



Institute
and Faculty
of Actuaries

CP 13/18: Solvency II – Equity Release Mortgages

IFoA response to Prudential Regulation Authority

28 September 2018

About the Institute and Faculty of Actuaries

The Institute and Faculty of Actuaries (IFoA) is a royal chartered, not-for-profit, professional body. We represent and regulate over 32,000 actuaries worldwide, and oversee their education at all stages of qualification and development throughout their careers.

We strive to act in the public interest by speaking out on issues where actuaries have the expertise to provide analysis and insight on public policy issues. To fulfil the requirements of our Charter, the IFoA maintains a Public Affairs function, which represents the views of the profession to Government, policymakers, regulators and other stakeholders, in order to shape public policy.

Actuarial science is founded on mathematical and statistical techniques used in insurance, pension fund management and investment. Actuaries provide commercial, financial and prudential advice on the management of assets and liabilities, particularly over the long term, and this long term view is reflected in our approach to analysing policy developments. A rigorous examination system, programme of continuous professional development and a professional code of conduct supports high standards and reflects the significant role of the profession in society.



CP 13/18
Prudential Regulation Authority
20 Moorgate
London
EC2R 6DA

28 September 2018

Dear Sir/ Madam,

IFoA response to Consultation Paper CP 13/18: Solvency II – Equity Release Mortgages

1. The Institute and Faculty of Actuaries (IFoA) welcomes the opportunity to respond to the PRA's consultation paper (CP) on Equity Release Mortgages (ERM). This consultation is important, as ERM meet a social need which is likely to continue to grow in importance. However, we believe that it is in the public interest for the valuation of any No Negative Equity Guarantee (NNEG) to be robust, and to reflect appropriately the underlying risk.
2. A number of parties within the IFoA have been involved in the development of our response to CP13/18; our:
 - ERM working party;
 - Life Standards and Consultations sub Committee; and
 - Life Insurance Board.

Members of the working party, Committee and Board are actively engaged with the investment of ERM assets by life insurers. However, it is important to stress that - and as with any of our consultation responses - we have considered the PRA's proposals from the perspective of the public interest. Given the relevance of Transitional Measures on Technical Provisions (TMTP) to the proposals, we have also had input from our TMTP working party.

3. As you may be aware, members of our ERM working party met with the PRA on 21 August to discuss both CP13/18 and impending research by both the IFoA and ABI on the valuation of NNEG. This response reflects that discussion from our perspective.

Summary

4. Our main comments in relation to the proposals within CP13/18 are as follows:
 - it is in the public interest that the valuation of any NNEG on ERM assets is both robust and adequately reflects the corresponding risk;
 - the proposals could have an adverse impact on the supply of equity release mortgages to consumers, and knock-on impacts on individual and bulk purchase annuity rates;
 - the PRA should therefore have regard to both policyholder security and policyholder value for money when considering the impact of the proposals;
 - we believe more research needs to be completed to understand if the NNEG is understated currently; this should be completed before any proposals are adopted;

- the retrospective nature of the proposals could give rise to a discrete shock in capital position for some firms. This would be disruptive to the industry, undermine confidence in the UK insurance system and increase the cost of raising capital due to the increased regulatory risk in the UK. This would be exacerbated if only a limited transitional period were available;
- furthermore, we do not understand why a change in estimate, which the proposed change in NNEG calibration seems to be, is being implemented as if it were an error;
- we suggest firms should be given a reasonable amount of time to prepare for the implementation of any new supervisory statement that follows CP13/18;
- the Effective Value Test (EVT) could lead to pro-cyclical behaviour by insurers;
- requiring the Individual Capital Assessment (ICA) to use the EVT is a significant departure from the practice assumed by firms in their ICA at the time of transition to Solvency II;
- we have some concern that the proposals are overly prescriptive. We would prefer the PRA to set out the principles and standards to be met.

General Comments

5. The IFoA believes it is important for there to be ongoing challenge of the methodologies and assumptions used when valuing the assets and liabilities held by insurers, including for ERM assets. We do note however a contrast between the PRA's potential concern over the treatment of ERM (leading to the proposals in CP13/18), and previous PRA industry communication that this was not an area with systemic risk. We think it would be helpful for the PRA to provide more background on the catalyst for its updated outlook.
6. We agree with the PRA that the valuation of ERM assets and NNEG and associated capital requirements should be robust, and should adequately reflect the underlying level of risk. This is in the interests of promoting a stable and healthy long-term insurance market in the UK. We also agree that firms should not be taking an inappropriate level of Matching Adjustment benefit in their Solvency II Balance Sheet.
7. However, appropriate asset valuation and capital requirements should neither under nor over-estimate the corresponding level of risk. As mentioned above, ERM meet a social need which is likely to continue to grow in importance. The availability and attractiveness of ERM assets to insurers is thus in the public interest. The regulatory treatment of ERM assets and NNEG risk should therefore have regard to both policyholder security and policyholder value for money.
8. We recommend that the PRA give careful and thorough consideration to the potential consequences of the proposals within CP13/18 before any implementation, including the impact on firms' capital requirements and volatility of capital position. We have a concern that the proposals could have an adverse impact on the supply of equity release mortgages to consumers, and knock-on impacts on individual and bulk purchase annuity rates.
9. In the light of such consideration, we believe it would then be helpful for the PRA to demonstrate why the approach being proposed is reasonable, and publish an impact assessment that demonstrates why the regulatory benefits of implementing the proposals outweigh any costs to the UK economy and the end consumer.
10. We see similarities in the proposed change to the regulatory treatment of ERM assets with the development of the TMTP, in that the TMTP was designed to ensure a smooth transition from the Solvency I to the Solvency II regime. The proposals within CP13/18 would effectively require a retrospective change to assumptions, and we have a concern that this could give

rise to a discrete change in the capital resources and requirements for some firms. In particular, a number of firms could face a discrete shock to their capital position, thereby threatening value for money for their customers, and their own standing in the market. Such impacts, were they to arise, would be disruptive to the industry and would need careful management, particularly if only a limited transitional period were available.

11. Within accounting frameworks, it is extremely rare for balance sheets to be retrospectively changed. This happens if an error is observed by management or its auditors. Conversely, if an estimate is updated through better information, more robust techniques or market practice, balance sheets are not retrospectively changed. In this case, the change to the NNEG calibration proposed is a change in estimate and it is therefore not clear to us why such a change should apply retrospectively to ICA balance sheets.
12. In our view, the proposals within CP13/18 could also result in prudence being introduced to the calculation of Technical Provisions. We do not think this is appropriate as, aside from the Risk Margin, the Technical Provisions should be determined using best estimate assumptions (which could include use of a stochastic distribution with a best estimate median). Rather than through the Technical Provisions, allowance for risk should instead be made in determining the Solvency Capital Requirement (SCR); for example, the significant stress applied to house prices in calculating the SCR.
13. Furthermore, in forcing a restriction to the Matching Adjustment into the balance sheet, firms will also need to allow for the EVT in stressed conditions when determining the SCR. This could introduce additional (excessive) prudence, reducing surplus further. We therefore suggest the PRA give careful consideration to where any allowance for NNEG risk is made in the Solvency II Balance Sheet.

NNEG Valuation: Research

14. The IFoA recommends that the consultation period for CP13/18 is extended until research can be published demonstrating that the approach proposed is appropriate (or otherwise). As mentioned above, the IFoA is commissioning research on ERM in conjunction with the ABI. The research is expected to give a view on:
 - whether or not Black-Scholes and the parameters proposed by the PRA in CP13/18 give an appropriate assessment of the cost of NNEG; and
 - what level of prudence is being introduced by using a risk-neutral approach to calculating the matching adjustment as proposed in CP13/18.
15. We explain the potential theoretical limitations of using Black-Scholes to model the cost of NNEG in the Appendix to this response. However, a key point is that assuming geometric Brownian motion over the long term, with a constant volatility assumption as proposed in CP13/18 could lead to the cost of NNEG being materially misstated. The residential property market has historically exhibited momentum effects and mean reversion as well as jumps and conditional heteroscedasticity.
16. Our research is due to commence on 1 October, with initial research outputs expected to be ready before 31 December, and final research findings available by Q1 2019. In view of current uncertainty over the cost of NNEG under the CP13/18 proposals, we recommend that the research is concluded before UK insurers are asked to implement the proposals in CP13/18, or any subsequent revision to these.

17. If the parameterisation proposed in CP13/18 using a Black-Scholes formula becomes standard market practice for modelling the cost of NNEG, it is possible that retirees could then face the twin challenges of worsening annuity rates and reduced Loan- to- Value ratios. This could then lead to a material impact on the ability of some retirees to fund their retirement needs. Given that the parameterisation being proposed has a large number of uncertainties with it, we believe it would be in the public interest if more robust research and analysis were produced before shifting the market to a new standard approach.

NNEG Valuation: Implementation Timescale

18. The CP includes the proposal to allow for a potential short phase-in period of up to three years for some firms. We believe that such a short period could be counter to the principle of 'encouraging trade and inward investment', a point raised by the Chancellor of the Exchequer to the Governor of the Bank of England in a letter dated 8 March 2017.
19. Some insurers have been investing in ERM assets to back long-term insurance liabilities for a number of years under the current regulatory regime approved by the PRA. Three years (at most) therefore seems to us to be a very short timeframe to allow insurers to adjust their balance sheets for a new regulatory requirement. This is particularly pertinent given uncertainty with the theoretical reasonableness of the proposals within CP13/18, and the required clarity in the PRA's expectations relating to these proposals.
20. Investors in insurance companies have also based their investment decisions on regulatory capital coverage ratios under the current regulatory regime. Requiring insurers to move suddenly to a new system has the potential to undermine confidence in the UK insurance system if significant regulatory changes can be made without providing a sufficiently long transition period. We believe this would not be acting in the public interest, and could make long term insurance in the UK more expensive for consumers, due to the increased regulatory risk.
21. The CP13/18 parameterisation could also have a material impact on some insurers in relation to the strength of their balance sheet, particularly if only a short transition period were allowed. We suggest that the effective date of the PRA's proposals should be at least six months after the publication of any new supervisory statement following CP13/18. This would give more preparation time for firms during the pre-implementation phase.

NNEG Valuation: EVT

22. In our view, the EVT could lead to pro-cyclical behaviour by insurers. Parameters such as volatility and deferment rate have been set by the PRA on a long-term 'through the cycle' view, while the risk-free interest rate term structure implied by the market will fluctuate on a daily basis. We believe it would be preferable to avoid a situation where a firm would pass the EVT one day, and then fail it the next, due to a short-term fluctuation in interest rates. In our view the test should reflect the underlying property risk exposure, which only materialises around 15-20 years after the loan is written.
23. Furthermore, the deferment rate is a function of net rental yields. If interest rates were to fall, it would not be unreasonable to expect rental yields to fall and vice versa. However, the EVT in its current form does not allow for this. This would then make a firm's balance sheet more sensitive to an interest rate down stress than perhaps it should be. The EVT therefore makes it harder for firms to exercise prudent asset liability and risk management.

24. Assuming that the EVT applies under stress, firms will be incentivised to change their entity-level hedging such that they hedge against a fall in interest rates, to mitigate the impact of the EVT under an interest rate down stress. This could lead to potentially dangerous behaviours, such as firms relying on derivatives to meet the PRA's diagnostic test and to preserve their solvency position. This could be considered uneconomic and highly imprudent from the purposes of the Prudent Person Principle. We believe this is a weakness in the current formulation of the EVT, among other shortcomings in applying the Black-Scholes model to residential properties. *See the Appendix for more detail.*

NNEG Valuation: Other Points

25. We note that the NNEG does not exist in isolation from corresponding ERM loan. As there is no free-standing option exercisable at will, a NNEG cannot therefore be valued in isolation, independently of the ERM loan. The treatment of the NNEG guarantee should therefore be consistent with the ERM loan/ asset valuation.
26. One of the weaknesses of Solvency I that Solvency II was intended to overcome was that the rules-based regulation had become outdated, and was not able to adapt to new methods and technologies as they developed. The valuation of ERM is still developing, and the methods used by insurance companies are developing with it.
27. The CP notes that 'other approaches for assessing the NNEG are possible', but the PRA set out their own methodology as the one that 'will meet their expectations'. This will effectively make the PRA methodology as the de facto method for calculating NNEG risk. However, there are weaknesses in the use of the Black-Scholes model. We therefore have some concern that setting out a prescriptive method and exact formula/calibration as a 'standard that meets PRA's expectations' will stifle much-needed further advancement in thought. Our preference would be for the PRA to set out the principles and standards to be met, and allow companies to interpret these and make their arguments as to why they have met those standards. In particular, we would encourage the PRA to clarify that the EVT set out in CP13/18 is not intended to replace practitioners' best estimate views of NNEG risk.
28. More generally, we are also concerned that this may set a precedent for future regulation, with firms being unable to draw on their own knowledge and experience or the research and thought leadership of the wider professional community.

Other Risks

29. In respect of 'Other risks', our view is that they behave differently to house price risks, where there is a clear direction which creates a stress and acts similarly to reduce the value of lifetime mortgages, reduce any matching adjustment benefit and threaten the security of senior tranche(s).
30. The structuring through a Special Purpose Vehicle (SPV) can create a two-tailed capital exposure to 'other risks'. The senior tranches may be exposed to default risk through both shorter-term liquidity risks and longer-term value risks. The balance between shorter term liquidity and longer term value risks depends on the structure of the SPV. Low decrements could create a greater risk of default. However, in this scenario, a low pre-payment stress would then be applied to the EVT calculation, increasing economic value. In summary, we do not believe other risks should be captured in the EVT as the direction of stress to apply is unclear and can lead to unintended results in the test. Instead, a firm should demonstrate that suitable allowance has been made for such mistiming risks through the internal rating process and internal model.

31. There is further complexity in the interaction between demographic factors and the size of the NNEG risk in assessing overall value. Low lapses/deaths increase the value of ERM in the current low interest rate environment. In high interest rate environments, the opposite dynamic could prevail. The direction of stress to be applied in the EVT cap is therefore unclear and may change over time (for example, if risk free rates were to rise sharply, high prepayments would be advantageous to the EVT calculation).
32. Given this, we suggest that 'Other risks' are better and fully evaluated through the internal rating process for senior tranches. The range and extremity of demographic stresses applied in the rating process should provide the evidence to judge whether an appropriate allowance for other risks has been made.

Impact on TMTP

33. The proposals to introduce the EVT into the Solvency I regime are a material change to the generally accepted methods that firms applied under the ICA regime. The changes introduced are a different method of evaluating the risk profile of ERM that result in materially higher NNEG allowance than that previously assumed (for the same risk profile of ERM). This is because CP13/18 effectively requires all firms to adopt a market consistent view rather than a realistic view when measuring this NNEG risk. Whilst we would agree it is appropriate for Solvency II to apply such an approach to the valuation of assets, we do not agree that it is appropriate or consistent with the Matching Adjustment principles to apply a market consistent approach to the derivation of the valuation interest rate. We also consider that requiring the ICA to use such a method is a significant departure from the practice assumed by firms in their ICA at the time of transition to Solvency II.
34. Solvency I contained many methods that under the Solvency II regime would be considered inappropriate. To resolve this, TMTP measures were put in place in order for firms to have an orderly transition to the new regime and to avoid the consequences of large-scale changes in previous approaches being applied to business previously written. We consider that a similar transition to CP13/18 for existing business should be further considered by the PRA.
35. We believe that the PRA should fully understand the TMTP impacts before implementing the CP13/18 proposals, and we welcome the PRA's request to firms for the assessment of impacts to their Solvency II Technical Provisions, TMTP and SCR. However, we believe it would be useful for the PRA to provide clarification of how these proposals would impact the Solvency I Pillar I regime.
36. The TMTP Financial Resource Requirement (FRR) test requires firms to limit the TMTP impact if it results in a lower FRR than the more onerous of the two Solvency I Pillars. As a result, the impact of the suggested treatment of the TMTP may apply differently to different firms depending on a number of factors, including:
 - whether the FRR test bites at all; and
 - the relationship between the two Solvency I Pillars.

It should be noted that these relationships may change over time and due to different economic conditions, which may significantly complicate the management of firms' balance sheets.

We note this could be a particular challenge for new entrants who did not hold ERM assets prior to 1 January 2016, and hence may not have developed an approach to determining Solvency I valuations.

37. We believe that firms would also benefit from clarification on the timing of any TMTP recalculation, if the PRA's assessment of ERM risk constituted a change in the risk profile of the business. Would this lead to immediate TMTP recalculation, or would recalculation be reflected at the next biennial recalculation date of 31 December 2019? We believe this would depend significantly on the materiality of the resulting TMTP impact.

38. Furthermore, we understand that removing future house price growth from the assessment of NNEG for the purpose of determining the ICAS technical provisions and for determining the economic values of ERM cashflows would increase the sensitivity of the technical provisions to changes in the level of interest rates. In particular, this may exacerbate the impact of interest rate falls that are already significant due to the risk margin. Given this, we recommend the PRA should seek to understand – prior to implementation - how these changes would change the sensitivity of a firm's Solvency II position to interest rate movements, including both prior to, and after, a TMTP reset.

Should you wish to discuss any of the points raised in further detail please contact Steven Graham, Technical Policy Manager (steven.graham@actuaries.org.uk / 0207 632 2146) in the first instance.

Yours sincerely

Jules Constantinou

A handwritten signature in blue ink, appearing to read 'Jules Constantinou', with a horizontal line underneath.

President
Institute and Faculty of Actuaries

Appendix: Valuation of NNEG with Black Scholes Model

1. For some time, the NNEG option embedded in ERM has been modelled using the well-known Black-Scholes model. The simplicity of application of this model for determining the value of a put option has attracted many academics, who focused on other aspects of ERM, into employing the geometric Brownian motion for house prices. Examples in ERM literature include Chinloy and Megbolugbe (1994) ⁽¹⁾, Ma et al. (2007) ⁽²⁾, Pu et al. (2013) ⁽³⁾ and Tsay et al. (2014) ⁽⁴⁾. The geometric Brownian motion for house prices was also used in the context of securitization of ERM, again based on convenience of closed-formula, as in Wang et al (2007) ⁽⁵⁾.
2. The review paper by Hosty et al (2008) ⁽⁶⁾ narrowly focused on the use of the Black-Scholes model in the UK ERM market, with the implicit lognormal model calibrated to the Nationwide House price index. Likewise, the Department of Housing and Urban Development (HUD) used the same framework for NNEG for their Home Equity Conversion Mortgage (HECM) programme introduced in 1989. The assumption that the house price return is a random walk was backed-up by studies such as Kau et al. (1992 ⁽⁷⁾, 1993 ⁽⁸⁾, 1995 ⁽⁹⁾) and Cunningham and Hendershott (1984) ⁽¹⁰⁾, and it implied that house price returns have no memory, so predicting future values is meaningless.
3. However, numerous studies that tested the random walk hypothesis in housing markets provided very strong evidence against it. Case and Shiller (1989) ⁽¹¹⁾ rejected the weak-form efficiency in the US housing market and pointed out the momentum (positive autocorrelation) effects in both the changes in house prices, and after-tax excess returns. Hosios and Pesando (1991) ⁽¹²⁾ and Ito and Hirano (1993) ⁽¹³⁾ obtained similar results for the Toronto and Tokyo housing markets respectively. Furthermore, the Institute of Actuaries (2005) ⁽¹⁴⁾ found that there were momentum effects in the Nationwide House Price Index in the UK. Tunaru (2017) ⁽¹⁵⁾ confirmed momentum effects in the short term and mean reversion over the long term, on an international basis.
4. Autocorrelation in a house price index suggests that the price series has some memory. There is the possibility of speculative price bubbles, as well as mean reversion to occur, as discussed by Szymanoski (1994) ⁽¹⁶⁾. In addition, house prices may also experience jumps. Using Chicago Mercantile Exchange futures price data, Mizrach (2008) ⁽¹⁷⁾ found evidence of jump risk in a 315-day sample. Using the US national average new home price returns for single family mortgages from January 1986 to June 2008, Chen et al. (2010b) ⁽¹⁸⁾ identified 14 instances of the monthly housing price changing more than 10% per month.
5. Without a liquid market in house price derivatives to hedge NNEG risk, there is no benchmark market price. Using the Black-Scholes formula in pricing NNEG will affect the cost of the guarantee, since allowance is not made for the features of mean reversion, momentum and jumps described above. Under geometric Brownian motion the volatility increases with the square root of time while for other models it does not; the value for long term derivatives such as NNEG could materially differ from that assumed under the Black-Scholes model.
6. Recent academic research noticed this financial economics obstacle and proposed alternative solutions that avoid this problem. Examples include: Lee et al (2012) ⁽¹⁹⁾ who proposed a jump-diffusion model; Chen et al. (2010) ⁽¹⁸⁾ and Lee et al. (2012) ⁽¹⁹⁾ who used an ARMA-GARCH model which will include an allowance for conditional heteroscedasticity; the approach by Sherris and Sun (2010) ⁽²⁰⁾ and refined by Alai et al. (2014) ⁽²¹⁾, Shao et al. (2012) ⁽²²⁾ and Cho et al. (2013) ⁽²³⁾ who used a VAR model based on economic scenarios; Wang et al. (2014) ⁽²⁴⁾ who aimed for a model capable to generate housing price jumps so they selected exponential Levy processes for house prices; and mean-reverting models were

discussed by Fabozzi et al. (2012)⁽²⁵⁾ and Tunaru (2017)⁽¹⁵⁾. All of these models depart substantially from Black-Scholes, not only theoretically but also numerically.

7. The evidence referred to above points out that there are two schools of thought: one based on using the Black-Scholes model, and another emerging on the basis of more appropriate modelling of house prices. There are advantages and disadvantages with both schools of thought. Ideally a model should have the simplicity of Black-Scholes but covering the time series features observed in house prices. Since ultimately the exercise of the NNEG option is determined by house prices, it seems logical to compare the two approaches through extensive simulation exercises.

References

- (21) Alai, D.H., Chen, H., Cho, D., Hanewald, K., Sherris, M. (2014). Developing equity release markets: Risk analysis for reverse mortgages and home reversions. *North American Actuarial Journal* 18, 217-241.
- (11) Case, K.E, Shiller, R.J. (1989). The efficiency of the market for single-family homes. *The American Economic Review* 79, 125-137.
- (18) Chen, H., Cox, S.H. and Wang, S.S. (2010). Is the Home Equity Conversion Mortgage in the United States sustainable? Evidence from pricing mortgage insurance premiums and non-recourse provisions using the conditional Esscher transform. *Insurance: Mathematics and Economics*, 46, 371-384.
- (1) Chinloy, P., Megbolugbe, I.F. (1994). Reverse mortgages: contracting and crossover risk. *Journal of the American Real Estate and Urban Economics Association* 22 (2), 367–386.
- (23) Cho, D., Hanewald, K. and Sherris, M. (2013) Risk Management and Payout Design of Reverse Mortgages Paper prepared for the 48th Actuarial Research Conference (ARC), Temple University, Philadelphia.
- (10) Cunningham, D.F., Hendershott, P.H. (1984). Pricing FHA mortgages default insurance. *Housing Finance Review* 3, 373-392.
- (25) Fabozzi, F., Shiller, R., Tunaru, R. (2012). A pricing framework for real-estate derivatives. *European Financial Management* 18, 762-789.
- (12) Hosios, A.J., Pesando, J.E. (1991). Measuring prices in resale housing markets in Canada: Evidence and implications. *Journal of Housing Economics* 1 (4), 303-317.
- (6) Hosty, G.M., Groves, S.J., Murray, C.A., Shah, M., (2008). Pricing and risk capital in the equity release market. *British Actuarial Journal* 14(1):41-109
- (14) Institute of Actuaries (2005). Equity release report 2005. Volume II: Technical Supplement: Pricing considerations. Available at: www.actuaries.org.uk.
- (13) Ito, T., Hirono, K.N. (1993). Efficiency of the Tokyo housing market. *Bank of Japan Monetary and Economic Studies* 11 (1), 1-32.
- (7) Kau, J.B., Keenan, D.C., Muler III, W.J. (1993). An option-based pricing model of private mortgage insurance. *Journal of Risk and Insurance* 60, 288-299.
- (8) Kau, J.B., Keenan, D.C., Muller, W.J., Epperson, J., 1992. A generalized valuation model for fixed-rate residential mortgages. *Journal of Money, Credit and Banking* 24 (3), 279–299.

- (9) Kau, J.B., Keenan, D.C., Muller, W.J., Epperson, J., 1995. The valuation at origination of fixed-rate mortgages with default and prepayment. *Journal of Real Estate Finance and Economics* 11 (1), 5–36.
- (19) Lee, Y-T, Wang, C-W and Huang, H-C. (2012). On the valuation of reverse mortgages with regular tenure payments, *Insurance: Mathematics and Economics*, 51, 430-441.
- (2) Ma, S., Kim, G., Lew, K. (2007). Estimating reverse mortgage insurer's risk using stochastic models, in: Presented at the Asia-Pacific Risk and Insurance Association 2007 Annual Meeting.
- (17) Mizrach, B. (2008) Jump and co-jump risk in subprime home equity derivatives, Working Paper, Department of Economics, Rutgers University.
- (3) Pu, M., Fan, G-Z and Deng, Y. (2013). Breakeven Determination of Loan Limits for Reverse Mortgages under Information Asymmetry, *Journal of Real Estate Finance and Economics*, 48, 492-521.
- (22) Shao, A., Sherris, M., and Hanewald, K. (2012). Equity Release Products allowing for Individual House Price Risk. Proceedings of the 11th Emerging Researchers in Ageing Conference, 2012.
- (20) Sherris, M., Sun, D., 2010. Risk based capital and pricing for reverse mortgages revisited. Working paper, University of New South Wales.
- (16) Szymanoski Jr., E.J., 1994. Risk and the home equity conversion mortgage. *Journal of the American Real Estate and Urban Economics Association* 22 (2), 347-366.
- (4) Tsay, J-T, Lin, C-C, Prather, L.J. and Buttimer, R.J. (2014) An approximation approach for valuing reverse mortgages, *Journal of Housing Economics*, 25, 39-52.
- (15) Tunaru, R. (2017). *Real-Estate Derivatives*. Oxford University Press, Oxford.
- (5) Wang, L., Valdez, E.A., Piggott, J. (2007). Securitization of longevity risk in reverse mortgages, SSRN Working Paper.
- (24) Wang, C.W., Huang, H.C., Lee, Y.T. (2014). On the valuation of reverse mortgage insurance. *Scandinavian Actuarial Journal*, 1-25.