistently reduces the fair insurance spread. For example, for a house price of 120, going from a house price volatility of 10% to 20%, the insurance spread without a buyback option increases 94 bp, while the insurance spread in the case of a buyback option increases only 71 bp. This observation is valid for any level of the house price and is especially pronounced for low values of H. With the buyback option, the fair insurance spread is less sensitive to changes in house price volatility.

Exhibit 6 | Par Coupon Rates and Insurance Spread: Base Level of 10%

	0.05		0.10		0.20	
	c^*	i^*	c^*	i^*	c^*	i^*
Panel A: Normal						
100	7.62	0.269	8.10	0.759	9.69	2.551
110	7.40	0.077	7.71	0.366	8.90	1.614
120	7.35	0.025	7.54	0.195	8.47	1.138
150	7.33	0.001	7.37	0.039	7.87	0.516
Panel B: Buyback						
100	8.08	0.203	8.48	0.552	9.80	1.762
110	7.92	0.061	8.18	0.275	9.20	1.189
120	7.88	0.019	8.04	0.149	8.84	0.856
150	7.88	0.001	7.91	0.031	8.34	0.396

Notes: This table shows par coupon rates and insurance spreads in percent for a security of face value equal to 100 with and without a buyback option for a fixed short rate of 5.74% and varying levels of the house price. The house price volatility parameter σ_H is varied around the base level of 10%.

To verify that the conclusions are not sensitive to a particular choice of parameters, sensitivity analyses were conducted on all the parameters in a spirit similar to what has been done above for the volatility parameters. For brevity, the results are not presented in full here but are merely summarized. First, across a wide range of assumptions on prepayment activity, the conclusions remain clear. Second, for realistic levels of the default parameter η, there is only a small effect of changes on the fair coupon rates and insurance spreads. Third, departing from the assumption of zero correlation between innovations to interest and house return processes causes the fair insurance spread in the model to decrease, but at the same time the relative effect from introducing the buyback option increases. Fourth, decreasing the service flow parameter s also reduces the fair insurance spread, but the relative effect of introducing the buyback option remains stable around 21% to 27%.

In summary, the introduction of the buyback option costs approximately 50 bp for the mortgagor and reduces the insurance spread by between 21% and 27% within the modeling framework. These conclusions are robust to changes in various important parameters of the model. Especially, should the most crucial parameter, the house price volatility, increase, the fair insurance spread moves less in absolute terms if the mortgage had an embedded buyback option.

Discussion

The findings can be stated as three points. First, introducing the buyback option reduces the fair insurance spread by 23.6%. Second, the reduction in insurance spread is stable across a wide range of economic environments and across levels of initial LTV. Third, the price of the buyback option for the mortgagor is 50 bp.

These findings have a range of implications distilled as five points. The first two points relate directly to the numerical findings while the remaining three points are based on interpretations of the results.

First, in so far as the GSEs do in fact pose a contingent liability to the U.S. government, introducing the buyback option will reduce the contingent liability of the government because it reduces the fair insurance spread. This is further enhanced by the fact that the insurance spread fluctuates less with changing economic environments if the mortgage contains a buyback option.

Second, the fact that the buyback option increases the fair coupon rate paid by the mortgagor with 50 bp means that the buyback option is *valuable* to the mortgagor. It means that within the model, states of lock-in are likely so having the buyback option is very useful to allow for a termination of the loan without incurring a loss. The interest rate environment is modeled here as estimated by Pearson and Sun (1989) and with this choice of parameters, states with high interest rates where the buyback option has significant value are likely. Further, historically, there have been cases of very high interest rates in the U.S. where a buyback option would have been valuable. Another way to view this finding is that the investors facing non-financial termination no longer receive the face value of debt in states where the interest rates are high and the bond is trading below par. Because they lose money, they require a compensation that the mortgagor has to pay. Granted, paying 50 bp extra for a loan to get a buyback option is the choice of the mortgagor: if the mortgagor believes that high interest rates in the future are likely and the chance of needing to move is equally high, the extra 50 bp may be a worthwhile extra expense.

Third, LMI households are expected to be more exposed to lock-in effects because they are at greater risk of losing their jobs. If this happens, it is vital to be able to terminate the loan at a low cost, given that the mortgagor may no longer be able to honor the scheduled payments. Thus, in this case the buyback option could be a useful tool to allow the mortgagor to terminate the loan cheaply and fairly, thus avoiding default. Further, the prior section noted that loans with a high LTV benefit from a reduced insurance spread. This means that benefits to both the mortgagors and the agency are present for LMI households.

Fourth, it is a stated goal of F&F to increase the home ownership for LMI households even if there is an ongoing controversy concerning whether this has been achieved (see, for example, Passmore. 2003; White, 2003; and Bostic and Surette, 2001). In light of the argument above, the buyback option could help LMI households become homeowners as the potential danger of lock-in are not present with a loan containing a buyback option.

Fifth, the use of a buyback option also relates to the discussion put forth in Campbell and Cocco (2002). Using a life-cycle model, they find that households with large mortgages, a risky labor income, high risk aversion and a low probability of moving would generally prefer a fixed-rate mortgage (FRM) to an adjustable-rate mortgage (ARM). However, people with (relatively) large mortgages and risky labor income generally have a high probability of moving, as they could be forced to relocate to keep a job and they would therefore be less inclined to use a FRM. If they choose an ARM, they will not have the problem of having to terminate a loan by prepayment if interest rates were high and their mobility will not be inhibited. On the other hand, if they choose an ARM, they will be fully exposed to interest rate fluctuations. This is clearly not ideal if the household needs to obtain a very large mortgage relative to the house price. Instead, they could opt for a FRM with a buyback option. With this contract, they avoid the interest rate risk of ARMs, but they will still be protected against lock-in.

A lingering issue concerns *how* the buyback option could be introduced into practice in the U.S. In Denmark, the use of the buyback option is facilitated by the fact that Danish mortgage-backed bonds are pure pass-through securities: each specific mortgage can be traced directly into a bond that is traded in the secondary market. This means that when a mortgagor wants to terminate the loan, it is possible to identify the bond it was financed through and buy back an equivalent portion of this at the prevailing market price. This means that loans have to be securitized for this to work and there should be a moderately liquid secondary market for the bonds such that fair prices are formed. This means that for loans in the U.S. held in portfolios by financial intermediaries, a buyback option cannot be offered directly since a fair price of the loan is not available. However, this problem could be ameliorated if the various intermediaries could agree on a methodology to value individual loans fairly. This could be done by discounting the scheduled cash flow using an agreed-upon curve with a spread depending on the credit rating of the mortgagor, say, and would enable buyback for loans that are not securitized.

Conclusion

Justifiably, it can be argued that the model framework used to examine the effects of a buyback option is very simplistic and not taking into account well-known aspects of mortgage modeling. For example, the model does not take into account the so-called burnout phenomena that mortgages, which have experienced high prepayment rates in the past, are less likely to experience future high prepayments. Furthermore, it does not take into account the unobserved heterogeneity of mortgage pools as in Downing, Stanton and Wallace (2001). The prepayment function of Jakobsen (1992) that is employed is not standard in the U.S. mortgage literature either, even though it is very much in tune with the general intuition that mortgagors prepay in an inherently suboptimal fashion. Further, as pointed out earlier, the conclusions appear not to be sensitive to the level of prepayment in the model.

Another valid point of critique is consistency in the way the use of the embedded options are modeled. The default and prepayment options are assumed to be exercised in a suboptimal fashion while the buyback option is used optimally in the sense that it is used immediately after it becomes worthwhile to use (*i.e.*, a binary decision). Instead, one could argue for a more smooth transition between the exercise of the buyback option and not; however, this is not essential for pricing. Whether you use a binary or a smooth version of the buyback option, the results are the same even though the choice has technical implications for calculation of sensitivity measures. However, keeping these reservations in mind, the model generates reasonable results, as the fair insurance spread is very much in line with the empirical estimate of Jaffee (2003).

The core result of this paper is that introducing the buyback option could reduce the fair insurance spread of the mortgage agencies by more than 20% and the insurance spread is more stable across economic environment. The prior section discussed how this could have implications for the U.S. mortgage market. In light of this discussion, there are real benefits to be reaped from introducing the buyback option: it could reduce the contingent liability of the U.S. government, help F&F in reaching their goal of increasing the ownership rate for LMI households, and, in general, prove to be of great value to mortgagors as a tool to prevent lock-in effects.

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