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The Value of Reverse Mortgage Loans: Case Study of the Chinese Market

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Abstract

This study contributes to addressing the problem of an aging population by providing important information that determines feasible monthly payments for the clients of Chinese reverse mortgage products and by promoting the implementation of reverse mortgages in China.

The variables used in this study include mean values obtained from time series data, of the rate of increase of housing prices, and the probability value, interest rate, and mortality rate obtained through the geometric Brownian motion (GBM). For mortality rates, China Life Insurance female mortality rates (2000-2003) were used.

This study aims to apply the main variables that affect reverse mortgage products in a monthly payment model based on Chinese financial market conditions, and determine loan values. In this study, Shanghai's reverse mortgage monthly payments, by age levels, were calculated through the loan-to-value (LTV) and payment (PMT) methods to evaluate the value of the reverse mortgages.

Based on the optimal combination of the three factors of payment amount, loan interest rates, and the level of acceptance of prices, efforts must be made to extract the best value for the elderly. Only in this way can the interests of both lenders and borrowers be protected, by increasing the market share and economies of scale of the reverse mortgage industry and effectively improving the living standards of the elderly.

Keywords: Reverse Mortgage, Loan-to-Value, Payment, China, Geometric Brownian Motion.

JEL Classifications: D6, E3, F65, G12.

1. Introduction

With the rapid growth of the Chinese economy in recent years, the living standards of its population have improved greatly. Moreover, owing to the one-child policy and medical improvements, the birth and death rates have simultaneously decreased. Consequently, because of an increase in life expectancy, the Chinese population is rapidly aging. According to international standards, a country becomes an aging society if its population aged over 60 is at least 10% of the entire population or that aged over 65 constitutes at least 7% of the total population. Therefore, China has been an aging society since 1999, which is somewhat earlier than other developing countries. In addition, since China has the largest number of elderly persons in the world and accounts for one-fifth of the world's elderly population, China's aging population is closely aligned with the world's aging population. According to statistics, by 2020, the Chinese population aged 60 and over will exceed 248 million and constitute 17.17% of the total Chinese population. The elderly population will exceed 450 million by 2050, and the proportion of this population will exceed 32% (China National Committee on Ageing, 2006).

The reverse mortgage system is a loan system that involves holding the houses of borrowers (elderly house owners) as securities. It is used as a means through which senior citizens, while residing in their homes, can receive a fixed amount of pension every month. It was established to help senior citizens with no income to finance their living expenditures. Countries with aging societies and developed countries, such as the United States and several European countries, have managed reverse mortgage products for a long time. The most prominent reverse mortgage program is the Home Equity Conversion Mortgage (HECM) program in the United States and, in the case of South Korea, since 2007, the housing pension program operated by the Korea Housing Finance Corporation. Reverse mortgage loans provide stable financial support to senior citizens until their death or until the disposal of the house due to the cancellation of the contract. Thus, it can be seen that the implementation of the reverse mortgage system can significantly contribute to a stable residential life and the stability of post-retirement living standards (Ma, 2008; Scholen, 1996; Rodda et al., 2000; Kim, 2007). Wang and Kim (2014) analyze the Chinese housing market environment. After determining the vari-

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ables that affect the establishment of reverse mortgage markets, the study investigated the order in which the reverse mortgage system was adopted by administrative areas in China, through principal component analysis. To address the problem of an aging population, the Chinese government plans to adopt a pilot program comprising a reverse mortgage pension system in Beijing, Shanghai, Guangzhou, and Wuhan by March 31, 2016.

However, reverse mortgages are long-term financial products and have many risks associated with future uncertainty (Kim and Ma, 2006). Moreover, in the process of managing the reverse mortgage system, lending financial institutions face the risks of decreasing housing prices, rising interest rates, and the longevity of borrowers. If these risks are directly incorporated in the loan terms, increases in the borrowing interest rate and decreases in the loan-to-value (LTV) ratio are inevitable. Consequently, problems arise because of the significant deterioration in the efficiency of the reverse mortgage system. Thus, the reverse mortgage system is evaluated very differently, depending on the assumptions made regarding the average house price growth rate, average interest rate, and loan termination probability (Lee et al., 2010). Studies on reverse mortgages so far in China have only introduced the system or discussed its effectiveness (Wang and Kim, 2014) there are very few studies on the pricing model. This study aims to derive the main variables determining a reverse mortgage, according to Chinese financial market conditions, and apply them to a monthly payment model. Hence, this study hopes to provide assistance in the effective adoption and implementation of the reverse mortgage system in the Chinese market.

This paper is organized in the following manner. In Section 1, Introduction, the goal and importance of this study are presented, along with its direction. In Section 2, Theoretical Discussion, a summary of the reverse mortgage system and the formula and main variables affecting reverse mortgages are explained. Section 3 outlines the methodology of the study. Section 4, Empirical Analysis, analyzes the value of reverse mortgages in the Chinese housing market based on the model developed in Section 3. Finally, Section 5, Conclusion, summarizes the study and explains its significance and limitations.

2. Theoretical Discussion

2.1. The HECM of the United States and Housing Pension of South Korea

Although the reverse mortgage system in the United States was adopted in the 1960s, it became more active after warranties were offered through the Federal Housing Affairs (FHA) office, a branch of the Department of Housing and Urban Development (HUD), in 1989. In the HECM program warranted by the FHA, losses incurred by financial institutions because of reverse mortgage loans remain, although in the case of bankruptcy, the promised monthly loan payment is still made to the borrower. Reverse mortgage products sold in the United States

include the HECM; "Home Keeper" of the Federal National Mortgage Association (Fannie Mae); and "Cash Account" of Financial Freedom, a private financial institution. Among these, the HECM holds more than 80% of the reverse mortgage market. In South Korea, private reverse mortgages were administered by banks such as Ma, S.R., Synn, J.W han Bank and Kookmin Bank, but the frequency of their usage dropped significantly because of problems such as non-guaranteed permanent residences and loan-to-value ratios being less than general housing mortgage rates. In July 2007, the housing pension system, which is a reverse mortgage product administered through a guarantee from the Korea Housing Finance Corporation, began as part of a social safety network. The Korean housing pension is a financial product, guaranteed by the government, in which people aged 60 or older use their homes as security, and receive monthly retirement funds in the form of a pension until their death. The Korea Housing Finance Corporation issues guarantee certificates to the banks for the pension subscribers (borrowers), after which the banks disburse the housing pensions to the borrowers. When both individuals in a married relationship die, any remaining pension amount is inherited by the heirs (Korea Housing Finance Corporation, 2013).

With reverse mortgage products, the senior house owner may choose the method of receiving loans, taking into account the value of the house, age, and health and fiscal status. Additionally, the loan payment method can be from several classifications. The HECM classifies the methods into the life annuity payment method, fixed term annuity payment method, limited borrowing method, and hybrid method combining all these categories (Ma, 2006b). In South Korea, there is the annuity payment method, through which monthly payments can be received without setting a withdrawal limit, and the hybrid method, through which a withdrawal limit is set and any remaining amount is paid monthly (Korea Housing Finance Corporation, 2013). If the annuity payment method or the hybrid method is selected, the type of monthly pension payments may be chosen depending on the borrower's fiscal status (as in Table 1).

<Table 1> Method of loan

Division	HECM	House Pension
Joining Age	62	60
Method of loan	Tenure Payment	Tenure Payment
	Term Payment	
	Line of Credit	Modified Tenure
	Modified	

2.2. Determination of the Reverse Mortgage Payment Amount

In the HECM model (Szymanoski, 1994), if the loan balance exceeds the house price at the end of the loan, the loan amount is determined at the point where the expected losses are equal to the expected guarantee fees to be paid during the borrower's lifetime. With the use of the trial and error method, the loan amount is determined with the condition that the pres-

ent value of the expected losses corresponds to the present value of the expected premium. Since the calculation process of the loan amount can be applied for any given age of the borrower and expected interest rate, it is possible to derive the LTV ratio of each mortgage loan. The monthly loan payments are calculated by applying the amount of the interest rate and guarantee fee rate in the LTV formula obtained using house prices (Park, 2012). The Korean house pension model, similar to the HECM model, is a method through which the appropriate amount of loan payments can be calculated using the balance of earnings and expenditures, in which the present value of the expected amount of damage from reverse mortgages is matched against the present value of expected guarantee fees (Ma, 2008).

$$PVMIP = UP_0 + \sum_{t=1}^{T(a)} \frac{mip_t \times P_{a,t}}{(1+i)^t} = PVEL \quad (1)$$

PVMIP = present value of the expected reverse mortgage insurance (guarantee) fees

PVEL = present value of the expected losses of reverse mortgage

UP_0 = initial guarantee fees at time $t=0$

(a) = time left for the borrower at age a to live until the maximum age limit of 100

mip_t = monthly guarantee fee $mip_t = (OLB_{t-1} + pmt) \times m$

pmt = monthly payment (pension) m = monthly guarantee fees

OLB = accumulated debt of the borrower at period t (loan balance)

$OLB_t = (OLB_{t-1} + pmt + mip_t) \times (1+i)$

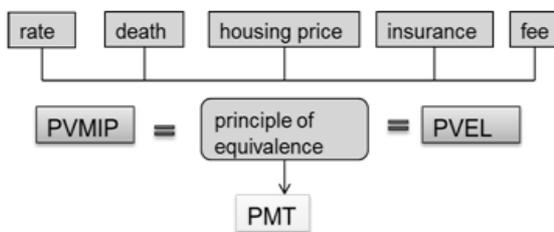
i = expected interest rate

$P_{a,t}$ = probability that the loan of the borrower at age a will survive until age $a+t$

q_{a+t} = probability that the monthly payments to a borrower will end at age $a+t$

H_t = house price at time t $H_t = H_0 \times (1+g)^t$, g = average appreciation rate of house price

Equation (1) can be also presented as a diagram as shown in Fig. 1.



<Figure 1> Reverse mortgage payment method

2.3. Main Variables of the Reverse Mortgage Model

2.3.1. Appreciation Rate of House Prices

Considering the fact that reverse mortgages are long-term

contract products, long-run predictions about the fluctuation of housing prices over the next ten years would be very important in designing a reverse mortgage product (Ma and Synn, 2009). In the HECM model, the geometric Brownian motion (GBM) is used in modeling the effective trends of possible long-term housing prices (Szymanoski, 1994). The GBM is a model that is commonly used when modeling the stochastic process of real estate, stock prices, and exchange rates. It is also a stochastic model when house prices follow a lognormal distribution. If the house price, H , follows the GBM, the stochastic model of housing prices is as shown in Equation (2).

$$dH/H = \mu dt + \sigma dz \quad (2)$$

H = House Price

μ = Expected Appreciation Rate of House Price

σ = Volatility of the Appreciation Rate of House Price

dz = wiener process

With the assumptions in Equation (2), the returns for house prices are deemed to be normally distributed and the rate of increase in house prices is considered equal to the expected rate, while the factors that deviate from the mean rate of increase in house prices are explained by volatility (σ).

Meanwhile, the annual appreciation rate of each property can be considered as an independent observation derived from the normal distribution with mean μ and standard deviation σ . As such, the cumulative appreciation rate, depending on the time span, also follows normal distribution; here, the mean is μt and the standard deviation becomes $\sigma \sqrt{t}$.

The expected house price at a future time period ($E(H(N))$), derived from the aforementioned GBM of house prices, is shown in Equation (3) (Appendix).

$$E[H(N)] = H_0 e^{\mu N + 0.5\sigma^2 N} \quad (3)$$

In the equation above, μ and σ are constants. In the HECM model, $\mu = 4\%$, $\sigma = 10\%$ are applied. In the study of Cha and Jung (2008), $\mu = 4.03\%$, $\sigma = 3.43\%$ were obtained through time series data of the house price composite index given by the Kookmin Bank of South Korea.

2.3.2. Interest Rate

The pension-calculated interest rate is a rational assumption used to estimate the size of optimum monthly payments, based on the actual expected short-term loan interest rates, which would be applied throughout the mortgage loan term (Lee et al., 2010). The two types of expected interest rates used in the HECM are fixed interest rates and floating interest rates. With the fixed interest rate method, the expected lending interest rate is determined by adding the margin of the fixed interest rate to 10-year government bond yields. However, most HECM loans have floating interest rates and the margin of the fixed interest rate is added to the one-year government bond yields set to the sterling interbank rates (the London interbank offered rate

(LIBOR)). Every year, the applicable interest rate is adjusted through fluctuations in LIBOR. In the case of the mortgage pensions in South Korea, the borrower's interest rate is aligned to the current interest rate by applying floating interest rates, equivalent to 1.1% being added to the 91-day certificate of deposit (CD) bond yield. The discount rate to be used for pension calculations is obtained from the 10-year Treasury bond, which is 6.33%. Since the lending interest rates are added to the loan balance by the loan-issuing financial institution one month after the disbursement of the monthly payments, the borrowers do not directly pay the interest rate through the monthly payment they receive (Korea Housing Finance Corporation, 2013). The monthly payments of the housing pension may increase or decrease depending on the fluctuation of CD interest rates. Moreover, owing to an increase in the interest rate, there may be a lack of collateral earlier than expected (Lee, 2011).

2.3.3. Mortality Table

Since the loan period is not defined for reverse mortgages, mortality tables are used to predict the number of people who will pay guarantee fees in the future and the number of people who become deceased after losses have started to occur during their lifetimes. The mortality rates are used for the predictions of expected losses. As life expectancy increases, the monthly payments decrease, and if the ratio of the expected survival rate to actual survival rate increases, the larger are the losses incurred by the Korea Housing Finance Corporation. The mortality tables consist of the probability of death (mortality) and the expected remaining life expectancy by age and gender. Mortality tables used for housing pensions are prepared through comparisons with the central population, based on the number of people who die in a certain year, as reported to the National Statistical Office.

In the case of the HECM, the national female mortality rates are used in the program's mortality tables. This is because, among consumers of reverse mortgage products before the implementation of the HECM program, approximately 75% of them were single, with 63% being female and 12% being male. When the HECM was implemented, there were no previous surveys for determining the probability of the termination of loans on reasons other than death; thus, assuming that this probability would simply be 0.3 times the female mortality rate, the probability of termination of reverse mortgage loans was assumed to be 0.3 times the female mortality rate. The monthly payments of the housing pensions are calculated using the National Female Mortality Table from 2010 (Korea Housing Finance Corporation, 2013).

2.3.4. Guarantee Fees

In terms of guarantee fees, the HECM model involves an initial premium, which is 2% of the house price at the start of the reverse mortgage and paid as a lump sum, and monthly guarantee fee, which is 0.5% of the annual interest added to the total loan amount (Ma, 2006b). The total loan amount of the borrower includes the initial subscription fees at the start of the reverse mortgage, monthly guarantee fees for the reverse mortgage, and service fees, interest, and other fees that the bor-

rower needs to pay, in addition to the loan principal. A single premium structure, such as this system, applies equally to all reverse mortgage products, regardless of the age of the borrower, house price, and the payment method of the reverse mortgage. In the case of the housing pension in South Korea, the fee includes an initial guarantee fee (subscription fee) and an annual guarantee fee. The initial guarantee fees, which are 2% of the house price, are paid on the first pension payment date. The annual guarantee fees are paid monthly and are 0.5% of the guarantee balance for the year. Financial institutions are paid by the borrowers the financial institutions are required to pay the guarantee fees to agencies, such as the Korea Housing Finance Corporation, and this is added to the total pension amount (loan balance) (Korea Housing Finance Corporation, 2013). The loan terms for reverse mortgages end for reasons such as the borrower's death, relocation, or early refund of the payment. However, with housing pensions, while there is no prepayment fee, borrowers cannot reclaim the initial guarantee fees that they have already paid. In the reverse mortgage system, the initial guarantee fees levied, and other initial costs, are used to discourage the early refund of reverse mortgage loans.

2.4. Literature Review

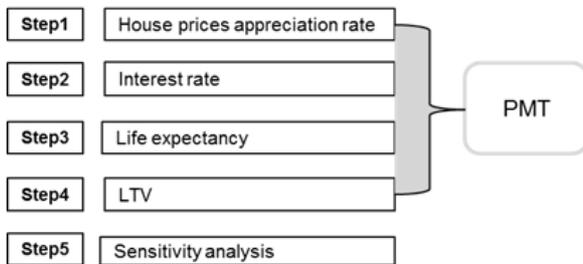
There have been many theoretical and empirical discussions on reverse mortgage loans. Researchers have conducted studies mainly on the risks borne by the suppliers of reverse mortgage products or the risk associated with guarantees. International studies have been conducted, for example, by Boehm and Ehrhardt (1992), Szymanoski (1994), Chinloy and Megbolugbe (1994), Quercia (1997), and Shiller and Weiss (2000). These studies were conducted largely on the HECM program, the American reverse mortgage system with public guarantees. The most prominent studies on reverse mortgages conducted in South Korea include that of Ma (2006a, 2008, 2011), Kim and Ma (2006), Ma and Lew (2008), Cha and Jung (2008), Ma and Synn (2009), Min and Cho (2009), and Chang et al. (2011). These studies have been conducted largely for analyzing the risk management plans for the guarantees relating to reverse mortgages. From the consumers' perspective, studies that evaluate the cost and usefulness of the reverse mortgage system include those by Lew and Ma (2012). According to Park (2012), reverse mortgages are a highly risky financial product with high uncertainty. In reality, when evaluating reverse mortgages, "overestimation" or "underestimation" can occur in the evaluation process owing to differences in incentives, expertise of the examiners, characteristics of the evaluated asset, insufficient accurate information, and asymmetric information.

Ma et al. (2007) evaluated the value of reverse mortgages by applying the 1-factor Vasicek model. Chang et al. (2011) applied the 3-factor linear term structure model and Lee-Carter mortality rate model to evaluate the value of housing pensions, analyzing the corresponding changes in the monthly payments of housing pensions and guarantee fee rates. To identify the adequacy of the main variables of the current reverse mortgage model, Lee

et al. (2010) reviewed the actuarial model by analyzing the risk associated with such variables. They verified the market risk implied in the housing pension model by using house prices and a stochastic interest rate generator model. By proposing security measures to mitigate such risks, they provided an alternative method for eliminating market risk. This study analyzed the value of Chinese reverse mortgages, using a reverse mortgage-pricing model suggested by Cha and Jung (2008).

3. Methodology

To calculate monthly reverse mortgage payments in China, the city of Shanghai was chosen for the study and age levels were set at 60, 65, 70, 75, and 80. The PMT formulas were calculated using a house price of 100 Yuan. This study was conducted as shown in Fig. 2.



<Figure 2> Steps for computing reverse mortgage PMT

To evaluate the value of reverse mortgages, it is necessary to make assumptions on increases or decreases in housing prices. This study used Equation (3) to calculate expected housing prices. To estimate the parameter values of Equation (3), the rate of house price appreciation, μ , and volatility of the rate of house price appreciation, σ , were used. The elements μ and σ were estimated using the data from the home sales price index for Shanghai, from January 2001 to May 2011 (137 months), as announced by the China Real Estate Index System (CREIS).

The Chinese financial markets apply the deposit and lending rates within the range set by the government. This study, therefore, uses fixed interest rates. For mortality rates, China Life Insurance female mortality rates (2000-2003) were used. The initial guarantee fee rate and annual guarantee fee were set at 2% and 0.5%, respectively, and these were assumed to be the same as those used in the American HECM program and the Korean housing pension.

In order to calculate the monthly reverse mortgage payments, the maximum LTV ratio and the net borrowing limit must be calculated first. The LTV becomes the house price at the end, discounted to the present value of the net borrowing limit of the reverse mortgage (PV), and to do this, the expected house price and discount rate at maturity should be calculated. The LTV is obtained by dividing the initial borrowing limit by the current house price and using this value, the PV may be de-

termined, considering the initial costs. Based on the calculated PV, the monthly pension payments until a future time period may be determined. In this study, the LTV was calculated using the following equation (Equation (4)).

$$LTV = \frac{H_N}{\prod_{t=1}^{T=N} (1+r)} / H_0 \tag{4}$$

LTV = maximum reverse mortgage loan ratio

H_N = expected house price at the future time of expiration N

r = interest rate

Once the borrower's maximum reverse mortgage loan ratio (LTV) is determined by age level, the net borrowing limit (PV) of the reverse mortgage can be obtained by multiplying the house price at the time of lending ($t=0$) by LTV, as in Equation (5), taking into account the initial guarantee fees.

$$PV = H_0 \times LTV - UP_0 \tag{5}$$

PV = present value of the net borrowing limit of the reverse mortgage

H_0 = house price at current period ($t=0$)

LTV = maximum reverse mortgage loan ratio

UP_0 = initial guarantee fees

In this study, the following equation (Equation (6)) was used to calculate the monthly payments.

$$PMT = \frac{PV}{\sum_{t=0}^{T_m-1} \frac{1}{(1+r)^t}} \tag{6}$$

PMT = monthly payment of the lifetime annuity payment method

PV = present value of the net borrowing limit of the reverse mortgage

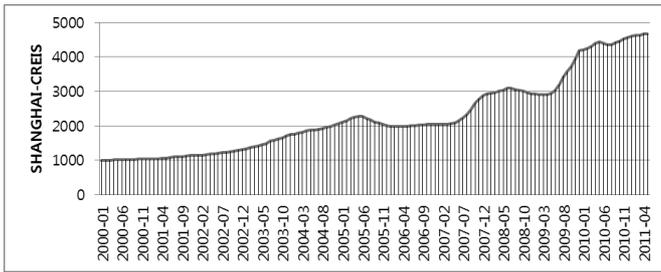
T_m = expected remaining life expectancy (months)

r = calculated pension interest rate

4. Empirical Analysis

4.1. Empirical Analysis

Fig. 3 shows the time series data on the comprehensive housing sales index from January 2001 to May 2011 (137 months), from the housing sales price index in Shanghai presented by the CREIS (National Bureau of Statistics of China, 2013).



<Figure 3> CREIS (Shanghai 2001.1-2011.5)

The statistical results of the comprehensive home sales index are shown in Table 2. The average annual appreciation rate of house prices, μ was 4.6% (Table 2).

<Table 2> Descriptive analysis

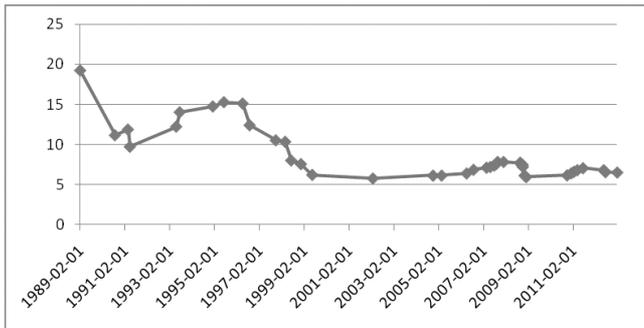
Mean	Std err	Std dev	Min	Max	Range
4.6%	93	1094	1003	4673	3670

The volatility (σ) of the appreciation rate of house prices was obtained by using the equation for historical fluctuations (Equation 7) and it was fixed at 5.91% per year.

$$\sigma = \sqrt{\frac{\sum(x_i - m)^2}{n - 1}} \quad (7)$$

- σ = historical fluctuations from time T
- n = n months
- x_i = the return at time T
- m = average of the return

In this study, the expected interest rate to be applied in reverse mortgages, of 6.5%, which was the interest rate announced by the People's Bank of China in 2013, was applied as a fixed rate (Fig. 4) (The People's Bank of China, 2013).



<Figure 4> Change in real estate loans of China

4.2. Calculation of LTV and PMT by Age Levels

The LTV was obtained by using the model chosen in the previous section and applying the average time at maturity by age level (expected remaining life expectancy, N, Table 3). The results of the LTV estimations are shown in Table 4.

<Table 3> Age-specific maturity

(unit: year)

Age	Average term to maturity	Using maturity
60	25.44	25
65	21.06	21
70	16.97	17
75	13.25	13
80	9.99	10

<Table 4> Age-specific expected house prices, interest rate, LTV

(unit: Yuan)

Age	N	Expected house prices	Interest rate	LTV
		E(H(t))	r	
	0	10,000,000	6.5%	-
	1	10,489,031	6.5%	98.49%
	2	11,001,977	6.5%	97.00%
	3	11,540,008	6.5%	95.53%
	4	12,104,351	6.5%	94.09%
	5	12,696,291	6.5%	92.67%
	6	13,317,180	6.5%	91.27%
	7	13,968,431	6.5%	89.89%
	8	14,651,531	6.5%	88.53%
	9	15,368,037	6.5%	87.19%
80	10	16,119,581	6.5%	85.87%
	11	16,907,879	6.5%	84.58%
	12	17,734,727	6.5%	83.30%
75	13	18,602,011	6.5%	82.04%
	14	19,511,707	6.5%	80.80%
	15	20,465,890	6.5%	79.58%
	16	21,466,736	6.5%	78.37%
70	17	22,516,526	6.5%	77.19%
	18	23,617,655	6.5%	76.02%
	19	24,772,632	6.5%	74.87%
	20	25,984,090	6.5%	73.74%
65	21	27,254,794	6.5%	72.63%
	22	28,587,638	6.5%	71.53%
	23	29,985,662	6.5%	70.45%
	24	31,452,055	6.5%	69.38%
60	25	32,990,158	6.5%	68.34%

The calculation showed that if reverse mortgage loans are received initially according to LTV, borrowers of age 60 would be able to borrow up to 68.34%; age 65, up to 72.63%; age 70, up to 77.19%; age 75, up to 82.04%; and age 80, up to 85.87%. The borrower's net borrowing limit (PV), when applying 2% as the loan guarantee fee rate (subscription fees included), is calculated using Equation (5). The results of the monthly payments that are calculated using Equation (6), based on the calculated net borrowing limit (PV), are shown in Table 5.

Table 5 shows the monthly payments if the borrowers aged 60, 65, 70, 75, and 80 own houses that are worth over one million Yuan; those aged 60, for example, would receive monthly payments of 4,522 Yuan. This income would not only improve the current income and quality of life of the elderly, but would also help alleviate the pressure on the Chinese social security system, which is a significant concern that the Chinese government sought to address by launching the reverse mort-

gage industry. Based on the optimal combination of the three factors of payment amount, loan interest rates, and the level of acceptance of prices, efforts must be made to extract the best value for the elderly. Only in this way can the interests of both lenders and borrowers be protected, by increasing the market share and economies of scale of the reverse mortgage industry and effectively improving the living standards of the elderly.

<Table 5> Regional mortgage payments

(unit: Yuan)

Division	60	65	70	75	80
H_0	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Residual life (month)	300	252	204	156	120
Interest rate (%)	6.5%	6.5%	6.5%	6.5%	6.5%
UP_0	2%	2%	2%	2%	2%
PV	669,732	711,774	756,462	803,992	841,426
LTV (%)	68.34%	72.63%	77.19%	82.04%	85.87%
PMT	4,522	5,184	6,136	7,647	9,554

4.3. Sensitivity Analysis

In order to observe the sensitivity due to fluctuations in the rate of increase in house prices, the appreciation rate of a house price was calculated from $\mu \pm 1\%$ and the results are shown in Table 6.

<Table 6> Sensitivity analysis for housing prices

Age	$\mu - 1\%$		μ		$\mu + 1\%$	
	LTV	PMT	LTV	PMT	LTV	PMT
60	53.22%	3,458	68.34%	4,522	87.74%	5,789
65	58.87%	4,142	72.63%	5,184	89.60%	6,380
70	65.12%	5,120	77.19%	6,136	91.49%	7,289
75	72.04%	6,662	82.04%	7,647	93.43%	8,696
80	77.70%	8,596	85.87%	9,554	94.90%	10,549

According to the results of the sensitivity analysis in Table 6 (for age 60), when setting a low appreciation rate for a house price, the LTV decreases by 15.12% and the PMT decreases by 1,064 Yuan. On the other hand, when setting a high appreciation rate for a house price, the LTV increases by 19.4% and the PMT increases by 1,267 Yuan. This demonstrates that reverse mortgage products are highly sensitive to the rate of increase in house prices.

<Table 7> Sensitivity analysis for interest rate

Age	$r - 1\%$		r		$r + 1\%$	
	LTV	PMT	LTV	PMT	LTV	PMT
60	86.51%	5,190	68.34%	4,522	54.10%	3,850
65	88.51%	5,798	72.63%	5,184	59.68%	4,552
70	90.62%	6,696	77.19%	6,136	65.85%	5,547
75	92.74%	8,155	82.04%	7,647	72.65%	7,103
80	94.37%	10,024	85.87%	9,554	78.21%	9,046

To observe the sensitivity due to fluctuations in the interest rate, the interest rate was calculated from $r \pm 1\%$ and the results are shown in Table 7.

The analytical results show that the lower the fixed interest rate, the higher the LTV and the PMT, and that if the interest rate falls, a higher pension amount is possible.

5. Conclusion

This study, by using the LTV and PMT formulas to evaluate reverse mortgages, calculated the reverse mortgage monthly payments in China's major city Shanghai, by age levels. The age levels were divided into 60, 65, 70, 75, and 80. The house price was set at one million Yuan. The variables used included fluctuations, an increase in the house price, interest rate, and mortality rate, and they were applied according to the Chinese financial market conditions.

The volatility of house prices and the house price appreciation rate were calculated to be 5.91% and 4.6%, respectively, using the comprehensive home sales index (January 2001 to May 2011) from the home sales price index of Shanghai provided by the CREIS. Mortality rates from the Chinese mortality tables were used, assuming fixed interest rates and future mortality rates at a certain time period.

This study showed that if reverse mortgage loans are initially received as LTV, borrowers aged 60 can borrow up to 68.34%; those aged 65, up to 72.63%; those aged 70, up to 77.19%; those aged 75, up to 82.04%; and those aged 80, up to 85.87%. By conducting a sensitivity analysis using a floating house price appreciation rate and interest rate, it was concluded that the actual pension amount that can be disbursed varies significantly, depending on how the house price appreciation rate and the interest rate fluctuate. The results indicate that reverse mortgages would greatly improve the quality of life of the elderly. The empirical results have important implications, and serve as a useful reference for the Chinese authorities in the future implementation of reverse mortgage policies.

The limitations of this study and potential future research areas are as follows. 1) The loan term was estimated using mortality rates from Chinese mortality tables. However, with developments in medical technology and the environment, these mortality tables need to be revised. 2) The average annual appreciation rate of house prices and the volatility of interest rates are influenced by complex changes in several variables at a specific point in time therefore, to accurately predict the future, a more in-depth study of historical volatility is needed.

Therefore, further studies would be necessary to provide more information on the above issues.

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Appendix

Derivation of Equation (3)

1) Definition and Assumptions of Variables

H_t = house price at "period t"

H_0 = initial house price at "period t=0"

$X_t = H_t/H_0$

$Y_t = \ln\left(\frac{H_t}{H_0}\right)$

B_t = loan balance at "period t"

$b_t = B_t/H_0$

then $X_t = e^{Y_t}$

If $g(Y) = e^Y$ then $E(X) = E(e^Y) = E(g(Y))$

Thus, obtaining $E(X)$ is the same as obtaining $E(g(Y))$.

First, Y_t is assumed to follow the GBM process, and thus from period t Y^t has the average of μt and the standard deviation of \sqrt{t} , following normal distribution.

Further, X_t follows the GBM process and log-normal distribution.

Thus, at time t=1, the mean and the standard deviation of Y_t are μ and σ .

X is the random variable of the set of observation X_t and Y is the random variable of the set of observation Y^t .

2) Derivation of $E(X)$

If $g(Y) = e^Y$ then $E(X) = E(e^Y) = E(g(Y))$

Thus, the expected value of the random variable X is equal to the expected value of the function $g(Y) = e^Y$. The expected value of the function $g(Y)$ is as follows:

$$E[g(Y)] = \int_{-\infty}^{+\infty} g(y) dF(y) = \int_{-\infty}^{+\infty} g(y) f(y) dy \quad (1)$$

Note that $F(y)$ is the probability distribution function of Y $f(y)$ is the probability density function of Y .

As Y is assumed to be normally distributed,

$$f(y) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}[(y-\mu)/\sigma]^2} \quad (2)$$

Equation (2) is a normally distributed probability density function of mean μ and standard deviation σ .

$$E[g(Y)] = E(e^Y) = [1/\sigma\sqrt{2\pi}] \int_{-\infty}^{+\infty} e^y e^{-0.5[(y-\mu)/\sigma]^2} dy \quad (3)$$

To standardize y , if it is substituted into $y = (y-\mu)/\sigma$, Equation (3) can be defined as follows:

$$E(e^Y) = e^{\mu+0.5\sigma^2} [1/\sqrt{2\pi}] \int_{-\infty}^{+\infty} e^{-0.5[y-\sigma]^2} dy = e^{\mu+0.5\sigma^2} \beta \quad (4)$$

The value of β is 1.

$$\beta = [1/\sqrt{2\pi}] \int_{-\infty}^{+\infty} e^{-0.5[y-\sigma]^2} dy = 1 \quad (5)$$

Through Equations (4) and (5),

$$E(X) = E(e^Y) = e^{\mu+0.5\sigma^2} \quad (6)$$

For variable X and constants μ and σ , time is a function therefore, Equation (6) can be defined as follows:

$$E(X(t)) = e^{\mu t + 0.5\sigma^2 t}$$

$$E(H(t)) = H_0 e^{\mu t + 0.5\sigma^2 t}$$