The Pricing of Reverse Mortgages in the Chinese Market

Di Lorenzo Emilia, Piscopo Gabriella
University Federico II, Napoli, Italy
Sibillo Marilena
University of Salerno, Fisciano (SA), Italy

Reverse mortgages (RM) are an attractive tool to increase retirement incomes and to face the needs of health care for elderly people. The investor in the RM market faces several risks: longevity risk, as retirees’ life expectancy increases, interest rate risk, especially in the low-rate post-crisis period, property market risk, in the last stage of the current business cycle. In our pricing model we incorporate the overall risk of the RM, focusing on the feature of the developing Chinese market.

Keywords: longevity risk, financial risk, reverse mortgages, pension product

Introduction

The Chinese welfare system is undoubtedly suffering due to the progressive population aging. Recent studies (cf. Hanewald, Bateman, Fang, & Wu, 2020; Fan, Fang, & Yang, 2018) show that the average age will exceed that of high-income countries from 2035 onwards, with a worrying increase of over 60, which in 2050 might amount to 23% of the world’s elderly population.

As argued by Merton and Lai (2016), it is therefore more pressing than ever to find an adequate financial, health, and welfare response to the needs of the elderly. Just as in the industrialized countries of the West, the Chinese government has launched innovative plans to support the pension system.

As examined by Lya (2018), already in 2013 the Chinese State Council launched a pension innovation plan, in which reverse mortgages have a central role. The 60-year-old owners with full ownership of the house in which they reside can apply for reverse mortgages.

The first contractual aspects proposed at the beginning of the information campaign provided for payment options consisting of a lump sum, or an income stream, or a credit line or, finally, in a combination of the previous solutions. Upon the death of the owner, the proceeds from the sale of his home are intended for the repayment of the entire loan, as well as for the payment of interest and commissions.

This innovative plan was implemented in 2014 by Happy Life Insurance Company first in Beijing, Shanghai, Guangzhou, and Wuhan (cf. Hanewald et al., 2020; Lya, 2018) and subsequently expanded nationally four years later.

Despite extensive information efforts, the outcome of the national campaign was extremely poor. The reasons for the general distrust of reverse mortgages could be adduced to the common distrust of complex

---

Di Lorenzo Emilia, PhD, Full Professor, Department of Economic and Statistical Science, University Federico II, Napoli, Italy.
Piscopo Gabriella, PhD, Associate Professor, Department of Economic and Statistical Science, University Federico II, Napoli, Italy.
Sibillo Marilena, Full Professor, Department of Economics and Statistics, University of Salerno, Fisciano (SA), Italy.
Correspondence concerning this article should be addressed to Piscopo Gabriella, email: gabriella.piscopo@unina.it.
financial products (which perhaps have not been well explained to a population with a poor financial culture) but above all to the consideration of the home as an asset to be left as family legacy to the children.

Hanewald et al. (2020) conducted a thorough survey aimed at understanding the role of intergenerational expectations regarding the consequences of reverse mortgage contracts.

In particular, their work shows that a detailed and transparent description of the product and a family involvement on the destination of the income resulting from it, make the product more interesting. In fact, the online surveys conducted by the authors show how the response of potential customers varies depending on the description of the product that is provided to them. In addition, great importance is given to the possibility of allocating the liquidity provided by the contract also to support children or grandchildren.

The reverse mortgages, if properly implemented and explained, therefore represent a valid tool to support retirement income, even in a multifaceted scheme of finalization of the same.

The paper is organized as follows. Section 2 is devoted to a brief outline of the contract and to the description of the pricing model. Numerical Application to Chinese market id offered in Section 3; finally remarks are discussed in Section 4.

A Brief Outline of the Reverse Mortgage

The reverse mortgage is a suitable tool for planning one’s future financial situation. It is particularly aimed at those people who reach an advanced age in economic conditions that place them in the category known as “asset rich-cash poor”. Through this instrument, the owner of a house is able to liquidate, and therefore in a certain sense, to unlock, the “house” asset in order to obtain a lump sum or an equivalent periodic financial flow that will enable him to meet his daily expenses and needs.

Schematically, with a reverse mortgage, the homeowner lends out the value of his property without losing the right to live in it for the duration of his life. Upon the death or eventual transfer of the owner, the home is sold and the proceeds will be used to pay off the debt incurred with the reverse mortgage.

The purpose of this paper is to calculate the lump sum, an amount which is also fundamental for the calculation of the periodic flow, if one intends to proceed to the payment of life-long instalments.

The quantification of this amount mainly depends on three risk factors: longevity risk, house price risk, and discount rate risk (cf. Di Lorenzo, Piscopo, Sibillo, & Tizzano, 2020). Under the assumption of a non-negative equity condition or guarantee, two rates interact in the process of discounting the value of the property at maturity, the rate \( r_0^{RM} (t-1, t) \) of the reverse mortgage estimated in \( t = 0 \) and relative to the period \((t-1, t)\) and \( i(t-1, t) \) the market rate for a bullet loan referred to the same period. The lump sum \( A \) calculated at time \( t = 0 \) is given by the following formula:

\[
A = \alpha HV_0 \left[ \sum_{t=1}^{\omega} \prod_{k=0}^{t-1} \left[ 1 + r_0^{HV} (k, k+1) \right] \min \left\{ \prod_{k=0}^{t-1} \left[ 1 + r_0^{RM} (k, k+1) \right]^{-1}; \prod_{k=0}^{t-1} [1 + i(k, k+1)]^{-1} \right\}^{t-1/\delta_x} \right]
\]

where \( \alpha HV_0 \) is the percentage of the house value awarded to the owner by contract, \( r_0^{HV} (k, k+1) \) is the rate of appreciation of the real estate market relative to the period \((k, k+1)\) and estimated in \( t = 0 \), and \( t-1/\delta_x \)
is the probability that the homeowner, aged $x$ at issue, dies between the age interval $(x + t - 1)$ and $(x + t)$.

**Numerical Application**

In this section we produce an empirical analysis of a RM issued on the Chinese market. Our aim is to evaluate the lump sum provided by the lender. The pricing model is developed in a stochastic framework for the simulation of the risk factors affecting the product. To take into account the longevity risk, the mortality terms in the model will be extracted from a projected life table produced implementing the Lee Carter model (Lee & Carter, 1992) on the Hong Kong population with available mortality data downloaded from the Human Mortality Database. As regards the financial risk, we model and project the interest calibrating the Cox-Ingersoll-Ross model (CIR) (Cox, Ingersoll, & Ross, 1985) on the Hong Kong 10 Year government bond daily yield from 2010 to 2020. Finally, we model the evolution of the house price through a Geometric Brownian Motion with parameters given by the mean ($\mu$) and standard deviation ($\sigma$) as in Huang, Wang, and Miao (2011). All simulations are repeated $B$ times.

Let us consider a RM contract offered to a retired Chinese aged $x = 70$; the contract maturity is $T = 30$. He owns a house that, at the issue time $t = 0$, is valued 100,000 yen, and takes out a RM on the 70% of his home. We set $B = 10,000$, $\mu = 0.10$, $\sigma = 0.05$ and the difference between the interest rate on RM and that of a bullet loan 0.01. So, by means of the formula in Section 2, the lump sum obtained is 50,225.24.

The home holder has to repay the accumulated interests on the mortgaged proportion of the house value $\alpha H V_0$, in this case equal to 70,000, but unlike a classic loan, he receive the smaller Lump Sum. This is due to the fact that he is buying also a guarantee that gives his/her heirs at the random time of his death the possibility to repay the smaller amount between the accumulated interest on the loan and the agreed percentage (in this case, 70%) of the realized value of the home at that date.

**Final Remarks**

RM is a financial product that is appealing for people in ageing societies like China where the house ownership is widespread and the pension system is under pressure. For the lenders and financial institutions, the forecasting of the future liquidation value of the asset through which they recover the lent money is fundamental as well as the estimation of the overall risk. Although the contract has been launched on the Chinese market for several years, its development is still in its infancy for cultural reasons and lack of literacy. Our research in this sense aims to stimulate the economic and financial debate to support the development of the contract.

**References**


