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Default and prepayment modelling in participating mortgages ☆

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ABSTRACT

Since the 2008 financial crisis, the mortgage market has been renovating its tools and instruments in order to avoid a new crisis. One such innovative instrument is the participating mortgage, in which the lender gains part of the net operating income and/or future appreciation. In this paper, we establish a financing model for participating mortgages, incorporating early termination options such as default and two prepayment clauses, defeasance and prepayment penalty. Later, we illustrate a detailed sensitivity analysis of the model. The values of early termination options depend on the choice of parameters in the model, as well as the term structure of short term rates. Finally, we show that a participation rate of 11.24% results in zero mortgage interest rate using the parameters in our simulation.

1. Introduction

Over the past two decades, mortgage products have become more prominent in the fixed-income market. The need for such products varies in accordance with the demand of the borrower and specific characteristics of the market. Participation mortgages (i.e. participating mortgages or PMs) allow borrowers to obtain below-market interest rates in return for a percentage of the property's future appreciation and/or net operating income. They were first introduced mid-1980s, as an alternative to the fixed rate mortgages, when interest rates were high. However, they were unpopular, because borrowers were reluctant to share in the appreciation of the property and adjustable rate mortgages, which had lower initial rates, were also introduced around the same time. Furthermore, due to poorly written loan origination agreements coupled with the capital requirements of the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA)[1] participating mortgages were never popular. Until relatively recently, little has been written on these mortgages, and even now, literature has not addressed the effects of default and prepayment risks in pricing such mortgages.

However, the recent financial crisis has proven that risk sharing may reduce the magnitude of the impact in case of the market crash. PM allows the borrower to have the ownership in the property while sharing the downside market risk with the lender. In conventional banking, the mortgage lender is interested with the refund of a given debt and does not consider the property appreciation. However, for a commercial participation mortgage the expected performance and risk of the investment determines the credit and debt positions of the lender and the borrower respectively. While the lender can receive a return higher than the market interest rate, borrowers may also have advantageous mortgage rates. Similar conditions can be transcribed for the borrower of a residential mortgage. She forgoes a ratio of the property's rent or sale proceeds in order to get lower mortgage payments. Additionally, participation conditions for any kind of property can be adjusted in the contract depending on the agreement between the borrower and the lender.

Caplin et al. (2008) argues that "development of shared appreciation mortgage (i.e. SAM) markets in the United States would moderate the impending decline in homeownership and lower the risk of future housing crashes. SAMs can increase the affordability of homeownership by reducing the amount of monthly payments and spreading risk more broadly between borrower and lender...". Thus, the participation mortgage can be re-introduced to the market in addition to packaging mortgages and creating

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[1] FIRREA chartered the Resolution Trust Corporation to manage insolvent thrifts formerly insured by the Federal Saving and Loan Insurance Corporation. It adapted a new regulation, making it difficult for saving institutions to hold certain amount of real estate loans. The total regulatory capital amount became 8% thereafter. The commercial real estate loans held by commercial banks had a 100% risk-weighted classification. Lastly, it also made banks onerous to liquidate commercial mortgages and curtailed originating them (see Hayre, 2001).

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mortgage-backed securities to reduce the mortgage rate[2] for affordable housing. Therefore, the PM can prevent the next potential financial crisis. However, the risk of default and prepayment for participation mortgage needs to be studied in order to prevent problem areas from arising. This paper examines these potential problem areas and establishes a path around them.

Few of the earlier studies emphasize the general framework of participating mortgages. The rest of the literature focuses on a similar but more specific type of mortgage called a shared appreciation mortgage. For example, Alvayay et al. (2005) represents a partial equilibrium model to estimate the extent of the lender's participation and conducts a comparative analysis of the factors affecting it. Ebrahim (1996) demonstrates that participating mortgages improve social welfare which implies that they are pareto superior to conventional mortgages. Ebrahim et al. (2011) establishes a basic framework of participating mortgages and describes a facility to the mortgage system. However, they use constant risk-free interest rate as a discount rate in their model. The definition of general participating mortgage in the paper is split up into different forms such as shared income, shared equity and shared appreciation mortgages. We extend their structure into a more realistic case incorporating default and prepayment options, adopting stochastic interest rate model.

Initial studies on participating mortgages rely on the model as an attempt to reduce the levels of high interest payments in the U.S. (see Dougherty et al., 1982). Additionally, Page and Sanders (1986) and Dougherty et al. (1990) also focus on the effects of interest rate risk on the SAMs. Sanders and Slawson (2005) is one of the more comprehensive studies, which forms the mortgage pricing model for SAMs adapting the fixed rate mortgage model of Kau et al. (1992).

The purpose of this paper is to contribute to the theoretical understanding of pricing participating mortgages by incorporating early termination clauses due to default and prepayment, and in particular to find the value of the options to the borrower. We employ three types of options namely default and two prepayment clauses, that are defeasance and prepayment penalty which are widely used in commercial and residential mortgages respectively. The option pricing method which is similar to Hilliard et al. (1998) is embedded into the model and Longstaff and Schwartz (2001) where the simulation method is used to calculate the option prices.

Our numerical analysis documents that an increase in the participation rate for appreciation increases in prepayment and does not result in significant increases in default values. However, an increase in income shares increases both the prepayment and default values. For shared equity mortgages, the lender forgoes interest payments from the borrower by receiving a proportion of both net operating income and sale proceeds. In an example, we show that if income and appreciation participation rates are 11.24%, then the mortgage interest rate becomes zero.

The remainder of the paper is as follows: the next section introduces the participation mortgage model; Section 3 includes prepayment and default risks into model; Section 4 documents the simulation results, finally, Section 5 summarizes the findings and concludes.

2. The model

Following Ebrahim et al. (2011), we introduce the profit process P_t (i.e. operating income from operations by renting the property) can be defined as

$$dP_t = (\tilde{r}_t - \delta_P)P_t dt + \sigma_P P_t dZ_t^P, \tag{1}$$

where $\tilde{r}_t$ is the expected return (i.e. risk adjusted yield) and δ_P is the constant periodic cash yield (i.e. similar to dividend yield in stock). Additionally, σ_P denotes the volatility of profit process and Z_t^P is a standard Brownian motion with respect to the physical measure. We define the real estate property value as H_t, which is generated from the following stochastic process

$$dH_t = (\tilde{r}_t - \delta_H)H_t dt + \sigma_H H_t dZ_t^H. \tag{2}$$

Kau et al. (1992) defines δ_H as a service flow from using the real estate over time. Note that the borrower and the lender share the maintenance cost for the property, in proportion to their participation in the mortgage. The volatility σ_H indicates how the property value deviates from its mean. Z_t^H is donated as the standard Brownian motion for the process.

For the tractability of the calculations, we assume the expected return on both the profit and real estate property value are the same, $\tilde{r}_t$, and follows Vasicek (1977) model (see Bakshi et al., 1997; Deng, 1997),

$$d\tilde{r}_t = \alpha(\tilde{\theta} - \tilde{r}_t)dt + \sigma_{\tilde{r}} dZ_t^{\tilde{r}}, \tag{3}$$

where α denotes the speed of mean reversion, $\tilde{\theta}$ is the long-run mean rate and σ_r denotes volatility. We assume $E[dZ_t^P dZ_t^{\tilde{r}}] = E[dZ_t^H dZ_t^{\tilde{r}}] = 0$.

We define the initial loan balance of Q_0, the loan to value ratio of L, and the maturity of the mortgage as T. The loan includes continuous mortgage payments of a_t for all $t \in [0, T]$ and the terminal payment (i.e. balloon payment, sometimes also called the bullet payment) B_T at maturity. The outstanding loan balance (i.e. OLB) at time 0, Q_0, is equal to sum of discounted expected value of the future mortgage payments and the terminal balance such that

$$Q_0 = \int_0^T e^{-\tilde{r}_0(s)s} E_0[a_s]ds + e^{-\tilde{r}_0(T)T} E_0[B_T], \tag{4}$$

where $\tilde{r}_0(s)$ is the term structure of risk adjusted yield. For simplicity, we assume a non-amortizing mortgage, also called interest-only mortgage, in which there is a balloon payment consisting of the entire principal amount of the mortgage at maturity. Therefore, the outstanding loan balance for each period equals to the initial loan payment, implying $Q_t = Q_0 = B_T$ for all $t \in [0, T]$. Continuous mortgage payments are determined with a constant proportion i of OLB and $a_t = iQ_t = iQ_0$ for all $t \in [0, T]$, where i is the mortgage rate representing the cost of using mortgage determined at time 0. If there is no prepayment, default, and any other risk, then the mortgage rate i equals to the risk-free interest rate.

In comparison to conventional mortgage, participating mortgages offer a participative contract between the lender and the borrower. In return for reduced mortgage rate, PM promises the lender to a part of either the excess payoff from the periodic net operating income or the gain of the sale proceeds or both. In other words, the borrower compensates the declined mortgage rate in the mortgage contract by giving a share of the excess profit flow (i.e. $(P_t - K)^+$) or the appreciation of the property value at the mortgage maturity (i.e. $(H_T - H_0)^+$) to the lender. K and H_0 denotes the fixed threshold for the profit flow and the initial value of the property respectively.

These threshold points can change depending on the agreement between the borrower and the lender. The share of the excess profit flow is binding by the contract, so both the lender and the borrower agree on the amount of the profit summed. Therefore, continuous mortgage payments, a_t, and the remaining balance at maturity B_T in participating mortgages now becomes

[2] Separating certain type of illiquid asset from the firm's general risk will allow the company raise funds at a lower cost than if it could have raised the fund by issuing debt or equity (Pennacchi, 1988). Similarly, when mortgages are packaged and mortgage backed securities are created, it reduces the mortgage interest rates further.