Interest accumulation in reverse mortgage loans with termination moral hazard*

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January 4, 2021

Abstract

This paper proposes a way to make reverse mortgage loans more attractive to both borrowers and lenders by reducing the risk that the loan balance grows to exceed the value of the mortgaged home. In particular, loan amounts would be increased at origination to purchase a life annuity. The annuity would be used to pay down principal and interest on the loan while the borrower remains in the home. This effectively transfers loan balances from long after loan origination, when the borrowers' home is likely to be worth less than the outstanding balance, to earlier dates when the home is most likely worth more than the borrower owes. Numerical examples show that the costs to lenders of limited liability may be significantly reduced by this smoothing of the loan balance across time. Lenders may thus be able to provide more cash to borrowers at loan origination while offering lower fees and interest rates. This proposal may ease a significant problem with reverse mortgage loans, which seem like a promising way to improve retirement finance, but have not proven popular: borrowers may not appreciate the significant costs that limited liability imposes on lenders. The results are sensitive to assumptions about the relative interest rates on the annuity and the mortgage loan.

1 Introduction

Most reverse mortgage products offered around the world provide borrowers with cash or lines of credit with no repayment required until the borrower dies or sells their home. At that date of termination, borrowers' liability is typically limited to collateral value. That

***Draft, contact** `thomas.davidoff@sauder.ubc.ca` **before citing.** This research elaborates on prior work sponsored by Brookings (Davidoff (2019)), and sponsored research for CMHC.

limited liability feature provides the borrower with a "put" option to sell the property back to the lender for the accumulated loan balance.

As shown in Davidoff and Welke (2006), the put option is subject to moral hazard on loan duration. Death may or may not be subject to strategic delay,[1] but moves while alive certainly are. Figure 1 shows the relationship between the mark-to-market equity remaining in the home among US Home Equity Conversion Mortgage loans and the probability that the loan terminates in a given month. Each month in the life a HECM loan between loan origination and termination counts as an observation. The data are truncated by the beginning of Zillow Zip Code Home Price Index values around 1997 and the end of the public HECM microdata in 2011. The data are for single female borrowers with loans originated between the ages of 65 and 75, with no correction for mortality, seasoning, or vintage. The mark-to-market equity is the initial property appraisal value grown by the Zillow index minus the original loan amount, grown by the 1-year treasury yield plus the loan margin, both as a percentage of the appraised value at loan origination.[2] We see clearly that termination rates are near or even below female mortality rates when equity is negative or small, and rise rapidly with remaining equity, to roughly 20% per year when equity exceeds the initial property value.

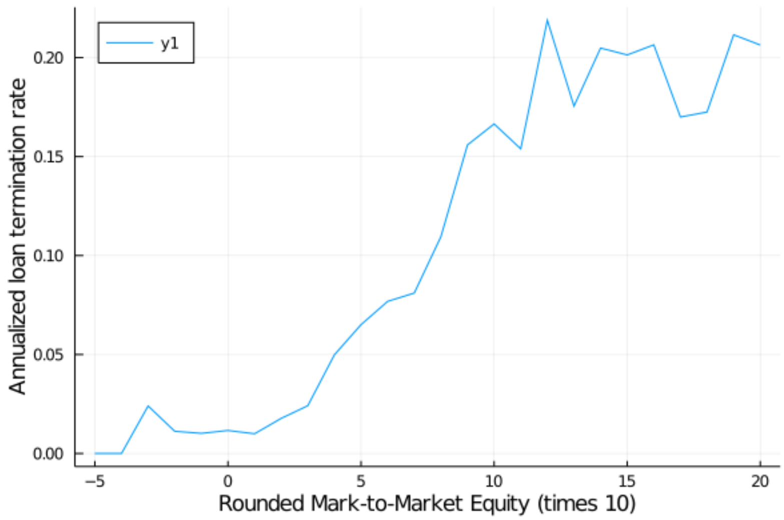
Central to the moral hazard problem on loan duration is the wedge that arises between the true economic "user" cost generated when the borrower remains in the home to both the borrower and the lender versus the economic cost to the borrower. The latter is almost never equal to the former: the interest rate spread that typically compensates the lender for the put option makes the cost excessive when the loan is likely to terminate with the home worth more than the outstanding balance, and limited liability makes the cost too low when the property value is likely to be less than the outstanding balance at termination. The cost to the borrower is low when the put option is likely to expire in the money, because the growing opportunity cost of the outstanding balance does not affect the borrower's (likely zero) payoff at loan termination.

Obvious mechanisms to alleviate the moral hazard problem have clear drawbacks. Requiring the loan to be paid off by a certain date (e.g. the "crossover date" when equity turns negative) would require senior owners to anticipate the evolution of their commitment to remaining in the home, which would require anticipation of health, financial, and family events. Requiring regular payments through a sale-leaseback would generate a total divorce between ownership and occupancy, leading to the familiar maintenance moral hazard issues

[1] Kopczuk and Slemrod (2003).

[2] An important source of HECM terminations has been refinance, but the sensitivity of terminations to remaining equity appears to have been greater prior to 2004, when refinance was made cheaper and easier by HUD regulations.

Figure 1: US Home Equity Conversion Mortgage annualized termination rates among borrowers aged 65-75 at origination. Horizontal axis: mark-to-market equity remaining in the home (estimated property value based on initial appraised value and Zillow Zip Code Home Price Index); vertical axis: outstanding loan balance (initial principal limit grown by 1-year treasury yield plus lenders margin plus .5% insurance premium



on the part of both landlord and tenant. Regular mortgage payments, as opposed to negative amortization thus seems attractive, but reverse mortgage borrowers tend to have very little income or financial wealth (Haurin et al. (2014), Moulton, Haurin, and Shi (2015), and Davidoff (2014)). Regular debt payments thus require some alternative form of income.

Historically, some reverse mortgage loans had annuitized payouts, and a particular variety of those loans was referred to as "fixed-debt reverse annuity mortgages." Fixed-debt RAMs split the annuitized payouts from loan proceeds into two components: an amount sufficient to cover interest on the loan amount, and the remainder going to the borrower. The former component reverts to the borrower at loan termination, per Cowan and Foley (n.d.).

A fixed-debt RAM is an attractive design in that it echoes the analysis of Artle and Varaiya (1978). The Yaari (1965) result that all liquid wealth should be annuitized by a retiree without bequest motives fails when a large fraction of wealth is tied up in a home that may only be liquidated with a sale while alive. In that case, a large fraction of the homeowner's wealth will be liquid only late in life, while a (constant) annuity provides smooth consumption over the lifetime, such that consumption would be too low early in retirement and too after the sale or by heirs after death.

The value of a home may be decomposed into two components:

1. The discounted value of net rents while the current occupant remains in the home plus

2. The expected discounted value of sale proceeds upon the occupants exit from the home (dead or alive).

No retirement home equity product without intervening payments can provide the borrower with more up-front cash than the second component of value 2, or else the lender or forward purchaser would lose money (assuming agreement on discounting). It is easy to see, however, that available proceeds will depend on product design. For example, compare (a) a forward sale for the expected discounted value of the property 2 with a free leaseback to (b) a sale for the current property value with an optional leaseback at market rents granted to the seller. In case (a), the borrower would very likely remain in the home until death, even if they would not have done so absent the agreement. Thus the forward sale price involves a suboptimally low sale price, and the free rent is insufficient economic compensation since the seller will remain in the home in states of nature where they value living in the home any amount between market rent and zero. In case (b), assuming the property value equals the value of discounted market rents, there is no such deadweight loss.

Sale leaseback arrangments have not proven popular.[3] However, the analogy between sale leasebacks versus forward sales applies to reverse mortgages, too. Consider a reverse mortgage with no repayment due until termination for the expected discounted value of resale proceeds: the available proceeds to the borrower must be limited to a worst case for duration, or compensated with an interest rate spread. And a higher interest rate spread on the mortgage worsens the incentive to move both when there is likely to be residual equity (in which case it is appealing for the borrower to exit due to the high occupancy cost) and by hastening the period in which residual equity is likely to be low.

With a fixed-debt reverse mortgage, assuming a constant property value, the seller is indifferent to the date of termination and requires no rate spread. In fact, with a property value equal to net rents ("NOI") divided by the difference between the (assume constant) cost of capital r and property growth rate g (assume $r > g$), a mortgage loan of 100% of current property value could be advanced as follows: the borrower must purchase an annuity with payments equal to $r - g$ times property value each period (and hence growing at rate g), so that the debt grows at the rate of property inflation g. That annuity would cost, if fairly priced, $\frac{\text{NOI}}{r-g}\,[r-g]\,A$, where A is the sum of the borrower's survival probabilities adjusted by the discounted growth of payments,

$$A \equiv \int_{t=0}^{\infty} \mathrm{e}^{[g-r]t} q(t)dt. \tag{1}$$

[3]The absence of any capital gain (as opposed to dividend) incentive to maintain the property would be an obvious candidate reason, per Shiller and Weiss (2000) and Miceli and Sirmans (1994). Viager contracts feature payments running in the opposite direction as a sale-leaseback.

In (1), $q(t)$ is the probability at date 0 of survival to date t That would leave loan proceeds of $\frac{\text{NOI}}{r-g}\left[1 - A\left[r - g\right]\right]$. $A < \frac{1}{r-g}$ as long as the incumbent owner is mortal. Because the inequality is strict, the available cash proceeds to the borrower at origination are positive. These available cash proceeds are equal to the expected discounted value of the home upon the borrower's death. The annuity covering interest would revert to the borrower after a move. Because that annuity payout per period is equal to net rent, the borrower always pays the true user cost to remain in the home an additional period.

Now consider a standard reverse mortgage loan with negative amortization for the expected resale value at death, $\frac{\text{NOI}}{r-g}\left[1 - A\left[r - g\right]\right]$. That loan would lose money in expectation for the lender if the loan accrues at rate r, if it is possible that the borrower might remain in the home past the date at which the loan balance "crosses over" the property value. Thus the loan rate must be greater than r or the available loan proceeds must be less than the second part of value described above available as cash proceeds to the borrower in the annuitized payment case above.[4]

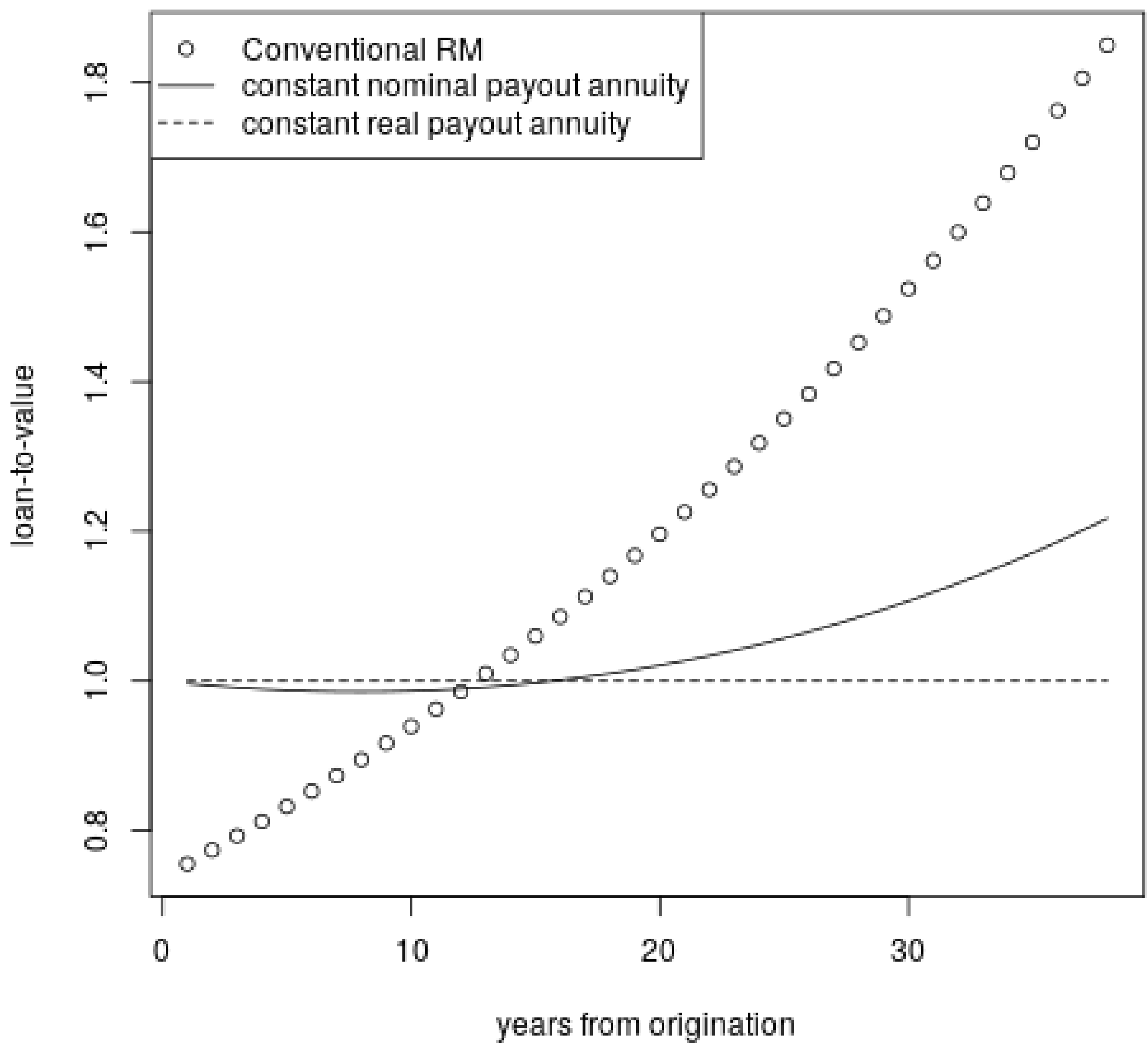
Fixed-debt reverse mortgage loans appear to have disappeared with the convention that loan proceeds be annuitized. However, there is no necessary link between annuitizing the interest payments and annuitizing the future value, item 2 above.

A second feature of an annuity-enhanced reverse mortgage loan is that balances are higher early in the loan's life and lower later in the loan's life. In the stylized case of deterministic growth, with a loan-to-value ratio fixed over time at 100% by annuitized interest payments, there is no crossover risk, and so a riskless interest rate in principle could be charged. By contrast, with stochastic mortality, even with deterministic termination, lenders would have to charge a premium due to limited liability with a growing balance and crossover risk. In that deterministic price case, it is clear that an annuity-enhanced fixed-debt loan can be priced risklessly. Figure 2 plots the loan to value ratio for a home with zero real price growth in the case of a standard accruing reverse mortgage, and a reverse mortgage with additional debt financing annuities that pay constant nominal (solid line) and real (dashed line) partial interest payments until the loan terminates.

We thus have reason to expect that augmenting a reverse mortgage with an annuity that pays the lender interest up until loan termination and then reverts to the borrower if still alive might generate Pareto gains to the borrower and lender. Assuming zero profits, the borrower would benefit from a lower cost loan in exchange for reduced default option value. There is strong reason to expect that borrowers undervalue the default options embedded in HECM loans, see Davidoff (2012), Davidoff and Wetzel (2013). Moreover, even for a rational borrower, some of the default value comes from Pareto-dominated mobility behavior, so

[4]At the limiting interest $r = \infty$, the loan would amount to a forward sale.

Figure 2: Loan to value ratios over time for a reverse mortgage loan with no supplementary annuity, and with remaining equity leveraged to purchase a constant or real annuity.



welfare gains should be available.

2 Numerical Analysis

The following analysis considers the cost to insure a reverse mortgage loan to a 70-year-old woman facing mortality probabilities given by Statistics Canada. The loan to value ratio at origination L_0 is assumed to be 50%, drawn immediately. That loan amount is roughly intermediate between maximal available loan-to-value ratios for HECM in the U.S. and CHIP Max in Canada at current interest rates. I assume an exogenous riskless rate of 1% or 5%, and required loan margins ("s") to lenders of 2%, consistent with prevailing government-insured HECM loan margins to lenders.[5]

In addition to the 50% loan-to-value reverse mortgage loan, I consider constant annuities of $x = 0\%, 10\%, \ldots 50\%$ of the remaining 50% of property value financed by additional debt. These annuities are paid to the borrower only after a move while alive. During the life of the loan, the payments go to the lender and reduce the loan balance by the constant payment a per year, with a given by

$$a = [1 - \text{load}]\ \frac{[1 - L_0]\, x}{A}. \tag{2}$$

In equation (2), A is the cost to provide a dollar of annuity flow as in (1), but with the payment constant, so $g = 0$. I consider the possibility that the annuitized amount $[1 - L]\, x$ accrues at a different rate from the standard reverse mortgage loan rate. From the insurer's perspective, a high interest rate increases the default option value they insure. If the insurer is a government agency, such as FHA in the US or CMHC in Canada, their borrowing cost is closer to the riskless rate than the mortgage loan rate. Alternatively, if the insurer is guaranteeing a high spread to the lender, they might match annuities with guaranteed bonds (such as US HMBS) to provide a rate of return on the annuities greater than the riskless rate plus mortality embedded in the return rate a. The parameter α in equation (4) measures the extent to which annuitants receive a lower underlying rate of return (r) than the rate at which the mortgage-financed annuity accrues interest ($r + \alpha s$), with s the spread assumed to be 2%. Equation (3) describes the growth of the standard loan, with interest accruing at rate $r + s$ minus annuity payments a. Equation (5) defines the balance due at any date t as the sum of the standard loan balance plus the annuity loan balance X.

[5] https://www.housingwire.com/articles/48215-hecm-margins-increase-for-the-first-time-in-a-year/

$$L_t = L_{t-1}\left[1 + r + s\right] - a, \tag{3}$$

$$X_t = X_t\left[1 + r + \alpha s\right], \tag{4}$$

$$b_t = L_t + X_t. \tag{5}$$

The parameter α is important to valuation, so I consider values of 0, .5, and 1.

I do not model borrower utility directly. As observed in Davidoff and Wetzel (2013) and Davidoff (2012), borrowers appear in some important ways to fail to appreciate put option value: credit line use is non-strategic. Generally, borrowers draw most available proceeds as soon as possible and make no use of the credit line thereafter (except for mechanical draws forced on borrowers to pay property taxes and insurance per Moulton, Haurin, and Shi (2015)). Also, early in the life of the HECM program, the put option appears to have been so underpriced as to render using HECM quite positive NPV to most seniors. In that case, the low takeup rate is very difficult to square with standard preferences.[6] The extreme sensitivity of empirical terminations shown in Figure 1 to prices might also be challenging to rationalize.

Instead, I simply assume that loan terminations look as depicted in Figure 1. A logit regression suggests that if y denotes equity (truncated at zero), and m female mortality, monthly termination rates are best fit by the probability of survival times the quantity λ:

$$\lambda_{t\omega} = \left[1 + \exp\left(-\left[-7.45 + 20.19 * m_t + 3.29 * \left[\max\left(v_{t,\omega} - b_t, 0\right) + \text{annuity valuation}_t\right]\right]\right)\right]^{-1} \tag{6}$$

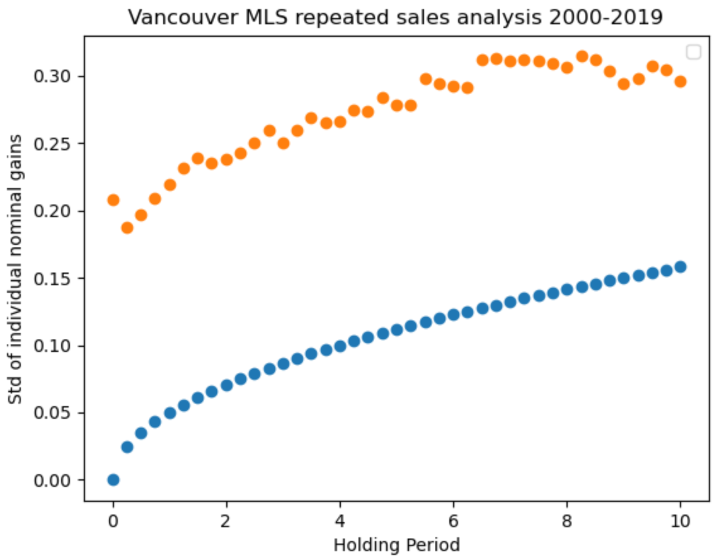
λ is thus the age and state-of-the-world specific rate of exit from the home, including mortality. The annuity valuation in equation (6) is the expected discounted value of the remaining annuity payments, with the borrower assumed to discount at the loan interest rate. The common inactivity in HECM borrowers' credit lines after initial draws, often with positive balances remaining, rationalizes this discount rate assumption.

Assuming underwater loans always exercise the default option (given limited liability), $S_{t,\omega}$ the probability of a loan's survival to date t given the borrower's behavior in (6) and the evolution of home prices in state of the world ω, the expected cost of providing default insurance to the lender is:[7]

[6] See Cocco and Lopes (2020) for an alternative perspective.

[7] The formulation assumes that exit from the home while alive and subsequent mortality are independent.

Figure 3: Standard deviation of individual home price transactions by length of holding period in Greater Vancouver (orange dots) versus 5% times root of years since origination (blue dots). Repeated sale transactions pooled within holding periods in quarters across homes and time periods.



$$\text{insurance cost} = \sum_{\omega=1}^{N} \sum_{t=1}^{T} S_{t,\omega} \lambda_{t,\omega} \max\left(0, b_t - v_{t,\omega}\right)/N, \tag{7}$$

$$S_t = S_{t-1} \lambda_{t-1,\omega}. \tag{8}$$

In (7), ω represents random draws of percentage changes in the home's value over the life of the loan. Interest rate movements matter, too, but it is almost innocuous to subsume volatility in r into volatility in g. It thus remains to parameterize volatility in home prices. I set the number of draws of normally distributed (as explained below) price levels to 20,000.

Calibrating home price movements is critical to valuation. Figure 3 plots the standard deviation of realized log price changes in Greater Vancouver transaction data between 2000 and 2019.[8] Repeated transactions of the same property are put into bins corresponding to the number of quarters for which they were held. For example, a home sold in quarter 1, 2015 and sold in quarter 3 2018 would be in the same group as a home sold in quarter 2, 2008, and sold in quarter 4, 2011. The standard deviations thus draw on both cross-sectional and time series variation in price growth across homes. The mortgage insurance position includes exposure to both.

[8] The source is multiple listing service data.

Table 1: Standad deviations of nominal 1 and 5 year home price index log growth yeare CREA index, top panel, 2005-2020. Bottom panel: Teranet index, 1990-2020. Select Canadian cities

Metro area	1-year gains standard deviation (CREA)	5-year gains standard deviation (CREA)
Calgary	.051	.267
Montreal	.024	.057
Ottawa	.033	.087
Toronto	.051	.091
Vancouver	.083	.134
Metro area	**1-year gains standard deviation (Teranet)**	**5-year gains standard deviation (Teranet)**
Halifax	.031	.098
Quebec	.040	.176
Montreal	.038	.157
Winnipeg	.045	.175
Vancouver	.070	.155
Victoria	.067	.191

Figure 3 is consistent with an emerging view: the variance of prices for individual transactions is not linear in time. Rather, there is a significant intercept along with a modest component that appears to add to the standard deviation with the square root of time. Per Giacoletti (2019), some, but not all of this relates to the selection described by Sagi (2017). Large fluctuations in both market and idiosyncratic home values trigger sales, so short tenures are associated with large movements in price.

Table 1 presents the standard deviation of 15 1-year (January to January) log price changes in the CREA home price index and 5-year non-overlapping changes (2010-2005, 2015-2010, and 2020-20150. The results are broadly consistent with a t-period volatility with variance linear in time. Unfortunately, CREA's short panel, going back to 2005, cannot inform the shape of standard deviations in time. Teranet, considered in the bottom of Panel 1 provides data back to 1990 for the cited areas. Teranet June-June, except for 1990 is July, first month of coverage.

Taking in all of this evidence suggests volatility consisting of two components: a one-time 10% standard deviation of individual returns applied to a sale in any period (based on a view that some, but not all of the idiosyncratic constant variation in prices identified in Figure 3 and in Sagi (2017) and Giacoletti (2019) stems from selection into transactions rather an underlying process), and a standard process with standard deviation of t period capital gains $\sigma\sqrt{t}$. Table 1 suggests a value of 5% as a moderately high level for the market-level σ.[9] The annual standard deviation is incremented by 1.5% to a total of 6.5% to reflect interest rate

[9]The US Federal Housing Finance Agency repeated sale index goes back farther than 1980 for some cities. In that data set, as in the Canadian data, there is support for at least a $\sigma\sqrt{t}$ formulation for the volatility parameter, with the 1-, 4- and 9-year horizons yielding standard deviations of .08, .24, and .44, respectively.

Table 2: Parameter notation and assumptions

Symbol	Meaning	Parameterization
r	Nominal riskless rate	1% or 5%
s	Spread to an insured lender	2% (per recent HECM vintages)
α	Fraction of s applied to annuitized component of loan	0, .5, 1
b_t	Reverse mortgage balance at date t	See equations (3) through (5).
ω	A realization of collateral values	
$v_{t\omega}$	Value of home at date t on path ω	Mean 2%, Std. Dev 10% + $.065\sqrt{t}$.
L_0	Initial loan to value for standard lump sum reverse mortgage	 50%
load	Loading on annuity (e.g. administrative fees)	7.5%
A	Fair cost to provide an annuity	
a	Annual cash flow from the annuity	
x	Fraction of $1 - L_0$ annuitized and paying debt until move Reverts to borrower after move	 0,.1,. . . .5
$\lambda_{t,\omega}$	Probability loan terminates (move or die)	per text
$S_{t,\omega}$	Probability loan not yet terminated	
m_t	Mortality at age t	For Canadian woman age 70 at origination

risk.[10]

I assume that the property value has expected growth equal to the rate of inflation. With each realization of price movements across time come the associated (not path-dependent) termination probabilities λ, and so the insurance cost can be valued given that draw of normally distributed prices. Table 2 summarizes notation and parameter assumptions.

Table 3 presents numerical results holding expected appreciation constant at 2%, but considering discount rates of 1% (reflecting current conditions) nd 5%. For each interest rate, results are presented for the critical wedge α between the interest rate available on annuities and guaranteed to lenders by the reverse mortgage loan insurer. For each pair of r and α, I consider levels of annuity enhancement from 0 to 50% of the initial home equity (so from 0 to 25% of home value). Simulations reveal in some conditions that considerably higher levels of annuity enhancement would further reduce insurance costs, but high loan-to-value ratios on senior retirement products might not gain regulatory and popular acceptance.

To interpret Table 3, compare the insurance costs with lower and higher annuitized values. For example, when there is no wedge α between the annuity return to investors

[10] Cocco and Lopes (2020) use value of 1.8% for the standard deviation of the real rate. There may be negative correlation between real growth and interest rates. Their difference is sufficient for computing put value.

(before mortality premium) and the reverse mortgage loan rate, the insurance cost falls from roughly 40 basis points to roughly 13. With a 5% interest rate, insurance costs fall from 12% to 7%. However, when there is a 2% wedge between those rates of return, the annuity enhancement increases the loan insurance cost.

3 Conclusion

Reverse mortgage loans involve a significant risk to lenders or their insurers that collateral will be worth less than the outstanding balance at loan termination. That risk is compounded by the negative amortization feature and moral hazard on loan termination induced by the put option. This paper considers the impact of flattening the loan to value ratio curve over time by increasing the initial loan amount to finance an annuitized loan that pays off mortgage interest as long as the loan is alive.

By flattening the curve of loan-to-value over time and by reducing moral hazard on duration, annuity enhancements can reduce the cost of insuring reverse mortgage loans by almost 50%. Not all of this is Pareto improvement, as borrowers may attach some value to the put option. A critical parameter in determining the impact of annuity enhancement on insurance cost is the wedge between the cost of financing the annuity and the rate of return on the annuity.

Table 3: Numerical analysis. These results tabulate insurance costs for a reverse mortgage loan to a 70 year old woman with loan termination behavior as described in equation (6). For each pair of a riskless rate r and the wedge between annuity and mortgage return rates α, and each of the fractions of remaining equity x annuitized, the discounted insurance cost (7), and the mean and standard deviation of loan length are presented. The length of the loan is the mean across scenarios ω of the sum of the probability of survival $S_{t\omega}$ to each loan anniverary time 1 minus the probability $\lambda_{t\omega}$ of exit conditional on survival and the path of prices given by ω.

r	annuity vs loan wedge α	annuitized x	Insurance cost	Mean length	std. dev. length
0.01	0	0	0.0039	10.88	3.33
0.01	0	0.1	0.0032	10.91	3.29
0.01	0	0.25	0.0019	10.94	3.22
0.01	0	0.4	0.0014	10.98	3.16
0.01	0	0.5	0.0013	11.05	3.10
0.05	0	0	0.1205	14.38	3.74
0.05	0	0.1	0.1098	14.37	3.71
0.05	0	0.25	0.0953	14.37	3.64
0.05	0	0.4	0.0802	14.24	3.56
0.05	0	0.5	0.0718	14.23	3.47
0.01	0.5	0	0.0040	10.85	3.31
0.01	0.5	0.1	0.0035	10.96	3.32
0.01	0.5	0.25	0.0032	11.09	3.31
0.01	0.5	0.4	0.0024	11.22	3.24
0.01	0.5	0.5	0.0025	11.30	3.21
0.05	0.5	0	0.1198	14.38	3.75
0.05	0.5	0.1	0.1162	14.44	3.69
0.05	0.5	0.25	0.1077	14.49	3.60
0.05	0.5	0.4	0.1016	14.56	3.45
0.05	0.5	0.5	0.0974	14.55	3.38
0.01	1	0	0.0040	10.84	3.33
0.01	1	0.1	0.0040	11.03	3.33
0.01	1	0.25	0.0043	11.28	3.35
0.01	1	0.4	0.0047	11.49	3.32
0.01	1	0.5	0.0051	11.68	3.32
0.05	1	0	0.1205	14.39	3.73
0.05	1	0.1	0.1223	14.52	3.67
0.05	1	0.25	0.1249	14.64	3.55
0.05	1	0.4	0.1298	14.84	3.38
0.05	1	0.5	0.1334	14.93	3.25

References

Artle, Roland and Pravin Varaiya (1978). "Life Cycle Consumption and Homeownership". In: *Journal of Economic Theory* 18.1, pp. 38–58.

Cocco, Joao and Paula Lopes (2020). "Aging in Place, Housing Maintenance, and Reverse Mortgages". In: *The Review of Economic Studies* 87, pp. 1799–1836.

Cowan, Stephen A. and Susan E. Foley (n.d.). "New Trends in Residential Mortgage Finance". In: *Real Property, Probate and Trust Journal* 13.4 (), pp. 1075–1115.

Davidoff, Thomas (2012). *Can 'High Costs' Justify Weak Demand for the Home Equity Conversion Mortgage?* Working Paper. Sauder School of Business, University of British Columbia.

— (2014). *Reverse Mortgage Demographics and Collateral Performance*. Working Paper. University of British Columbia.

— (2019). *fAnnuity-enhanced reverse mortgage loans*. Economic Studies. Brookings Institution.

Davidoff, Thomas and Gerd Welke (2006). *Selection and Moral Hazard in the Reverse Mortgage Market*. working paper. UC Berkeley.

Davidoff, Thomas and Jake Wetzel (2013). *Do Reverse Mortgage Borrowers Use Credit Ruthlessly?* Working Paper. Sauder School of Business, University of British Columbia.

Giacoletti, Marco (2019). *Idiosyncratic Risk in Housing Markets*. Working Paper.

Haurin, Donald et al. (2014). "Spatial Variation in Reverse Mortgages Usage: House Price Dynamics and Consumer Selection". In: *The Journal of Real Estate Finance and Economics*, pp. 1–26. ISSN: 0895-5638.

Kopczuk, Wojciech and Joel Slemrod (2003). "Dying to Save Taxes: Evidence from Estate-Tax Returns on the Death Elasticity". In: *Review of Economics and Statistics* 85.2, pp. 256–265.

Lockwood, Lee M. (2013). *Bequest Motives and the Choice to Self-Insure Late-Life Risks*. Working Paper. Northwestern University.

Miceli, Thomas and C.F. Sirmans (1994). "Reverse Mortgage and Borrower Maintenance Risk". In: *Journal of the American Real Estate and Urban Economics Association* 22.2, pp. 257–299.

Moulton, Stephanie, Donald R. Haurin, and Wei Shi (2015). *An Analysis of Default Risk in the Home Equity Conversion Mortgage (HECM) Program*. Tech. rep. 1, pp. 17–34.

Sagi, Jacob (2017). "Asset-Level Risk and Return in Real Estate Investments". In:

Shiller, Robert and Allan Weiss (2000). "Moral Hazard in Home Equity Conversion". In: *Real Estate Economics* 28.1, pp. 1–31.

Yaari, Menahem E. (Apr. 1965). “Uncertain Lifetime, Life Insurance, and the Theory of the Consumer”. In: *Review of Economic Studies* 32, pp. 137–150.