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Credit, Equity Conversion, and Housing Endowment: Analysis of Reverse Mortgage Markets

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Abstract

This study contributes to solving the problem of an aging population by providing important information that determines feasible annuity payments for the homeowners of reverse mortgage products and by promoting the implementation of mortgage loans. From the empirical analysis, we demonstrate that demand for reverse mortgages recently took a big jump after the 2008 global financial crisis because housing prices gradually declined, which generated home equity conversion preferences in the United States. This study also examines loan-level reverse mortgages and presents a number of findings. First, we employ the reverse mortgage data to show that elderly homeowners are more likely to purchase reverse mortgages 5-10 years after retirement. This finding illustrates the particular phenomenon that the younger elderly homeowners have more initial principal limit and reverse mortgage demand. Second, we also evaluate the possible variation in the retirement income for the aged people who utilize reverse mortgage, therefore leading to the increment in the income replacement ratio as the borrower's age grows. The findings have important implications for policymakers and elderly individuals. This paper's empirical results also show that the reverse mortgage is an appropriate housing endowment among older American homeowners' portfolios.

JEL Classifications numbers: D12, H31, G18, G21.
Keywords: Home Equity Conversion, Housing Endowment, Annuity Payment, Income Replacement Ratio.

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1 Introduction

Reverse mortgages (hereafter RMs) are increasing in popularity with seniors who have equity in their homes and want to add their income. At the same time, RMs could mitigate the burden of aging individuals on public budgets by aiding elderly homeowners to participate in financing their own retirement spending. A reverse mortgage can provide house-rich but cash-poor elderly homeowners with a category of promising financial products for obtaining loans from mortgage lenders using their homes as loan collateral without losing ownership of their homes. This provides a potential channel for these homeowners to withdraw from their substantial home equity, thus improving consumption and retirement security[4]. Reverse mortgages can provide a person with a method for gaining access to his or her own home's equity without having to worry about making payments on the mortgage. This is often called "aging in place."

1.1 Demand for reverse mortgages in the United States

Only a few hundred reverse mortgages originated each year during the 1980s and early 1990s. However, as of October 1999, more than 38,000 senior homeowners had taken reverse mortgages. Since the mid-1990s, growth has been steady with as many as 8,000 new loans originating each year. HECMs are still uncommon, even in the United States, since not even 1% of potential beneficiaries have entered an equity release scheme (Caplin, 2001). However, the trend of HECMs seems to have changed dramatically, and the market size has been growing in recent years (at least up to the 2008 financial crisis). Shan's (2011) report shows that the number of RM loans escalated from fewer than 10,000 in 2001 to more than 100,000 in 2007. Shan also observed that lower interest rates, increased awareness of the product, and rising home values are three plausible explanatory factors. Possible reasons for the lack of customer preference include the positive relationship between income and home equity wealth, the slow speed at which the elderly utilize innovative products, an aversion to placing a lien on one's home, the perception of home equity as savings for high origination costs, and unexpected expenses. The amount generated from a loan may be limited because of the owner's low home value or the limit the FHA places on loan amounts relative to the average home values in the area (U.S. Department of Housing and Urban Development [HUD], 2003).

In this article, we investigated the underlying factors determining interest in the product with the quantile regression (QR) model. Previous researchers focused on risk theory to explore RMs and set parameter values for simulation analysis instead of using actual data. However, numerous actual loan data have accumulated since RMs were implemented. Unlike previous research papers have appeared in a handful of empirical studies on reserve mortgages issue. This study takes an alternative view of empirical and theoretical studies, practice in particular. Specifically, we construct a European option, which considers the

4In the U.S., the Federal Housing Administration (FHA) launched the Home Equity Conversion Mortgage (HECM) program in 1989 after the National Housing Act of 1987 was passed. The only reverse mortgage insured by the U.S. federal government is called a home equity conversion mortgage (or HECM), and is available only through an FHA-approved lender.

Black-Scholes formula, to derive the annuity payment of the mortgage value for analyzing credit, and home equity conversion of the reverse mortgage markets. The theoretical framework highlights the home equity conversion and applies the quantile regression method to examine empirical analysis that previous literature did not cover.

Further, we need to account for credit, home equity conversion, and housing endowment to explore reverse mortgages and look at the characteristics of both types of mortgages; conventional home equity loans are different from reverse mortgages in several respects. First, the housing equity of a traditional mortgage usually increases day by day, but a reverse mortgage generally declines over time. Second, because traditional borrowers promise to make periodic payments, their financial ability to repay is another concern. Thus, the maximum loan amount that can be borrowed is determined by the borrower's credit history and income level. However, a reverse mortgage is determined based on different factors.

The remainder of the paper is organized as follows: In Section 2, we review the relevant literature. In Section 3, we evaluate the annuity payment of RMs and describe the econometric model. In Section 4, we introduce the data sources and present the estimated results to explain how the main indicators are constructed. In Section 5, we conclude the paper.

2 Literature Review

The role credit plays in the monetary transmission mechanism has been researched intensively for the traditional mortgage and the reverse mortgage. Recent insights suggest that the information asymmetries present in credit markets make the existence of financial accelerators possible. The intuition is that, owing to these information asymmetries, homeowners' borrowing is constrained, and they can borrow only by putting up collateral, which in turn depends on their net worth (see Bernanke and Gertler, 1995; Kiyotaki and Moore, 1997). If the value of the net worth is pro-cyclical, then the value of the collateral changes over the cycle. Consequently, the borrowing capacity may then increase in upturns and decrease in downturns leading to changes in net worth. For credit, we take as our variable the average mortgage amount approved over time. Although mortgage credit typically constitutes a substantial portion of private sector credit, mortgage credit is likely to exhibit different short-run and long-run dynamics given that it is collateralized. In addition, the original maturity is substantially longer than for other consumer loans. There is a practical reason why some authors use a broader measure of credit, as it is less affected by breaks in individual components across countries. This broader measure has been used in other studies such as Fitzpatrick and McQuinn (2007). It is also one reason we chose to limit the aggregate to mortgage credit.

Willingness to convert home equity must be considered. A possible explanation for the limited interest in RMs may be financial illiteracy. Leviton (2002), for example, explained that because of poor financial education, many elderly homeowners overestimated their net worth regarding RMs. Previous studies also reported a positive correlation between households with mortgage equity withdrawals and lack of financial literacy (Duca and

Kumar 2014, Fornero et al. 2014). Current income, education level, gender, and age are also the main determinants of home reversion loan uptake.

On the housing endowment issue, Venti and Wise (1991) reported that approximately 80% of the wealth of older households in the United States was stored in the form of housing equity, which could be sold as needed.[5] In practice, the HECM market share has been small everywhere. To explain why the RM market is so weak, other researchers have focused on the high costs of RMs. For example, there is the possibility of moral hazard with low-income households, which tend to default on their contrast obligations. The adverse selection of longer-lived mortgagors (Davidoff and Welke, 2005)[6] can translate into high insurance fees and make the product expensive. In contrast, in other literature, Mitchell and Piggotts (2004) reported that methods of unlocking home equity in Japan could be developed to boost consumption among the elderly, reduce public pension liability, and mitigate the demand for long-term care facilities. Creative ways for financing old-age consumption in Japan, by tapping home equity, might substantially improve retirement security in this rapidly aging society. To the best of our knowledge, most of the previous studies explored the potential demand for reverse mortgages and investigated why the market is much smaller than expected using public survey data. Among the few papers that examined loan-level reverse mortgage data, Szymanoski, Enriquez, and DiVenti (2007) focused on modeling the termination outcomes of reverse mortgages and examined the originations, and Shan (2011) examined the originations of reverse mortgages at the ZIP code level. This article complements the existing literature by looking at the value of the home equity conversion to the mortgage holder. Since home equity depends on the mortgage holder's conversion decision, minimizing the liability value is equivalent to maximizing the mortgage value.

3 The Reverse Mortgage Model

The reverse mortgage and the traditional mortgage are identical in that both types of loans face fundamental borrowing restrictions. The largest difference between them is equity variation. RM borrowers can also withdraw housing equity, increasing their debt by more than the investment in the housing stock without the need to sell the property.

3.1 The supply side of RMs market

In terms of financial institutions to provide the reverse mortgage, in practice, the FHA also

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5 They also investigate that a reverse annuity mortgage for older and low-income couples means a substantial subsidy increase in their disposal income. The median payment for low-income single men is almost 50% of their median income. Indeed, the income replacement rates of the median annuity mortgage payment are much higher for low-income people and/or women over age 85 compared to other mortgage programs.

6 Davidoff and Welke (2005) explored adverse selection by comparing the mobility rates of RM borrowers with no RM borrowers and found out advantageous selection, as the elder homeowners who take out reverse mortgages are also more likely to sell their homes and thus repay their loans earlier.

usually assumes that housing prices evolve following a geometric Brownian motion process in its reverse mortgage pricing model (Quercia, 1997). To explore the impact of the housing price uncertainty, we likewise assume that the housing price follows a geometric Brownian motion process as follows:

$$dP_t = \mu P_t\, dt + \sigma P_t dW_t \tag{1}$$

where μ is the expected percentage growth in house price, σ is the volatility parameter of house price, and W_t is a standard Brownian motion. We consider a financial intermediation with a market value of liabilities L_t and a market value of assets A_t , σ_A and σ_B represent the volatility of liabilities and assets. To model the development of assets and liabilities, we use a geometric Brownian motion. Under the real-world measure $\boldsymbol{\mathcal{P}}$, the stochastic processes are described by

$$dA_t = \mu_A A_t\, dt + \sigma_A A_t dW_A^P(t) \tag{2}$$

$$dL_t = \mu_L L_t dt + \sigma_L L_t dW_L^P(t) \tag{3}$$

with μ and σ denoting the drift and volatility (assumed to be constant over time) of the stochastic processes. W_A^P and W_L^P are standard $\boldsymbol{\mathcal{P}}$-Brownian motions with a correlation of coefficient ρ, i.e., $dW_A dW_L = \rho(A, L)dt$ .Changing the real-world measure $\boldsymbol{\mathcal{P}}$ to the equivalent risk-neutral martingale measure Q leads to the constant riskless rate of return r_f as the drift of the processes. Let us assume that at t = 0, the lender pays X_0 to the householder. Mortgage interest is accruing continuously at annual rate r. We assume further that the contract is executed at time T corresponding to the life expectancy of the borrower (for example ten years).

Furthermore, with regard to questions on how to cope with longevity risk, therefore, adjusting the pension benefits according to the life expectancy at retirement would still involve substantial longevity risk. In this scenario, longevity risk is associated with the risk that future mortality and life expectancy outcomes turn out different than expected. In addition, Lee and Miller (2001) proposed replacing the matching according to model implied number of deaths in a certain period by a matching on the basis of observed life expectancy[7]**.** We consider the impacts of changes in mortality rate and remaining lifetime on the loan amounts of reverse mortgages. In addition, we also take into account the life expectancy table, which is usually utilized to calculate the remaining lifetime of people at difference ages in actuarial practice. Moreover a maturity allows the claim of a closed formula for the pricing a European put option. In existing mortgage-pricing literature (see Kau et al., 1992, 1995; Bardhan et al., 2006), housing prices P are typically assumed to follow a geometric Brownian motion process under risk-neutral measure so that the literature can model uncertainty on the dynamics of these prices as follows:

$$P_t = P_0\left[\left(r_f - q - \tfrac{1}{2}\sigma^2\right)T + \sigma W_t\ \right] \tag{4}$$

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[7]General approaches taken in practice to manage the effect of changes in life expectancy are estimated on the Life Expectancy Table at http://www.ssa.gov/OACT/STATS/table4c6.html, while the level for the sector is estimated from data for a projected trend in mortality gathered by the Social Security Administration.

Strike price X_t represent the option exercise price of reverse mortgages and the aggregate loan principal and interest at time t. T denotes duration option contracts (i.e. life expectancy), q is the yield of the underlying asset. Thus, we can derive the following proposition.

Proposition:

Let's assume that the underlying asset price processes follow a standard geometric Brownian motion, the breakeven annuity payment $\overline{A_T}$ *of a reverse mortgage loan is given by*

$$\overline{A_T} = \left[\frac{r(1+r)^{T-1}}{(1+r)^T - 1}\right] \times \left[L_v P_0 - X_t e^{-r_f T} N(-d_2) + P_0 N(-d_1)\right] \tag{5}$$

where $d_1 = \dfrac{\ln(P_0/X_t) + (r_f - q + \frac{\hat{\sigma}^2}{2})T}{\hat{\sigma}\sqrt{T}}, d_2 = d_1 - \hat{\sigma}\sqrt{T}$

$$Put = X_t e^{-r_f T} N(-d_2) - P_0 N(-d_1)$$

The put option is affected by the volatility parameter $\hat{\sigma} = \sqrt{\sigma_A^2 + \sigma_L^2 - 2\rho\sigma_A\sigma_L}$

Proof sees Appendix .

3.2 Empirical framework

In addition, we propose the following QR model in which the distribution of $HECM$ loans presents right skewness in Figure 3. Therefore, the OLS empirical result was easily affected by extreme values and led to a biased estimate.[8] Particularly, the financial economic data used, including mortgage market data, have heavy tail, asymmetric, and abnormal qualitative features. Quantile regression aims at estimating either the conditional median or other quantiles of the response variable.The housing prices and credit are characterized by

$P_H = g(IPL, i_t, M_p, age)$, and (6)

$IPL = L_H = h(P_H, i_t, M_p, gender, age)$ (7)

The other various proxy variables are defined as follows:

P_H ：Housing prices or appraisal property, i.e., the appraised value of the home.

IPL：Initial principal limit represents the mortgage credit in RM markets on the supply side.

M_p ：The current monthly payment amount scheduled to be paid by the borrower each month as the home equity extraction.

i_t ：Mortgage interest rate as the home equity extraction.

8 OLS in terms of the estimate of the regression coefficient number refers to the dependent variable regarding the "average" marginal effect on the independent variable, the focus in the allocation of central trend; and QR is estimated the department of the number refers to independent variable about the dependent variable, given the sub-median marginal effect, e.g., see Koenker and Hallock (2001).

To design the regression model, we use the functional form for equations (6) and (7) and the econometric regression model proposed by LaCour-Little et al. (2010) and is expressed as follows:

$$P_H = g(IPL, i_t\ , M_p, age)$$

$$lnP_H \overset{\text{regression}}{\Rightarrow} \alpha_0 + \alpha_1 lnIPL + \alpha_2 i_t + \alpha_3 lnM_p + \alpha_4 age + \varepsilon_1 \quad (8)$$

$$IPL = h(P_H, i_t\ , M_p, gender, age)$$

$$lnIPL \overset{\text{regression}}{\Rightarrow} \beta_0 + \beta_1 lnP_H + \beta_2 i_t + \beta_3 lnM_p + \beta_4 gender + \beta_5 age + \varepsilon_2 \quad (9)$$

Borrower age,$gender$, and interest rate are classified as semi-categorical variables to capture potential nonlinear relationships with loan amount and housing prices. Other variables used in continuous form are log transformed, allowing convenient interpretation of coefficient as elasticity with comparable magnitudes. This article has further adopted two-step ordinary least squares (2SLS) to avoid the collinearity problem.

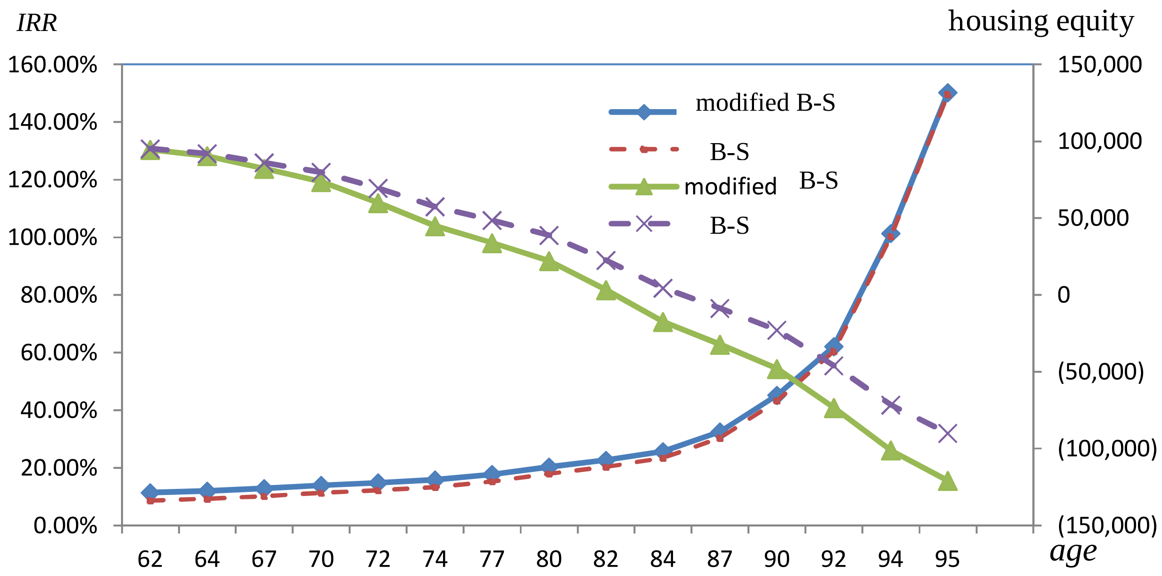
4. Numerical and empirical analysis

4.1 Numerical results

Our numerical analyses will be divided into two parts. First, we analyze the use of the Brownian motion process (GBM) for the Black-Scholes model. In the second part of our numerical analyses, we implement the modified method for the Black-Scholes (B-S) option pricing model. For European options, we compare the results to the ones obtained by simulations**.** All the input parameter values are set to reflect as closely as possible the market practice.Specifically,the basic parameter values are set at P_0=251,163, r=2.81%,r_f=2% from Table **1.** Parameters in Figure 1 and 2 are given by: $\sigma_A = 0.15$, $\sigma_L = 0.15$, $\rho = 0.5$ and q= 2.5%. We note that under this setting, indicates that the higher income replacement ratio (IRR) state, whereas the older borrower state. The Figure 1 show that the modification of Black-Scholes decline the volatility of housing prices, decrease IRR,and raise the home equity. Figure 1 also presents that holding everything else unchanged, there exists a positive relationship between the houseowner's age and the annuity payment. At a given modified B-S option approach, the borrower's age is enhanced from 62 to 95 as the income replacement ratio rises from 11.4 % to 149.65 %. To test the impact of the LTV on the risk and profitability of the different reverse mortgage products, we compare the results for LTVs of 30%, 40%, 50%, 60%, 70% and 80% for the 74-year-old borrower. As expected, the income replacement ratio in Figure 2 grow with the increase in the loan-to-value ratio L_V, and maturity T. This is because the risk exposures of insurers increase when one of the three factors, L_V, and T, grows.

4.2. Data description

The data analyzed in this study are loan-level administrative HECM data provided by HUD.[9] To select our sample, we observe all HECM loans made over the period 1989 to



Notes

1. As shown in the illustration above, modified B-S Option based on formula (5)
2. The 2012 median household income refer to U.S. CENSUS BUREAU, http://www.census.gov/
3. $\text{Income replacement ratio}(IRR) = \dfrac{\overline{A}}{\text{2012 median income}}$

[9] Data are from the HUD website at http://www.hud.gov/offices/hsg/rmra/oe/rpts/hecmdata/hecmdatamenu.cfm. Data is available from the corresponding author upon request.

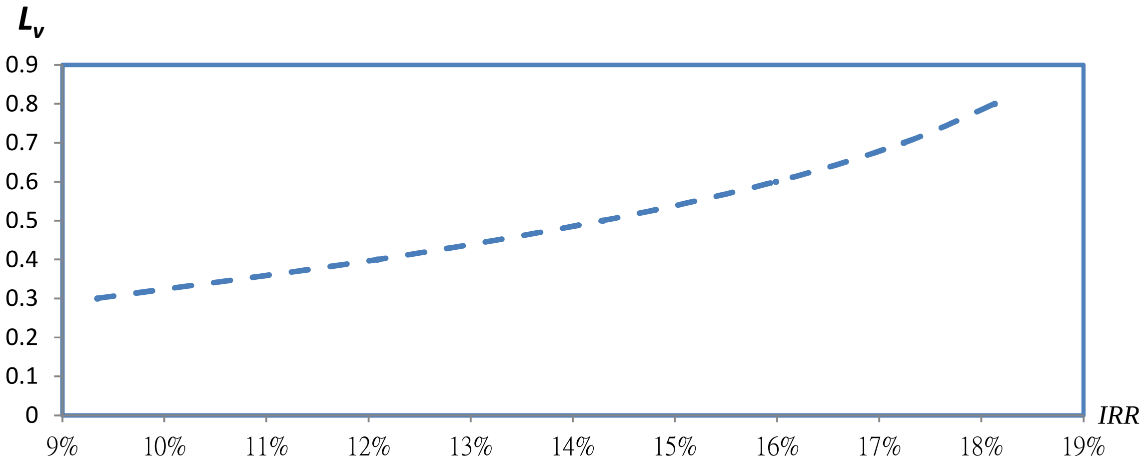


Figure 2: The relationship diagram at different loan-to-value *Lv* and *IRR*

2010, a total of 855,096 records. In the process of data cleaning, we dropped borrowers who had missing value data, including where the age and monthly payment amount were marked "NA." Therefore, the final sample has 658,082 observations[10].

4.3. Empirical results

The regression empirical test analyzes the influence factors concerning reverse mortgages in the United States. The descriptions of the relevant empirical results are as follows.
Figure 3 shows the number of HECM loans that originated each year from 1989 to 2010. In the early years, only a small portion of homeowners took out HECM mortgages. In contrast, HECM loan originations grew substantially in the early 2000s. Table 1 in Panel C shows approximately 85% of the borrowers in the analysis sample chose the line-of-credit payment plan. Only about 10% of the borrowers chose the tenure or modified tenure plans, suggesting that most HECM loans do not have an "annuity" component. Table 1 in Panel A illustrates that the mean mortgage interest rate for an RM is 2.81%, excluding up-front costs.[11] It provides a lower interest rate compared with the traditional mortgage.[12]

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[10]The data set has information on the age, gender, and marital status of the borrower, the appraised value of the property at origination, the mortgage interest rate, and the supply of mortgage credit, the chosen payment plan, and the monthly payment amount.

[11]The up-front costs include the initial MIP, origination fee, and other closing costs. The initial MIP is set at 2% of the MCA. The origination fee is capped at $2,000 or 2% of the MCA, whichever is greater.

[12] The traditional mortgage average lending rate is 6.9% higher than the RM from the new homes contract interest rate at characteristics of conventional first mortgage loans for purchase of single-family homes. Source from U.S. Federal housing finance agency, research and analysis, monthly interest rate survey data, historical summary table, see http://www.fhfa.gov/default.aspx?Page=252. For more information: http://www.fhfa.gov/.

The initial principal limit accounts for 60.99% in proportion to the appraised value of the property, which reveals that the loan-to-value ratio (LTV) is much lower than that of the traditional mortgage. The average monthly payment is available to USD 1,045.77. This amount provides elderly homeowners additional income for living and medical expenses. It grants elderly homeowners the ability to cover life expenses. The borrower's average age is 73 years old. More importantly, as shown from these results, RMs are a significantly appropriate housing endowment among American elderly homeowners.

The distribution of the borrower's age shifts on the left side over time in Figure 4, and the resulting graph is similar to Bishop and Shan (2008). We expect that this change will be profound, since the U.S. reverse mortgage market has shifted to younger elderly homeowners. This means that recent borrowers are younger than early borrowers when they take out the loan. There is a spike at age 62 in the distribution for recent borrowers but

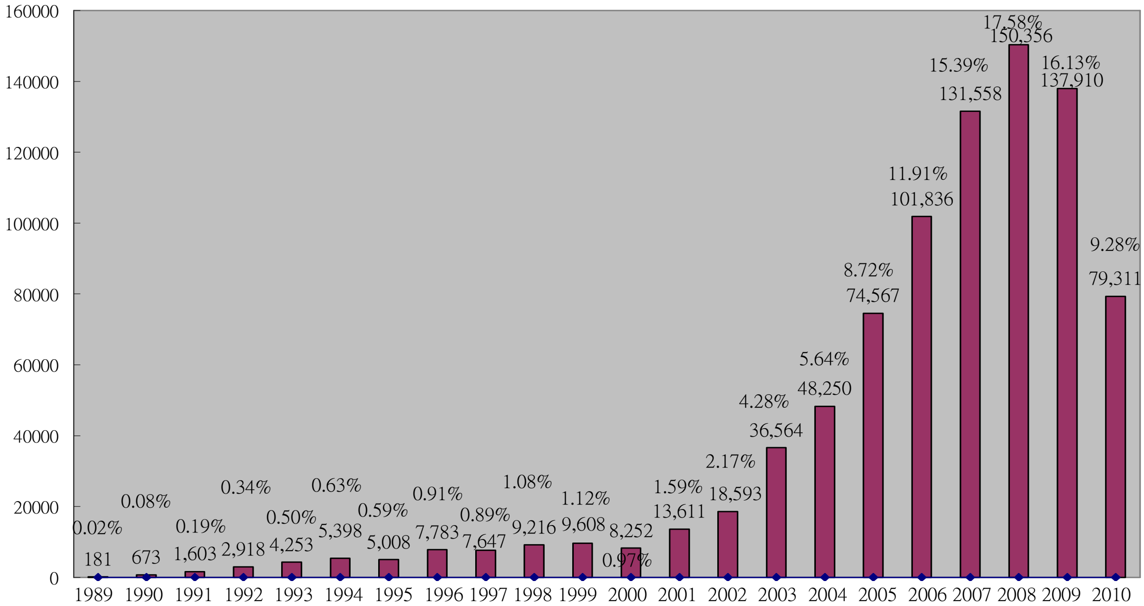

Figure 3: Number of HECMs

not early borrowers. This spike suggests that homeowners younger than age 62 may want to purchase reverse mortgages if allowed.

We want to know whether the home equity-related elements are significantly correlated with interest in the product, while the conversion motive does not appear statistically significant. In practice, we often prefer to use different measures of central tendency and statistical dispersion to obtain a more comprehensive analysis of the relationship between variables. Housing is the product of heterogeneity. This study, using the quantile regression model, is divided into 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} quantiles. The results of the estimates for the five quantiles were as follows: $\{\tau \in 0.1, 0.25, 0.50, 0.75, 0.9\}$. Households are identical to occupied housing inventory by householders older than 60 years of age on the

Table 1: Descriptive Statistics

Panel A: Summary Statistics

	Mean	Median	Maximum	Minimum	Std. Dev	Skewness	Kurtosis
H_A	251163.3	205000	999999	6000	172357.6	3.51	88.81
IPL	153203.5	136325	625500	1000	85214.52	1.03	4.38
i_t	2.81	1.80	21.95	0	1.68	1.21	3.19
Borrower_Age	73.00	72.00	107.00	61.00	7.43	0.61	4.19
M_p	1045.77	745 .5	98458.06	0.00000	9.12	47.36	3667.21
Households (thousands)	103785.7	105136	112527.0	93477.00	5678.67	-0.242	1.83
Above_60_Owner (thousands)	22708.76	22476	26656.80	20268.00	1757.02	0.75	2.65
Observation	658082						

Panel B: Group Unit Root Test for Variables

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-133.896	0.0000

** Probabilities are computed assuming asympotic normality

IPS test results

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Lag
H_A	-28.111	0.0000	-1.456	0.818	13	13
IPL	-23.850	0.0000	-1.456	0.818	13	13
i_t	-40.983	0.0000	-1.456	0.818	13	13
M_p	-140.10	0.0001	-1.476	0.795	6	12
Average	-55.465		-1.460	0.813		

Notes: Before performing the 2SLS and quantile regression analysis to avoid spurious regression, we apply the panel data unit root test proposed by Im, Pesaran, and Shin (2003, IPS) to examine HECM data stationary, including the IPL, it, HA, and Mp variables. The unit root test results show that all variables reject the null hypothesis that the unit root exists under the 1% significance level. All variables are in a stable sequence.

Panel C: Payment Plan Loan Type sequential illustration

	Term	Line of Credit (LOC)	Tenure	Term and LOC	Tenure and LOC	other
Number	10,072	57,616	18,907	33,265	28,793	9,429
Percent(%)	1.53	84.73	2.87	5.05	4.38	1.43

Tenure and LOC (TNLC) as of the currency date

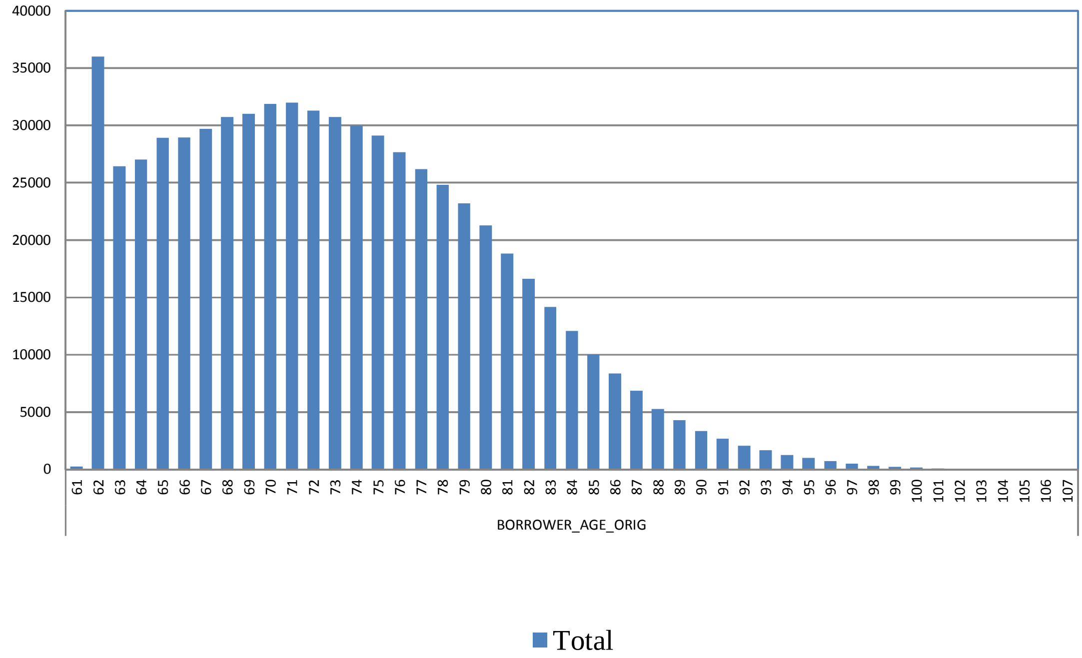

Figure 4: Distribution of Borrower Age

theoretical distribution graph and quantile plot. The elderly homeowners' data have the same characteristics as the households' data[13]. Empirical quantile regression analysis of equations (8) and (9) present that we respectively apply housing prices and mortgage credit, i.e., Initial Principal Limit (IPL) as dependent variables in Table 2. Quantile regression approach analyzes the impact on house prices for mortgage credit, interest rate, gender, monthly payment, and borrowers' age from panel A in Table 2 and the impact on mortgage credit for housing prices, interest rate, monthly payment, and age from panel B. In addition, it reveals the negative estimated coefficients of borrower's age. The remainders of the estimated coefficients are positive in panel A. The phenomenon of the quantile estimated value indicates that there is no increase or decrease from lower quantiles. As shown in panel A, the housing prices are associated with mortgage credit, similar to Fitzpatrick and McQuinn (2007). Furthermore, another result of our study presents an older homeowner along with lower housing prices. This result is consistent with Ong's (2010) work. It is due to a decline in household income to keep the home in good repair as homeowners enter old age. As reported in panel B of Table 2, the mortgage credit for the explanatory variables is found with housing prices showing a significant positive relationship. This evidence suggests that public sectors should adopt credit quantity control to curb the growth of property prices during housing price booms. In addition, interest rates not only reveal a significant negative correlation between mortgage credit and the IPL but also confirm

[13] In robustness check not shown, the distribution of graph is available from the corresponding author upon request.

market theoretical results, in line with previous empirical evidence from Gerlach and Peng (2005) and Goodhart and Hofmann (2008).

5. Conclusions

The study finds the key factors in the willingness to apply for RMs since the proportion of elderly homeowners using reverse mortgages has been increasing rapidly. We have identified several crucial determinants of the reserve mortgage loan factor, which include the initial principal limit (i.e., the mortgage credit), home equity conversion, and housing price. This paper shows that RMs provide elderly homeowners an option to raise the income replacement ratio after retirement[14]. As we have shown, monthly payments are positively associated with housing prices. The empirical results also show that interest rates have a negative relationship with the demand for mortgage credit and senior citizen homeowners prefer a line-of-credit payment. Reverse mortgages play a significant role in senior citizens' portfolios as an option for funding retirement.

As discussed, this article's results imply some policy implications. First, policymakers should consider the evolution of housing prices, since the conditions and the size of mortgage provision are related to the value of the asset, which is used to back the relevant loans. For instance, after the global financial crises, a decline in housing prices has adversely affected the projected credit performance of the HECM.[15]

Table 2: Quantile Regression and 2SLS Coefficient Estimates

Panel A: dependent variable ln P_H

Variable	0.1	t-Statistic	0.25	t-Statistic	0.5	t-Statistic	0.75	t-Statistic	0.9	t-Statistic	2SLS	t-statistic
$\ln \boldsymbol{IPL}$	1.515	19.083***	1.422	25.104***	1.515	19.083***	1.748	1026.13***	2.225	648.75***	1.7479	22.8***
$\boldsymbol{i_t}$	0.215	12.593***	0.701	5.225***	0.210	125.93***	2.721	71.82***	4.557	71.48***	0.94	13 .85***
GENDER	0.093	2.574 **	0.479	2.09**	0.092	1.573**	0.862	2.886**	0.646	1.3279	0.912	1.021
BORROWER_AGE	-2.035	-407.12***	-2.123	-531.62***	-1.351	-309.28***	-1.869	-204.43***	-1.958	-105.06***	-2.787	-18.54***
$\ln \boldsymbol{M_p}$	0.423	1.993*	0.043	3.021***	0.142	2.19**	0.103	1.397	0.158	1.593*	0.368	2.771**
C	1.374	352.25***	1.498	548.41***	1.374	352.25***	1.118	154.81***	9.435	63.49***	3.611	69.36***
Pseudo R-squared		0.624		0.7031		0.685		0.631		0.564		0.737

[14] Venti and Wise (1991) also explored the idea that a reverse annuity mortgage would mean only a 4% increase in typical low-income couple ages 55-60; it would mean an approximate 10% increase for low-income people ages 65-70. For those who are 85 and older, the increase range would be about 35%.

[15] The Obama administration is requesting taxpayers to aid the Federal Housing Administration's program for reverse mortgages for the first time. According to budget documents released, the administration has required that Congress appropriate $798 million for the Home Equity Conversion Mortgage (HECM).

Source: Obama Administration Requests $798 Million To Aid Reverse Mortgage Program by Published in FHA, Gov. May 7th, 2009.

http://reversemortgagedaily.com/2009/05/07/obama-administration-requests-798-million-to-aid-reverse-mortgage-program/

Panel B: dependent variable ln IPL

Variable	0.1	t-Statistic	0.25	t-Statistic	0.5	t-Statistic	0.75	t-Statistic	0.9	t-Statistic	2SLS	t-statistic
$ln\ \boldsymbol{P_H}$	0.332	578.69***	0.447	673.45***	0.585	1098.32***	0.685	1840.13***	0.679	1340.85***	0.481	1340.54***
$\boldsymbol{i_t}$	-2.637	-115.93***	-2.265	-94.55***	-1.285	-117.93***	-5.97	-45.82***	1.458	9.129***	-9.651	-28 .48***
$ln\ \boldsymbol{M_p}$	0.151	1.061	0.022	1.786	-0.013	-1.224	0.274	3.044**	0.021	0.992	0.346	1.82*
Age	0.423	1.279	0.043	1.021	0.324	1.438	0.563	1.287	0.093	1.179	0.587	1.43
C	1.823	352.25***	3.805	92.41***	-7.374	-289.25**	-1.63	154.81***	-2.835	-364.49***	-6.516	-119.87***
Peudo R-squared		0.44		0.521		0.646		0.731		0.769		0.719

Notes: 1. We use ***, **and * to denote significance at the 1%, 5%, and 10% levels.
2. The table presents the 0.1, 0.25, 0.50, 0.75, and 0.9 quantile regression coefficient estimates and t-statistic value.

As a result, the budget provides fixed and variable appropriations of credit subsidy to support continuous operation of the program even if the actual loan activity exceeds projections. Second, the administration should develop various customized programs in RM product to reduce the burden of long-term care insurance (LTCI). The more restrictive conditions are to obtain an RM, the less willing people are to apply for it. On this viewpoint, for example in other countries, there have been no applications for the reverse mortgage program in Taiwan.[16] The gradual aging of the population in American society and the aging housing stock are both gradually increasing. Due to the long-term care demands of an aging society, the government should develop various customization programs based on local circumstances. However, the some shortcomings of RM must be improved. The cost of borrowing is too high, the loan-to-value ratio is low, the unpaid principal balance exceeds 98% of the fair market value of the home, the FHA shall to withstand the collateral risk, etc.

In the future, a RM program could be an important portfolio that helps senior citizens take control of their personal finances. Housing prices and mortgage credit (debt) play important roles in the demand for the reverse mortgage market. In the face of these influences, whether the reverse mortgage market will continue to grow remains an open issue.

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[16] See Central News Agency July 31, 2013, for the announcement by the Ministry of Health and Welfare. Nobody applied for the Reverse Mortgage program in Taiwan. The Ministry of Health and Welfare is currently running a trial “Housing Endowment" program, but due to constraints on eligibility and inheritance, no applications are being accepted. The trial period ran from May 1 to July 31, 2013. The Social and Family Affairs Administration reported 194 telephone consultations, but no applications. http://www.cna.com.tw/News/aIPL/201307310396-1.aspx

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Appendix

At t = T, the lent capital has produced a debt of $X_0e^{rT} = X_t$, however this amount is capped at P_t **,** so the final payoff for the financial institutions (bank) is: $max(0, X_t - P_t)$

In other words, the bank's portfolio contains a loan and a short position on a put. This option is European, written on Put ,with maturity T and strike of X_t **.**Hence we can use the Black-Scholes formula to value this position. At t = 0, as $e^{-rT}X_t = X_0$ the worth of the portfolio is:

$$X_0 - [e^{-rT}X_tN(-d_2) - P_0N(-d_1)] \quad = X_0 - Put(0) = L_vH_0 - Put(0)$$

Where $N(.)$ being the standard normal distribution function. Uncertainty in this formula enters with the term P_0**,** since the real value cannot be observed exactly without a sales transaction. The next calculation is made assuming that P_0 is known, hence we can get the true prices of the contingent claims. The price of the European put option on a futures contract is given by

$$Put = max(0, X_t - P_t) = e^{-r_fT}E_Q[(X_t - P_t)I_A]$$

$$= X_te^{-r_fT}E_QI_A - P_0e^{-qT}E_Q\left(e^{-\frac{1}{2}\sigma^2T+\sigma W_t^H}I_A\right) = X_te^{-r_fT}Q(A) - P_0e^{-qT}\overleftarrow{Q}(A) \qquad \text{(A1)}$$

From equation (4) and where in (A1), the Radon-Nikod´ym derivative is

$$\frac{d\overleftarrow{Q}}{dQ}\Big|_T = e^{\left(r_f - q - \frac{1}{2}\sigma^2\right)T + \sigma W_t^H} \qquad \text{(A2)}$$

$$Q(A) = N(-d_1)$$

We can get $Put = X_te^{-r_fT}N(-d_2) - P_0N(-d_1)$

The annuity payment and lump-sum payment of reverse mortgage are discussed in two ways, the strike price at lump sum payment is

$$X_t = L_vH_0(1+r)^T \qquad \text{(A3)}$$

The strike price at annuity payment is

$$X_t = (1+r)^T\sum_{t=0}^{T-1}\frac{A_p}{(1+r)^t} \qquad \text{(A4)}$$

Under the lump sum payment and life annuity payment, the aggregate loan principal and interest at maturity of the loan term are express as the option strike prices are executed. Since equation (A3) and equation (A4) are equal, can be obtained .Then, we can get

$$A_p = \frac{L_vP_0}{\sum_{t=0}^{T-1}\frac{1}{(1+r)^t}} = \frac{L_vP_0r(1+r)^T}{(1+r)^T - 1} = a_TL_vP_0 \qquad \text{(A5)}$$

Where $a_T = \frac{r(1+r)^{T-1}}{(1+r)^T-1}$ represents the present value of the annuity factor, A_p denote the fixed annuity payments that borrower obtained at the beginning of every year. Furthermore, $\overleftarrow{A}$ denoted as under the redeemed option that borrower can be obtained the equivalents pension payments amount at the beginning of each year. Under equivalents payment, borrowers received the equivalents amount in the beginning every year at T years as follows

$$\overleftarrow{A} = \frac{L_v H_0 - Put}{a_T} = \frac{L_v H_0 - Put}{\sum_{t=0}^{T-1} \frac{1}{(1+r)^t}} = \frac{L_v H_0 - Put}{\frac{r(1+r)^{T-1}}{(1+r)^T - 1}} \tag{A6}$$

Therefore the arranged gain can be written as equation (5) and the proof is complete.