On the reverse mortgage in China: An Empirical Analysis Based on risk neutral pricing method

Kaichuang Dai

School of management, Wuhan University of Technology, Wuhan, China
*Corresponding author e-mail: 18086067143@189.cn

Abstract. "Reverse mortgage loan of housing" refers to the mortgage of housing property rights to financial institutions by the elderly with housing property rights. After comprehensive evaluation of borrower’s age, expected life, the present value of house, future appreciation and depreciation and other situations, the value of the house is divided into parts, and the cash is paid to the borrower on a monthly or annual basis until the borrower’s death.

1. Introduction

With the aging society in China, the limits of the current pension models and concepts are increasingly coming into highlight, and the gap between demand and supply in the pension market is also increasing. It is imperative to explore and develop new pension models which are suitable for Chinese national condition. Restricted by concept of traditional consumption, most of savings of Chinese elderly are preferentially invested in their own houses. They become typical rich in house but poor in cash after retirement, because they have relatively single source of and relatively low level of income, which makes their pension needs difficult to be fully met. Therefore, invigorating the real estate which owned by Chinese elderly to create stable income and meet their pension needs in this way relieve the pressure of social pension system should be the breakthrough point of pension model innovation in China. Among them, to develop housing to reverse the mortgage market and development of reverse mortgage housing business has been proved to be an effective housing pension model in developed countries in Europe and the United States.

2. What is reverse mortgage loan?

"Reverse mortgage loan of housing" is to impawn the house property rights to financial institutions by the elderly with housing property rights. After comprehensive evaluation of borrower’s age, expected retained life, present value of the houses, future appreciation and depreciation and other situations. The value of the house is divided into parts, and the cash is paid on a monthly or annual basis to the borrower until the borrower’s death. It enables the applicants to use the selling amounts of the houses in advance. The borrower will still obtain the housing rights and be responsible for the maintenance while obtaining the cash. After the borrowers’ death, the corresponding financial institution gains the property right of the house which can be sold, leased or auctioned. Using this income to repay the principal and interest of the loan. The corresponding institution also enjoys appreciation part of the house property.

Population aging has become an important global problem. Since the 1990s, China’s Aged tendency of population has been increasing. At the end of 2000, China has entered an all-round aging society. Data statistics shows that, the number of people over 60 years old in China has reached 203 million by
the end of 2013, and the aging level is as high as 15%. It is estimated that the population of aged 65 and above would reach 240 million, 345 million respectively in 2020 and 2050, and reach the peak in 2060, approaching 370 million. China’s aging population is ahead of the level of economic and social development, but the current pension security system and the traditional family pension model has been difficult to cope with the increasingly serious aging problem, so it is imperative to explore a new way of self pension for the elderly. In 2013, the State Council issued several opinions on speeding up the development of the elderly care serviced industry, which clearly proposed the pilot project of “carrying out the reverse mortgage endowment insurance for the elderly”, that is, "providing for the elderly by housing”.

3. What is risk neutral pricing?
Risk neutral pricing draws a conclusion if price of derivative securities depends on the tradable basic securities without any arbitrage possibility in the capital market, the price of the securities does no matter with the investors’ risk attitude.

The analysis process of the hypothesis problem has nothing to do with the risk preference to investors, that is, investors enter the so-called "risk neutral world". Using this method to price, we do not need to adjust the risk of future cash flow and necessary rate of return, simplify the complex problems, and make the research more systematic and comprehensive. This method is more suitable for the current situation of China’s trading market which has not been standardized, and the main risk factors of reverse mortgage are highly descriptive, which provides the feasibility for the use of this method.

4. Model building
In this paper, considering the dynamic of three major factors, namely the value of real estate, rate of interest and expectancy of life, the pricing of reverse life annuity mortgage is studied and analyzed based on the fact that present value of premium of guarantee is equal to the present value of expected claim loss.

4.1. Interest rate model
Considered the nominal rate of interest will make problem too complex. For the sake of simplification, it is assumed that the rate of interest R(t) obeys CIR. The rate of interest is known to be measurable, \(q_r\) is the average interest rates of long-term, \(k_r\) it’s the speed of the reversal, \(s_r\) is the instantaneous standard deviation, \(W_r\) its standard Brownian motion. \(W_r^Q(t)\) is Standard Brownian motion at Q, defined by CIR model. The continuous form of interest rate stochastic process under risk neutrality can be written as follows:

\[
dr(t) = \left(k_Q - \theta_Q r(t)\right) dt + \sigma_r \sqrt{r(t)} dW_r^Q(t)
\]  (1)

4.2. House price model
This paper assumes that the housing price follows the logarithmic normal jump diffusion process, and studies the fluctuation of housing price. The real house price fluctuation formula is transformed into a risk neutral model to evaluate the reverse mortgage loan. Its form is as follows:

\[
\ln \frac{H(t)}{H(0)} = \int_0^t r(s) ds - \left(\frac{\lambda_Q}{2}\sigma_H^2 + \lambda_Q \eta_Q\right) t + \sigma_H W_H^Q(t) + \sum_{i=1}^{N(t)} J_i^Q
\]  (2)

\(W_H^Q(t)\) is the standard Brownian motion in risk neutral, \(W_r^Q(t)\) and \(W_r^Q(t)\) The correlation coefficient between them is \(\rho_{rt}\).

4.3. Mortality model
In this paper, the widely used LC model is used to predict mortality. The central mortality rate of people aged x at time t is \(m_{x,t}\). Follow the following process:

\[
\ln(m_{x,t}) = \alpha_x + \beta_x k_t + e_{x,t}
\]

\(\alpha_x\) represents the logarithm mean of natural mortality in the population of age x, \(\beta_x\) is the rate of change in death, \(k_t\) represents the trend of mortality over time, \(e_{x,t}\) represents the error term.

On the prediction of \(k_t\) value, many countries have done research on fitting. The results show that the fitting result of ARIMA (0,1,0) model is most close to the actual situation. We use this model to predict the future value of \(k_t\).
4.4. Pricing model construction

When signing the contract, it is stipulated that the initial demand amount of the borrower is equal to the initial house price $p_0\%0T$, annual premium equal to the outstanding balance $p_m\%0T$, the loan interest rate adopts floating interest rate, equal to the short-term interest rate plus interest margin $p_r\%0T$. The borrower shall purchase reverse mortgage guarantee insurance from the insurance company and pay premium for the insurer. When the borrower dies, if the loan balance exceeds the house value, the lender will get compensation from the insurance company. If there is no arbitrage, the present value of premium is equal to the present value of expected claim loss under risk neutral. The present value of premium can be expressed as:

$$\sum_{j=1}^{m-x_0+1} (S(t_{j-1}) - S(t_j))C(t_j),$$

Among $C(t_j) = E_Q\{[BAL(t_j) - H(t_j)]e^{-rt}\}$.

5. Empirical analysis

5.1. Data source

For the estimated interest rate model, we select the monthly data of the people’s Bank of China about benchmark loan interest rate published for more than five years as the proxy variable. In the housing price model, we choose the volatility of second-hand price index of house in large cities as the price volatility parameter. For the borrower’s future life prediction, we use the data of Chinese men’s annuity life table issued by the CIRC.

5.2. Empirical results

Under the maximum likelihood estimation method, the housing price index is 0.03. In the process of LC model simulation, the risk market price is 0.5. We choose male borrowers aged 60-100 to calculate their reverse mortgage amount in 10-year-old segments. The specific results are shown in the table.

| Age   | 60  | 70  | 80  | 90  | 100 |
|-------|-----|-----|-----|-----|-----|
| Initial house value(m) | 1   | 1   | 1   | 1   | 1   |
| Average life span(y)   | 21  | 14  | 8   | 4   | 2   |
| Annuity amount(m)      | 4   | 7   | 12  | 23  | 32  |

From the data in the table, we can know that the older the borrower, the larger the amount of reverse mortgage. Every year, the borrower not only still owns the original residence, but also gets a considerable amount of money.

6. Conclusion

The model of pricing of risk neutral of reverse mortgage has no defect using static parameters. The result of this pricing simulation is helpful for both the supply and demand of loans. It can not only meet the needs of the elderly to increase their income to meet Chinese elderly pension needs, but also enable the financial institutions to increase profits in consideration of risks.

From the perspective of loan payment, the amount of loans that the reverse mortgage borrowers can get increases steadily with their age. The payment method of floating interest rate makes the borrower and the financial institution of the loan jointly undertake, and the amount of the loan under the payment method of fixed rate of interest. This shows the housing reverse mortgage loan can let elderly with housing and pension needs get additional cash on a regular basis when they have the original residence, which can greatly improve and improve the living security level of the elderly. In addition, encouraging the elderly to participate in the housing-based pension model can not only solve their worries in their later life, but also stimulate the consumption potential of the market, promote economic development, improve the liquidity of real estate, stabilize house prices and alleviate social conflicts.

The aging population can not be ignored, it brings challenges to the global economy. As a stable and reliable way to increase the income, the loan can effectively reduce financial burden of the government’s social security system. The term cash flow and benefits from reverse mortgages provide security for the elderly.
When we study to reverse mortgage, we consider the dynamic factors of interest rate, house price and mortality. From the data results, the fluctuation of interest rate and housing price is significant for fair annuity payment, and the improvement on mortality has a great impact on loan pricing. If these effects are ignored, it will affect the interests in insurance companies or borrowers.

In the current reality, there are still some difficulties in promoting reverse mortgage in China. First of all, because the risk factors involved are too complex and changeable, the factors we consider are only a part of them, which can not fully reflect the actual situation. Therefore, other factors need to be further included in the later research to make the pricing model more perfect and the results more realistic and reasonable. Secondly, we should not neglect the importance of the role of government. Government has formulated the policy requirements and implementation standards related to mortgage products, so as to ensure unification of industry norms. Therefore, we should also pay attention to the policy-making issues in the later research.

References
[1] Fan Ziwen. Research on the development of reverse mortgage in China [J]. China finance, 2006 (13)
[2] Tian Meng, Deng yinglu. Longevity risk modeling and derivative pricing of random mortality in China [J]. Insurance research, 2013 (1): 14-38
[3] Zhu Wei, Chen Bingzheng. Longevity risk analysis of personal Annuity under dynamic mortality rate [J]. Insurance research, 2012 (2): 21-28
[4] Bühlmann, H., Delbaen, F., Embrechts, P., Shiryaev, A.N. No-arbitrage, Change of Measure and Conditional Esscher Transforms[J].CWI Quarterly, 1996, 9:291-317.
[5] Ito, T., Hirono, K.N. Efficiency of the Tokyo Housing Market[J]. Bank of Japan Monetary and Economic Studies, 1993, 11 (1) :1-32.
[6] Chai Xiaowu, Meng Xiaosu. Reverse mortgage system [M]. Hangzhou: Zhejiang University Press, 2008
[7] Chen Jin. Mechanism of risk pricing model of reverse mortgage [D]. Hangzhou: Zhejiang University, 2010