CSCanada
Management Science and Engineering
Vol. 10, No. 2, 2016, pp. 24-26
DOI:10.3968/8261

ISSN 1913-0341 [Print]
ISSN 1913-035X [Online]
www.cscanada.net
www.cscanada.org

The Interest Rate Risk of Reverse Mortgages

HUA Zheng[a],*; SU Xikun[a]

[a]School of Business Administration, South China University of Technology, Guangzhou, China.
*Corresponding author.

Received 5 January 2016; accepted 14 April 2016
Published online 26 June 2016

Abstract
Along with the aging problem, pension problems become a social problem. Reverse mortgage loan is introduced to solve the problem. The elderly get owner-occupied housing mortgages, while the borrowers retain the right to the use of the building. There are many kinds of risks in practice, interest rate risk can not be ignored. Through learning how the interest rate fluctuates, I have simulated the future interest rate fluctuations and analysed the influence of rate on reverse mortgage loan pricing. In the final, I put forward policy recommendations for decentralized interest raterisk.

Key words: Reverse mortgage; Interest rate risk; Simply jump process; Monte carlo

Hua, Z., & Su, X. K. (2016). The Interest Rate Risk of Reverse Mortgages. *Management Science and Engineering*, *10*(2), 24-26. Available from: URL: http://www.cscanada.net/index.php/mse/article/view/8261
DOI: http://dx.doi.org/10.3968/8261

INTRODUCTION
As China entered the aging society, the elderly population rises constantly, the pension becomes a key issue of the whole society. Reverse mortgages are a financial product to solve the problem. Without of moving out, old people can get the loan by mortgaging their houses. Mayer and Katerina (1994) put forward the housing reverse mortgage loan which can maximize the general houses into wealth, provide a guarantee for the old and improve the elderly life effectively. Further more, the retired old people could have a decent and comfortable life. Zimring (2004) thought that the new product is both an opportunity and challenge for the elderly. On the one hand, the products bring income to the elderly, so that they can get better medical treatment and insurance. On the other hand, people prefer to stay in the same place.The old are not willing to mortgage houses. Now, the products appear in China. Among all the risks in practice we face, the most important one is interest rate risk.

1. INTEREST RATE RISK

1.1 Introduction of the Interest Rate Risk
The interest rate is vital in the reverse mortgage, and it directly affects the credit ceiling that borrower can get. When interest rate rises, the loan amount will reduce while the lending agencies gain more, and vice versa. So far, our country has not set any standards about the interest rates in the reverse mortgage. Therefore, the development of the financial product didn't meet expectations. According to the specific situation, floating interest rate matchs the housing reverse mortgage loan, and the model is similar to the average interest rate of loan contract. So its fluctuation is in the same way to the common loan contract.

According to the regulations of the Central People's Bank, when the statutory mortgage loan interest rate is adjusted, the commercial banks to the personal housing mortgage loans will recalculate the payments of the next year. Therefore, the loan interest rate presents by leaps and bounds in our country.

1.2 Model Specification
Referring to the study of Lin Hai, Zheng Zhenlong, we set up a floating interest rate model.

$$\mathrm{d}R_t = K_t \cdot \mathrm{d}P .$$

P obeys the Poisson distribution parameter λ. λ is the jumping frequency. K_t represents the jump-amplitudes and obeys the normal distribution $N(0,(\sigma R_t)^2)$. Interest

rate values are discrete, so we can make the parameter estimation by moment estimation. λ=hop-count(n)/total sample $qty(N)$, σ^2=Var$(dR_t/R_t)/\lambda$.

1.3 Data Collection and Calculation

First we need to estimate parameter lambda. This article uses the monthly benchmark lending rate published by the Central Bank from1996 to 2006 as the original data. Data is shown in the following table.

We can estimate the parameters λ and normal distribution according to the historical data.

Table 1
Benchmark Lending Rate From1996-2016

Time	6 months	6-12 months	1-3 years	3-5 years	More than 5 years
1996-05-01	9.72%		13.14%	14.94%	15.12%
1996-08-23	9.18%	10.08%	10.98%	11.70%	12.42%
1997-10-23	7.65%	8.64%	9.36%	9.90%	10.53%
1998-03-25	7.02%	7.92%	9.00%	9.72%	10.35%
1998-07-01	6.57%	6.93%	7.11%	7.65%	8.01%
1998-12-07	6.12%	6.39%	6.66%	7.20%	7.56%
1999-06-10	5.58%	5.85%	5.94%	6.03%	6.21%
2002-02-21	5.04%	5.31%	5.49%	5.58%	5.76%
2004-10-29	5.22%	5.58%	5.76%	5.82%	6.12%
2006-04-28	5.40%	5.85%	6.03%	6.12%	6.39%
2006-08-19	5.58%	6.12%	6.30%	6.48%	6.84%
2007.03.18	5.67%	6.39%	6.57%	6.75%	7.11%
2007-05-19	5.85%	6.57%	6.75%	6.93%	7.20%
2007-07-21	6.03%	6.84%	7.02%	7.20%	7.38%
2007-08-22	6.21%	7.02%	7.20%	7.38%	7.56%
2007-09-15	6.48%	7.29%	7.47%	7.65%	7.83%
2007-12-21	6.57%	7.47%	7.56%	7.74%	7.83%
2008-09-16	6.21%	7.20%	7.29%	7.56%	7.74%
2008-10-08	6.12%	6.93%	7.02%	7.29%	7.47%
2008-10-30	6.03%	6.66%	6.75%	7.02%	7.20%
2008-11-27	5.04%	5.58%	5.67%	5.94%	6.12%
2008-12-23	4.86%	5.31%	5.40%	5.76%	5.94%
2010-10-20	5.10%	5.56%	5.60%	5.96%	6.14%
2010-12-26	5.35%	5.81%	5.85%	6.22%	6.40%
2011-02-09	5.60%	6.06%	6.10%	6.45%	6.60%
2011-04-06	5.85%	6.31%	6.40%	6.65%	6.80%
2011-07-07	6.10%	6.56%	6.65%	6.90%	7.05%
2012-06-08	5.85%	6.31%	6.40%	6.65%	6.80%
2012-07-06	5.60%	6.00%	6.15%	6.40%	6.55%
2014-11-22	5.60%	5.60%	6.00%	6.00%	6.15%
2015-03-01	5.35%	5.35%	5.75%	5.75%	5.90%
2015-05-11	5.10%	5.10%	5.50%	5.50%	5.65%
2015-06-28	4.85%	4.85%	5.25%	5.25%	5.40%
2015-08-26	4.60%	4.60%	5.00%	5.00%	5.15%
2015-10-24	4.35%	4.35%	4.75%	4.75%	4.90%

The data source：The People's Bank of China.

The duration of the housing reverse mortgage loan contract is long. Usually, it can last for more than 20 years. So the model uses a benchmark lending rate over five years.

There are totally 236 sets of data and will be 235 sets of data following the first difference. A total of 33 non-zero data in the different sequence represents the jumping frequency. So we can calculate the $\lambda=\frac{33}{235}$ =0.1404, σ^2=Var(dr_t/r_t) / λ, variance $S^2=\frac{1}{235}\sum(\frac{dr_t}{r_t}-0)^2$ = 0.0008945, then σ^2 = 0.0008945/0.1404. σ=0.07981. Therefore, the model of loan interest rate fluctuation can be described as $dr_t=K_t \cdot dP$. P obeys the poisson distribution of parameters of 0.1404 and K_t obeys the normal distribution $N(0,0.07981r_t)$.

1.4 Simulation and Data Analysis

From the calculation above, the model of loan interest rate fluctuation can be described as $dr_t = K_t dP$. P obeys the poisson distribution of parameters of 0.1404 and K_t obeys the normal distribution $N(0,0.07981r_t)$.

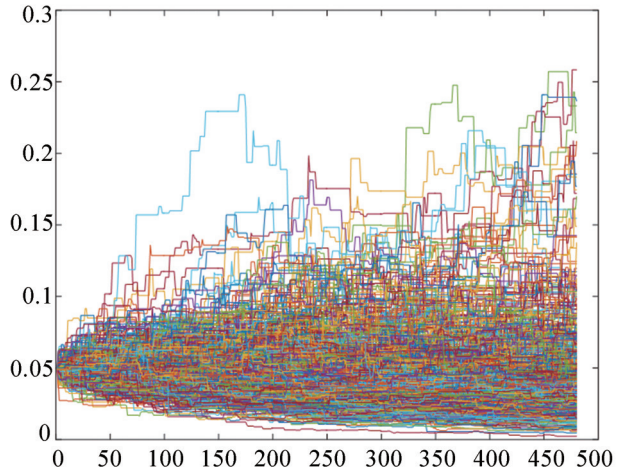

Figure 1
Interest Rate Fluctuation Path Prediction

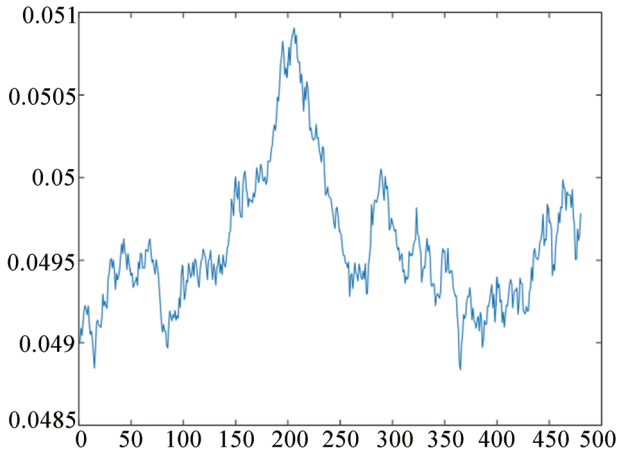

Figure 2
Interest Rate Fluctuation Trend Chart

We simulate the interest rate through using the monte carlo method, and obtain the 500 paths shown in Figure 1. Then we can calculate the average value of interest rate and then conclud that the future fluctuations trend of interest rate which is shown in Figure 2.

It can be seen from Figure 2 that interest rates basically fluctuate up and down around the initial value after equalization.

1.5 The Influence on Pricing Model

In the reverse mortgage loan, interest rate fluctuation affects mostly the accumulative amount of due borrowing. The main profit for lending institutions is based on the balance between the total loans and housing price. It is very important for lending institutions to determine interest rates and the loan amount at the beginning of the contract.

For example, regardless of the initial charge, the available loan amount for a x-year-old man can be described as

$$AR_x = \frac{\sum_{t=1}^{\omega-x+1}(\mathrm{H}_0 \prod_{s=1}^{t}(1+g_s)(1-\beta)^t) q_x^{t-1}}{\sum_{t=1}^{\omega-x+1} p_x^{t-1} \prod_{s=1}^{t} 1+r_s}.$$

r_e represents the annual loan interest rate. Interest rates have a marked impact on the pricing model.

2. THE MANAGEMENT OF INTEREST RATE RISK

According to the management theory, the basic management method of interest rate risk can be divided into four categories. They are the self adjustment, avoidance, decentralize and transfer.

The mechanism of self-adjustment is a common method for lending institutions. When they anticipate the interest rates go up or down in advance, they can take actions to adjust it in advance. But there is still a great risk. Misjudgments may bring great losses to lend institutions. To prevent losses, lenders tend to choose the floating interest rate. What is more, compared with the fixed interest rate, floating interest rate can be adjusted based on the market any time they need. On the other hand, due to the process of reverse mortgages, the lending institutions only have cash outflow in the early stage. Housing mortgage loan and reverse mortgage loan are completely opposite to each other on the cash flow. If lenders can effectively combine the two products, can they keep balance of cash flow? And this measure can effectively control the risk.

Avoidance is used more in foreign markets. Lenders use a variety of financial derivatives, such as forwards, options, swaps, to hedge the impact of interest rate changes.But those are not available yet in our domestic market which combining reverse mortgage loan and financial derivatives. In addition, lenders can introduce interest-rate ceiling or floors, so that the borrower or the lender can get the benefits.

Decentralization requires lenders to expand the scope of business as much as possible. On the circumstance that the number of borrowersis adequate, the interest rate risk impact of individual borrowers is insignificant.

Transfer means that risk can be transferred out. Lending institutions and insurance companies can cooperate together to get rid of risks.The margin profit will be reduced which is costly for lending institutions.

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