



Kent Academic Repository

Andrews, Doug W. and Oberoi, Jaideep S (2015) *Home equity release for long term care financing: an improved market structure and pricing approach.* Annals of Actuarial Science, 9 (1). pp. 85-107. ISSN 1748-4995.

Downloaded from

<https://kar.kent.ac.uk/48176/> The University of Kent's Academic Repository KAR

The version of record is available from

<https://doi.org/10.1017/S1748499514000268>

This document version

Author's Accepted Manuscript

DOI for this version

Licence for this version

UNSPECIFIED

Additional information

Versions of research works

Versions of Record

If this version is the version of record, it is the same as the published version available on the publisher's web site. Cite as the published version.

Author Accepted Manuscripts

If this document is identified as the Author Accepted Manuscript it is the version after peer review but before type setting, copy editing or publisher branding. Cite as Surname, Initial. (Year) 'Title of article'. To be published in *Title of Journal*, Volume and issue numbers [peer-reviewed accepted version]. Available at: DOI or URL (Accessed: date).

Enquiries

If you have questions about this document contact ResearchSupport@kent.ac.uk. Please include the URL of the record in KAR. If you believe that your, or a third party's rights have been compromised through this document please see our [Take Down policy](https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies) (available from <https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies>).

Home equity release for long term care financing: an improved market structure and pricing approach

Doug Andrews
Department of Statistics and Actuarial Science, University of Waterloo

&

Jaideep Oberoi*
School of Mathematics, Statistics and Actuarial Science, University of Kent

Abstract

Home equity release products have been promoted as a potential solution to residential long term care costs for the elderly. Unexpectedly low utilization of home equity release loans has prompted efforts to better model and price the No-Negative-Equity-Guarantee (NNEG) built into the contracts, but loan rates are still widely perceived by homeowners as being unattractive.. We propose the introduction of a new adjustable rate loan based on a regional house price index, with the NNEG being borne by a specially created intermediary. The proposed approach allows us to directly address and separately price the basis risk between individual house price returns and index returns. Additionally, it offers the opportunity to create securities based on residential real estate that would be attractive to a wider class of investors. The alternative risk-sharing mechanism creates a more transparent and simple pricing structure for the loans. We then use house sales data to demonstrate the approach. We find in our sample that it would be possible to make higher loans than seen in previous literature using standard roll-up contracts. In the most favourable scenario for our simulations, the maximum loan is 89 per cent of the appraised home value if the loan is advanced as a lump sum and 95 per cent if the loan is advanced in instalments.

Keywords

Home equity release; Long term care financing; No-negative-equity-guarantee; Adjustable rate loan; Securitization; House price index; Basis risk

*Correspondence to: Jaideep Oberoi, School of Mathematics, Statistics and Actuarial Science, University of Kent, Canterbury, CT2 7NF, UK. Email: j.s.oberoi@kent.ac.uk

1. Introduction

In many countries, home equity represents a substantial portion of the net worth of the population over age 55. Many members of this older age cohort will be required to fund their own care costs at a level exceeding their incomes. As a result, it will become more necessary for them to access the equity in their home. A standard method to do this is to sell the home, but this raises the question of where the individuals will reside. Related considerations arise as to whether it is preferable to rent or downsize, remain in the same neighbourhood or relocate. Further there are logistical issues regarding moving, discarding, selling or otherwise disposing of property and the transaction costs that might be incurred. For many, there appears to be a desire to remain in the home, which may generate a “possession value” that is greater than the market value on sale. To accommodate the combined desires of providing access to home equity and enabling the homeowners to remain in their homes, home equity release (HER) products have been developed.

The usefulness of HER in old age has been long recognised e.g., see Leather (1990). Recently, more attention is being paid to the potential for HER to assist in funding long term care (see e.g. Andrews, 2009, 2012; Dilnot *et al.*, 2011; Hancock, 2000; NIHE, 2010). However, the take-up on these products in the United Kingdom, Canada and the United States has been very limited. In this paper we describe a proposal for a competitive market framework that would help unlock housing wealth, with the specific objective of providing funds for the care expenses of an aging population while allowing them the option to age in place. We show with the help of house price data how this structure leads to a potentially more efficient risk-sharing mechanism, and to a more transparent pricing model.

Many of the HER loans (sometimes on account of legislation) contain a provision often referred to as the No-Negative-Equity-Guarantee (NNEG). This provision implies that if the value of the home is less than the value of the outstanding loan, there is no further obligation to repay the loan (beyond the funds received on home sale). In the United Kingdom, the NNEG is a requirement of the Equity Release Council, the main industry body in the HER sector. Various authors have suggested, based on surveyed perceptions (Overton, 2010) or pricing models (Hosty *et al.*, 2008; Li *et al.*, 2010), that the typical price charged for the HER loans when the NNEG is present makes the loan unattractive to the borrower and explains, at least in part, why take-up of such products has been low.

Hosty *et al.* (2008), Ji *et al.* (2012), and Li *et al.* (2010) have developed models to price the NNEG that produce prices considerably less than those implied from rates available in the market. These pricing approaches must simultaneously model several sources of risk such as interest rate risk, house price risk, and longevity risk. Furthermore, the models are estimated based on average house price returns rather than individual house prices, and they either ignore or do not directly evaluate the basis risk between an index and individual house price returns. From the lender’s perspective, the longevity risk built into the NNEG makes it necessary to exercise prudence in the size of the loan relative to the house value. As a result, the debate remains open on the necessary level of conservatism in determining the proportion of home value that may be offered as a loan.

We develop a twofold approach to this problem: we present a more transparent pricing structure that takes into account the known risks, while attempting to benefit from opportunities for efficient risk allocation. We also demonstrate this approach using individual house price data unlike existing models that are based on average returns.

The first element is the social aspect of funding the Long Term Care (LTC) expenses of retired individuals. Andrews (2009, 2012) has suggested that the NNEG risk is more suitably borne by the state through an agency or through a Public-Private Partnership (PPP). He suggests that if the PPP holds the NNEG risk, the remaining loan would become a relatively standard mortgage product with an uncertain exit date. Further, the PPP may lay off part of the longevity risk by entering into swap contracts with interested counterparties.

In this paper, we propose a specific structure for HER loans that involves a securitization and a new form of loan to be offered to homeowners, at an adjustable rate based on the regional house price index (HPI). The use of HPI based mortgages to alleviate basis risk was first proposed by Shiller and Weiss (2000). Our proposal involves the establishment of a centralized system that supports efficient sharing of risks and a transparent method for pricing HER loans. These objectives are achieved by independently pricing the NNEG consisting of basis and longevity risk, while offering HPI linked securities backed by physical homes. It is important to note that both elements work together more effectively than in isolation. For instance, the United States has a mechanism for providing NNEG insurance via an agency, but this has not been sufficient to increase the take up of loans due to limitations of pricing the long term fixed rate contracts.

Currently, most loans are offered as fixed-rate roll-up mortgages, whereby a fixed rate of interest is accumulated in the mortgage until the contract is settled. Long term variations in housing prices are sometimes characterized as very slowly reverting to a mean trend, so a fixed rate loan presents a further element of risk relative to house price growth. Recent literature has focussed on modelling the dynamics of index-level returns. For instance, Li *et al.* (2010) fit an ARMA-GARCH model to monthly returns on the Nationwide Index of house prices, and formulate a pricing model for the NNEG as a put option based on the estimated dynamic. By unbundling the loan into an NNEG and a floating rate loan, it would be possible to have more competitive pricing due to improved risk-sharing implications over longer time horizons.

In determining the pricing of the relative portions and demonstrating the advantages of this approach, we focus on the risk that price changes for individual houses are less than the changes in an HPI. This basis risk is a significant element of HER loan risk that has not been explicitly accounted for in previous work on pricing the NNEG. We argue that unbundling and quantifying this risk leads to greater efficiency in risk allocation. We also document a term structure in this risk and account for it in our pricing strategy.

Using a data sample from Kent County in England, we provide a more accurate estimate of the costs involved if the NNEG were provided by a PPP, based on available data. The premium for the NNEG helps determine the maximum

permitted loan relative to the house valuation. Overall, our structure offers the potential for significantly raising the proportion of house value available to the elderly seeking to cover residential care costs.

Our structuring and data work also offer some additional benefits with respect to the current state of the market and the NNEG pricing approach. With respect to the data, our use of the Land Registry's HPI, which is a repeat-sales index based on all recorded transactions, reduces the bias that arises from using a particular mortgage provider's price index.¹

With respect to the investment market, we have proposed the creation of a security that would offer investors exposure to regional residential real estate prices. Given the significant variation over time of the regional distribution of house price changes (Dorling and Cornford, 1995), such securities would serve to fill an important gap in the portfolios of several investors, especially pension funds interested in long term real estate exposures. As these securities would be backed by actual homes, they could aid in a more efficient determination of prices by complementing the derivative contracts. The derivatives markets in residential real estate are still relatively limited compared to those for other assets such as equity and commodities. The absence of liquid and transparently structured securities backed by real estate implies that pricing models for derivatives, even those with linear payoffs, are complex and challenging to implement.²

It may be important to broaden the base of possible investors. Currently the maturity profile of HER suits the liability matching requirements of insurers and specialized investors, who are the main lenders under HER schemes.³ However, the diversification potential of housing equity investments can be accessed by a wider investor base under the proposed scheme, helping alleviate any potential constraints on supply of funds.

The rest of the paper proceeds as follows. In the next section we describe the proposed structure for the HER product and related market arrangements. We present the methodology and data in Section 3, and our results in Section 4. Section 5 discusses an extension of the structure, with a further possibility to reallocate risks. The final section identifies some areas for future research and concludes.

2. An Alternative HER Product and its Pricing

The structure we propose involves a central intermediary, ideally in the form of a PPP. The PPP would receive applications from home owners in need of funds to finance LTC while living in their home (i.e. aging in place). The applicants may not require institutional LTC at the time of application, but may require funds for residential care or

¹ The advantages of repeat-sales indices are widely known (Bailey *et al.* 1963; Case and Shiller 1987, 1989). For more information on the construction of the index, see Calnea Analytics (2007).

² Fabozzi *et al.* (2012), for instance, rely on the assumption that the market price of risk is known.

³ We thank a referee for pointing out that reduced annuity sales under new pension regulations in the UK may lower demand for HER assets among insurers.

to modify the home to make it more accommodating to the applicant's needs and mobility. In our simulations, we assume that the borrowers are a couple aged 65, with one partner requiring care and the other healthy.

Andrews (2012) has stated several reasons that the PPP structure is desirable. The loan would include a NNEG provision. The state may be better placed to bear this risk and may also be able to use some of the homes acquired for social housing. The PPP structure provides a vehicle for the state to pass some of the risk to the private sector through a residual account, and to enhance the attractiveness and availability of the HER product.

The PPP would process the applications, which would include an appraisal of the home, a determination of the amount of equity, an assessment of its prospects for house price inflation in line with an established HPI, and an underwriting of the mortality and morbidity (i.e., the LTC risk that will affect the time of sale of the home and the cessation of the loan). The PPP would then specify the maximum loan amount and the loan rate basis. Once the PPP carries out an evaluation of the NNEG, it screens investors to get the best terms for the borrower. We label the initial value of the house as V_0 , and the NNEG premium as c .

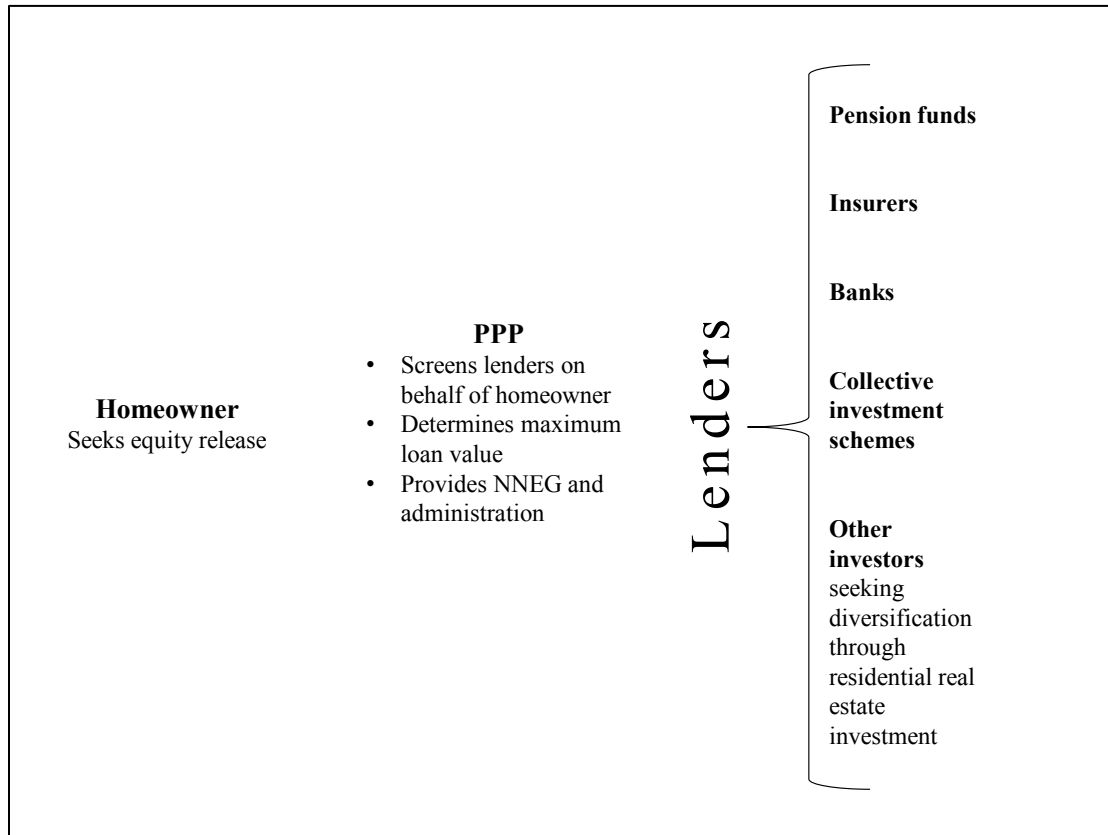
The investors forward the loan funds, and then the loan accumulates interest and an NNEG premium until the exit date. The interest consists of the floating rate basis, plus an annual charge m . This annual charge is designed to cover both an administrative fee for the PPP, and a fee representing administrative expense for the lender along with the 'income component' of housing returns. The administration charge for the PPP is in respect of loan application, initiation, and underwriting and on-going inspection and maintenance of the property. As the HPI reflects average capital growth in house prices, the loan must also include a charge representing the income generated by residential real estate investment (based on standard no-arbitrage arguments). Given the potential liquidity and lower transaction cost of the securities when managed through the proposed structure, we argue this charge should be bounded from above by the net rental yield (after ownership, maintenance, vacancy period expenses, and rental management costs). This charge would be determined by the market, and thus we allow for a range of values in our simulation below.

Exit from the contract is assumed to occur when the homeowners move out due to a change in their circumstances, as specified in the methodology section below. At the time of exit, investors are repaid based on the accrued loan (minus the PPP's administrative fee), while the NNEG charge is retained by the PPP. Thus, the total return to the investor is the sum of the floating and fixed parts, and may be negative if the HPI falls below the accumulated fixed charge. While this is similar to an equity investment in housing, it would presumably outperform such an investment if rents fall in line with HPI. The roles of the various parties are described in Figure 1 and the associated cash flows are in Figure 2. This versatile structure does not preclude other forms of securitization, such as the initiation and bundling of loans by a PPP, as long as the valuation parameters are agreed in advance.

The standard HER loan, referred to as a roll-up mortgage, is based on a fixed interest rate. Instead, we consider writing the loan on an adjustable rate, i.e., floating rate based on the rate of return on the regional HPI. We argue that this allows for a more efficient pricing approach as it does away with a major problem of predicting long-term

real estate price movements. Also, Shiller and Weiss (2000) suggest that providing an incentive to the homeowner-borrower to maintain the property may reduce the “moral hazard” problem and result in better performing loans. This adjustable rate approach maintains the interest of the homeowner-borrower in the on-going pricing of the loan, which may result in greater attention to property maintenance resulting in improved loan performance and a lower NNEG charge. Finally, the resulting creation of securities that is based on average regional house price appreciation would be attractive to several investor classes.

Figure 1. Role of PPP in arranging home equity loans



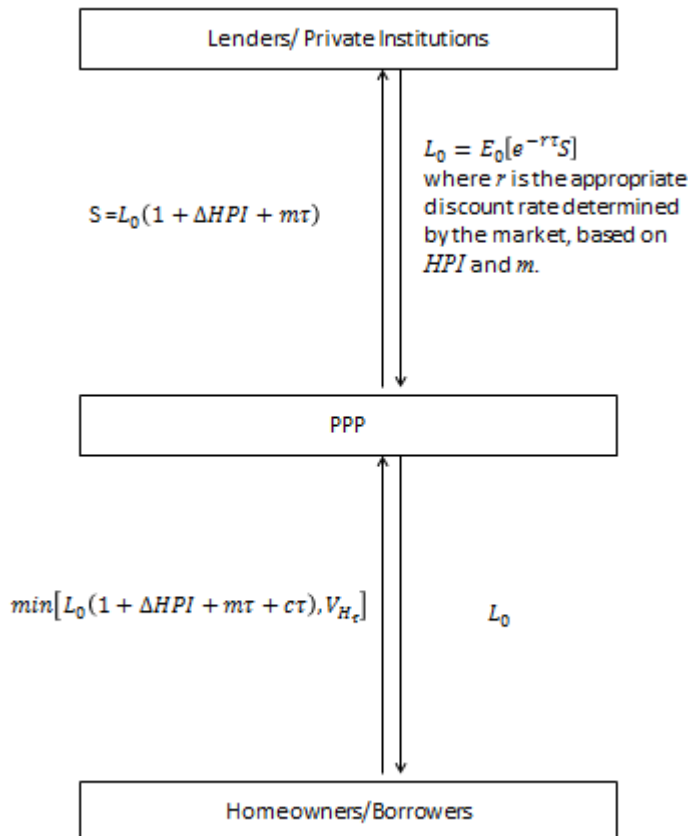
One explanation for observed conservatism in pricing HER loans is that price appreciation of a particular property may be difficult to predict. Although HPI may increase in a way that is readily modelled, a particular house may not keep pace with HPI. In previous papers on NNEG pricing, this source of risk has not been directly treated.⁴ Shiller and Weiss (2000) consider that once equity has been released in the property, there may be little incentive for the residents to maintain the property; hence, reducing the asset value. Although they refer to “moral hazard”, a failure to maintain the property may be due to incapacity attributable to old age or due to (fear of) lack of income. Based on an analysis of Australian data, Ong (2009) found that being 75 years of age or older lowers annual house price appreciation by 1.4 percentage points and further that being aged 75 or older lowers home improvement expenditure by over AUD 3,000 per year and is attributable to a decline in income in old age. Based on a review of American

⁴ Hosty *et al.* (2008) address this risk by raising the assumed volatility of returns.

Housing Survey data for the period 1985 to 2001, Davidoff (2004) observed that annual spending by homeowners 75 and older is approximately USD 270 less on routine home maintenance and USD 1,100 less on home improvement than by younger homeowners with similar homes. He observed that older homeowners realize weaker price appreciation than younger owners of similar homes in the same markets over identical horizons by approximately three per cent per year. These arguments support a role for the PPP in regular inspection and maintenance of the property, and justify the inclusion of a small administrative fee. We envision regular (perhaps annual) inspections of the property and a contractual agreement that the residents maintain the property to some (minimum) standard.

Figure 2. Cash flows associated with the proposed structure

This figure explains the structure of the financing arrangement. The entire loan of L_0 is realised from the lender, and advanced to the homeowner by the PPP at initiation (the right hand side leg). The homeowner pays the PPP the minimum of the home value at exit $V_{H\tau}$ and the value of the loan determined by the change in *HPI*, the NNEG charge c and the ‘income’ charge m , which is determined by the market so that L_0 is the discounted market value of the expected cash flow to the lender (S) at time of exit τ . The PPP pays S to the lender at τ .



Overall, we argue that we are presenting a more efficient allocation for society as a whole because it gives investors the possibility of equity-like exposure to residential real estate without the hassles of ownership, while it offers borrowers the access to necessary funds without the loss of ‘possession value’. While the latter objective is met by any HER product, the joint achievement of the two objectives at lower cost suggests the existence of an economic surplus that would be of interest to policymakers.

3. Methodology and Data

In this section, we describe in detail the methodology and data used.

3.1 Model and Simulation Setup

Let H be the reference HPI, and let the annualized return on H be \bar{h} . The investors thus expect to receive $\bar{h} + m$ on the loan (L_0). The NNEG charge c must then account for the fact that individual borrower house price inflation (h_t) may not match \bar{h} . If the value of the loan exceeds the price of the house on exit, the PPP is responsible for the difference. The value of the securities would also depend on the actual time of exit τ . Due to the nature of this contract (i.e. for financing LTC expenses at home) we can consider τ to be independent of $\{h_{i,t}\}_{t \geq 0}; i = 1, \dots, N$ where t represents the time passed since initiation of the loan. The expected time of exit at initiation of the contract is denoted τ_0 .

The initial loan can then be written as

$$L_{i,0} = \lambda E_0 \left[V_{i,\tau_0} \exp \left(- \int_{t=0}^{\tau_0} (\bar{h}_t + m + c) dt \right) \right]$$

where $\lambda \in (0,1]$ is a policy based proportion and V_i refers to the value of the home. We will henceforth assume that λ is 1 – note that this would imply the highest value for c . Note also that the “moral hazard” argument of Shiller and Weiss (2000) and their recommendation to use an index as a reference rate for the loan has the additional requirement the borrower must still have sufficient equity in the house, suggesting that $\lambda < 1$ would then be more appropriate. However, we have assumed the administration fee and related provisions would substitute as an alleviation mechanism. The entire value of the loan $L_{i,0}$ is realised from investors, and thus $S_{i,0} = L_{i,0}$.

At exit τ the PPP receives $\min \left[L_{i,0} \exp \left(\int_{t=0}^{\tau} (\bar{h}_t + m + c) dt \right), V_{i,\tau} \right]$, which is the lesser of the accrued loan and the value of the house. In turn, the PPP must pay the investors $S_{i,\tau} = S_{i,0} \exp \left(\int_{t=0}^{\tau} (\bar{h}_t + m) dt \right)$ less the administration charge. In our simulations below, we assume this administration charge to be 20 basis points per year and add it to m .

The value of the property at τ is $V_{i,\tau} = V_{i,0} \exp\left(\int_0^\tau h_{i,t} dt\right)$. Suppose we let $E_0\left[V_{i,\tau_0} \exp\left(-\int_0^{\tau_0} \bar{h}_t dt\right)\right] = V_{i,0}$.

Then, $L_{i,0} = V_{i,0} \exp(-(m+c)\tau_0)$, (1)

Equation 1 determines the loan value relative to the initial house value.

We can then show that the NNEG charge should satisfy
$$c\tau_0 \geq \frac{1}{N} \sum_i \int_0^\tau (\bar{h}_t - h_{i,t}) dt + m(\tau - \tau_0)$$

This shows that the outcome for the PPP depends on $\int_0^\tau (\bar{h}_t - h_{i,t}) dt$ and the extent to which the actual date of entry into LTC exceeds the expected date (the longevity risk).

For the simulation, our approach is to determine certain conditions under which an HER loan would continue or would result in sale of the house underlying the loan. Ji *et al.* (2012) developed a semi Markov multiple state model for reverse mortgage terminations. They consider three different modes of reverse mortgage termination: death, entrance into a LTC facility, and voluntary prepayment; and also model the event-triggered dependency between the lifetimes of a husband and wife. They discuss Markov approaches to joint-life mortality, which is relevant to reverse mortgage terminations, as the termination is frequently affected by events that happen to a couple. In this paper we follow their mortality modelling and parameterisation. We use a Gompertz mortality model ($\mu_x = BC^x$) parameterised according to Ji *et al.* (2011, Table 3). We follow their adjustments to mortality probabilities to reflect the “bereavement effect” associated with death of a spouse.

We further assume that applicants eligible for the HER loan through the PPP would be couples of approximately age 65 at a time when one of the couple has requirements for some form of care expenditure. We use a Markov model to estimate the likelihood of a change in status that would result in the home having to be sold and the loan repaid, in each year. Once a person requires care we do not permit the possibility of recovery. We consider the following end of year states of the healthy partner X and care-requiring partner Y:

1. No change in state of X and Y
2. X healthy, Y deceased
3. X requires care, Y requires care
4. X deceased, Y requires care
5. X requires care, Y deceased
6. X deceased, Y deceased

A change to states 3, 4, 5 or 6 would result in sale of the house and settlement of the loan. If the couple remains in state 1 the loan continues. If the transition is to state 2 we assume that the loan continues and calculate the probability that in subsequent years X will be in the states:

7. X healthy
8. X requires care
9. X deceased

Transitions to states 8 or 9 would result in sale of the home. An alternative assumption would have been to assume voluntary loan repayment on transition to state 2. We have not assumed any prepayments as our focus is on the issue of funding LTC at home. The equity position in the home will remain relative to the overall value of the home, so unlike traditional HER products, market-timing decisions by borrowers do not pose as big a risk to lenders under our structure. Lenders receive a rate of return tied to the index and can reinvest in the index at the time of prepayment.

The expression for the calculation of the expected date of house sale is

$$\sum_{j=1}^{\omega} j \left[\prod_{m=0}^{j-1} C_m A_j + \sum_{k=1}^{j-1} x_k \prod_{l=0}^{k-j} C_l B_j \prod_{n=k+1}^{j-1} D_n \right], \text{ with } C_0 = 1, (2)$$

where subscripts represent time, C represents the probability that there is no change from the original state (i.e. remain in State 1); x represents the probability that the state changes to X healthy Y deceased (State 2); A represents the probability that both partners are deceased and/or require care at the end of the year (States 3, 4, 5, or 6); B represents the probability that the single healthy X dies or requires care by the end of the year (States 8 or 9); D represents the probability that the single healthy X continues in that state (State 7). The states are determined at the end of the year. The associated probability tree for the first four years is shown in Figure 3.

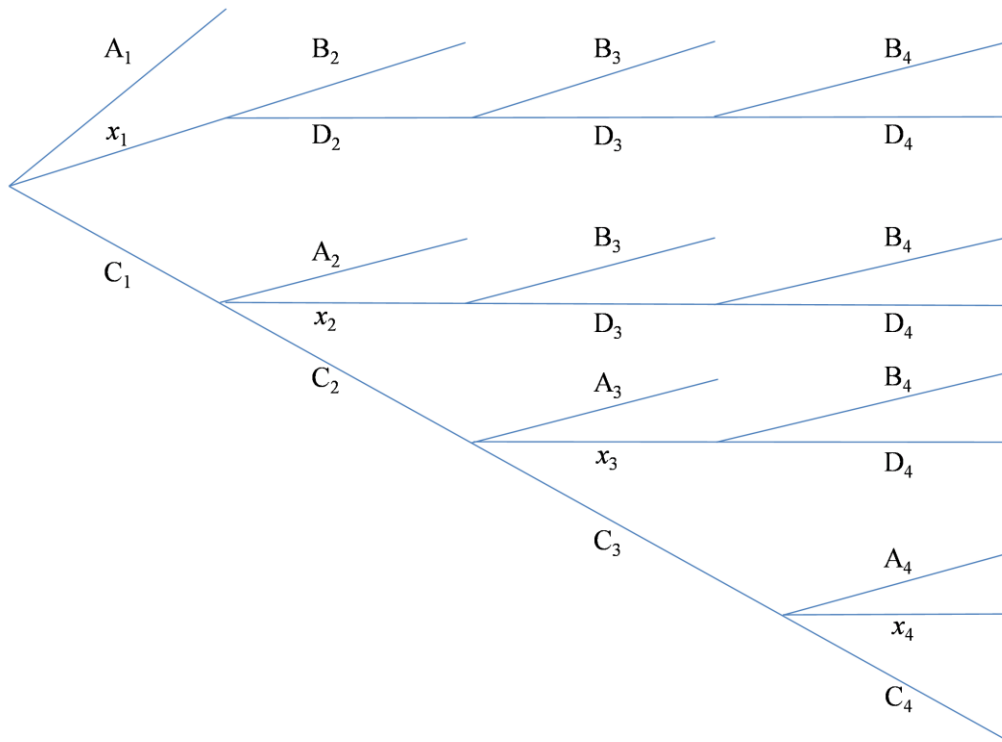
In the event of sale, we compare the appreciation of the index derived from the HPI, which would have been used to price the loan to the likely increase in the individual house's value. Differences in price that result in the NNEG provision being triggered are captured. One million simulations are run to estimate the likelihood and timing of the triggering of the NNEG. We then calculate break-even NNEG premiums using different discount rates. Based on the break-even NNEG premiums we are able to determine an appropriate annual charge for the NNEG. We repeat the process but assume the loans were made by instalments rather than having an outstanding balance from initiation to final repayment.

For the annual charge we consider a range of values ranging between 0 and 400 basis points annually, plus the 20 basis points administration charge payable to the PPP. As a comparison, a recently launched investment product known as an income Housa (Castle Trust, 2014) in United Kingdom offers investors a return equal to the change in a national HPI plus 2-3% annual income over a fixed term of between 3 and 10 years.

The choice of 20 basis points for the administration charge as mentioned above is arbitrary, but given its simple interpretation, the impact of changing this charge on the total loan eligibility is straightforward to calculate and not very significant from the perspective of our simulation.

Figure 3. Probability tree for the first four years after loan initiation

When the loan is initiated, X is the healthy partner and Y is the partner requiring care expenditures at home. C represents the probability that there is no change from the original state; x represents the probability that the state changes to X healthy Y deceased; A represents the probability that both partners are deceased and/or require care at the end of the year; B represents the probability that the single healthy X dies or requires care by the end of the year; D represents the probability that the single healthy X continues in that state. The states are determined at the end of the year. The associated probability tree for the first four years is shown.



3.2 Data

We purchased data from the United Kingdom Land Registry regarding house sales during the period January 1, 1995 to December 31, 2011 for post codes in the county of Kent, England, CT1 and CT2, which correspond to the Canterbury area, and ME8, which corresponds to the Medway area. We then matched and filtered the data, so that only houses that were sold at least twice during the period were included. We use the first sale to determine the market price and subsequent sales to determine individual house returns over the relevant time horizon. We then compare this return to the change in the HPI for the same period pertaining to the county of Kent, as calculated and published by the

Land Registry. This gives us a set of data points representing the difference between actual house price increases and the county-wide HPI.

Table 1(a). Complete data set: Number of transactions by area code, type and period

<i>Area Codes --></i>	CT1	CT2	ME8	Total
Total Number	8,495	7,337	14,892	30,724
Freehold	6,036	6,186	13,746	25,968
Leasehold	2,459	1,151	1,146	4,756
Detached	908	1,465	2,612	4,985
Semi-detached	2,343	2,732	5,175	10,250
Terraced	2,887	2,045	6,061	10,993
Flat	2,357	1,095	1,044	4,496
New	1,132	612	672	2,416
Old	7,363	6,725	14,220	28,308
1995-1999	2,126	2,213	4,879	9,218
2000-2004	2,648	2,495	4,981	10,124
2005-2009	2,928	1,950	3,965	8,843
2010-	793	679	1,067	2,539

Table 1(b). Complete data set: Average price (in GBP) of transactions by area code, type and period

<i>Area Codes --></i>	CT1	CT2	ME8	Combined
Overall Average	150,414	156,598	127,520	140,794
Freehold	158,132	165,660	131,679	145,922
Leasehold	131,469	107,894	77,638	112,792
Detached	243,326	238,423	192,823	215,423
Semi-detached	145,463	143,998	130,727	137,632
Terraced	139,344	140,350	105,137	120,671
Flat	133,103	108,906	78,188	114,458
New	190,589	136,889	136,543	161,953
Old	144,238	158,392	127,094	138,988
1995-1999	72,157	80,877	71,852	74,089
2000-2004	142,665	151,570	126,399	136,857
2005-2009	197,881	219,365	182,502	195,723
2010-	210,835	241,607	182,986	207,361

The data set received from the Land Registry contained 30,724 transactions, which included 18,747 repeat transactions i.e., more than one transaction on the same property. There were multiple repeat transactions for some properties. Tables 1 and 2 summarize the data with respect to the full data set and the data set of repeat transactions. Because the 18,747 figure includes the initial sale, the number of annualized returns in respect of repeat transactions was 10,555. While using this dataset, several filters are necessary, including cases where the type of the property is

changed between transactions. As an example, this can happen because of conversion of a house into several apartments at the same address. We also need to eliminate apparently unreasonably high returns which arise from significant price changes, typically when two transactions are recorded close together e.g., one day apart.

Table 2(a). Data for repeat transactions: Number of transactions by area code, type and period

<i>Area Codes --></i>	CT1	CT2	ME8	Total
Total Number	5,055	4,391	9,301	18,747
Freehold	3,787	3,582	8,496	15,865
Leasehold	1,268	809	805	2,882
Detached	452	764	1,487	2,703
Semi-detached	1,464	1,561	2,993	6,018
Terraced	1,928	1,278	4,094	7,300
Flat	1,211	788	727	2,726
New	258	301	341	900
Old	4,797	4,090	8,960	17,847
1995-1999	1,393	1,272	3,009	5,674
2000-2004	1,763	1,628	3,296	6,687
2005-2009	1,459	1,144	2,407	5,010
2010-	440	347	589	1,376

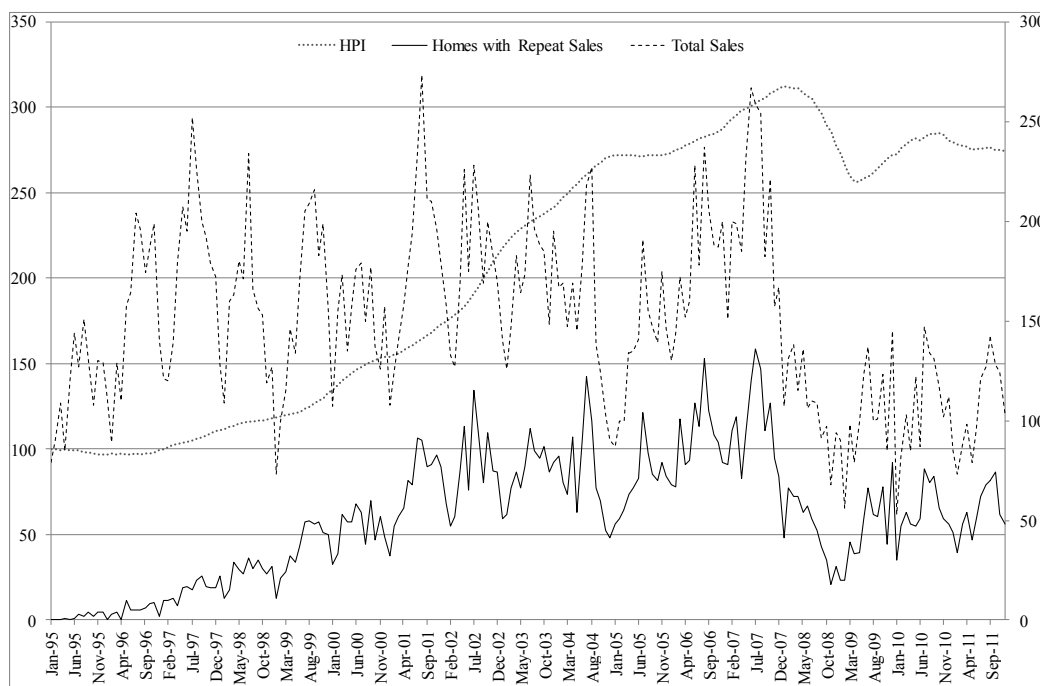
Table 2(b). Data for repeat transactions: Average price (in GBP) of transactions by area code, type and period

<i>Area Codes --></i>	CT1	CT2	ME8	Combined
Overall Average	140,954	151,600	124,510	135,289
Freehold	150,527	161,283	129,141	141,503
Leasehold	112,366	108,728	75,632	101,084
Detached	237,601	233,383	195,402	213,194
Semi-detached	142,313	143,236	130,289	136,573
Terraced	134,738	138,788	103,170	117,743
Flat	113,135	109,657	75,891	102,197
New	164,957	111,179	112,519	127,103
Old	139,663	154,575	124,966	135,702
1995-1999	70,295	78,928	68,643	71,354
2000-2004	136,379	145,499	123,683	132,342
2005-2009	192,965	217,564	181,446	193,048
2010-	210,522	229,150	181,872	202,956

From Tables 1(a) and 2(a) it can be seen that the number of transactions is approximately equal for the Canterbury (post codes CT1 and CT2) and the Medway (post code ME8) subsets of the data. The average price for the repeat transactions is less than the average price for the full data set as per Tables 1(b) and 2(b). Also, the average price for Canterbury transactions exceeds that for Medway transactions.

Because the data is for the period January 1, 1995 to December 31, 2011, the repeat transaction data is more voluminous during the middle portion of this time period and more closely matches the transaction volumes for all transactions from the 2000s onwards. This occurs because if an original sale took place before the period started the first sale would not be treated as a repeat sale. This effect can be seen in Figure 4.

Figure 4. Monthly transaction volumes for CT1, CT2 and ME8 area codes and the overall HPI for Kent, England



We considered adjusting for the “under representation” in the earlier years by excluding the first five years of observations. However, HPI increased very strongly between 2000 and 2008, when volumes were heavy. We decided not to make this adjustment because it would lead to loss of observations from a relevant period with different market patterns.

With respect to the period after 2008 when volumes decreased substantially, an argument could be made that during this period there may have been sales desired but insufficient buyers. This is a potential problem with pricing the NNEG associated with the HER loan for two reasons. House sales under HER loans are triggered by biometric events and not house-price appreciation and during a period of lower volume there may also be lower prices. However, from Figure 4 it can be seen that the repeat sales in our study capture a relatively consistent proportion of the index volume; hence, no adjustment was made for this consideration.

The strong overall increase in HPI shown in Figure 4 masks the extreme variability in monthly HPI experienced over the time period, which is shown in Figure 5(a). Given this variability the data period is useful for pricing the NNEG.

Figure 5(a). Monthly HPI returns

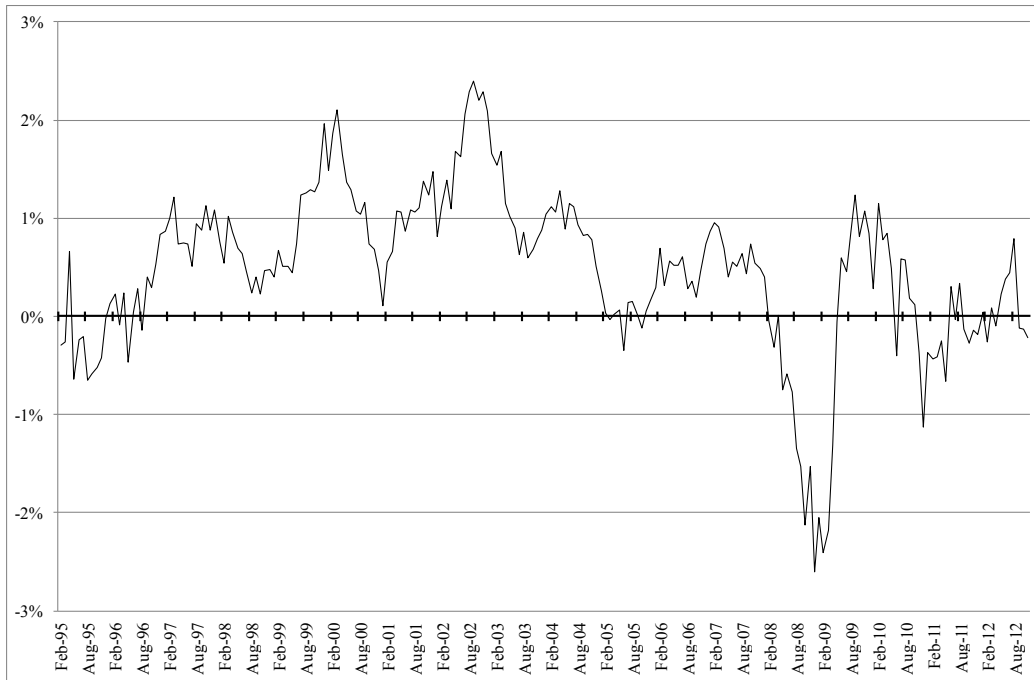
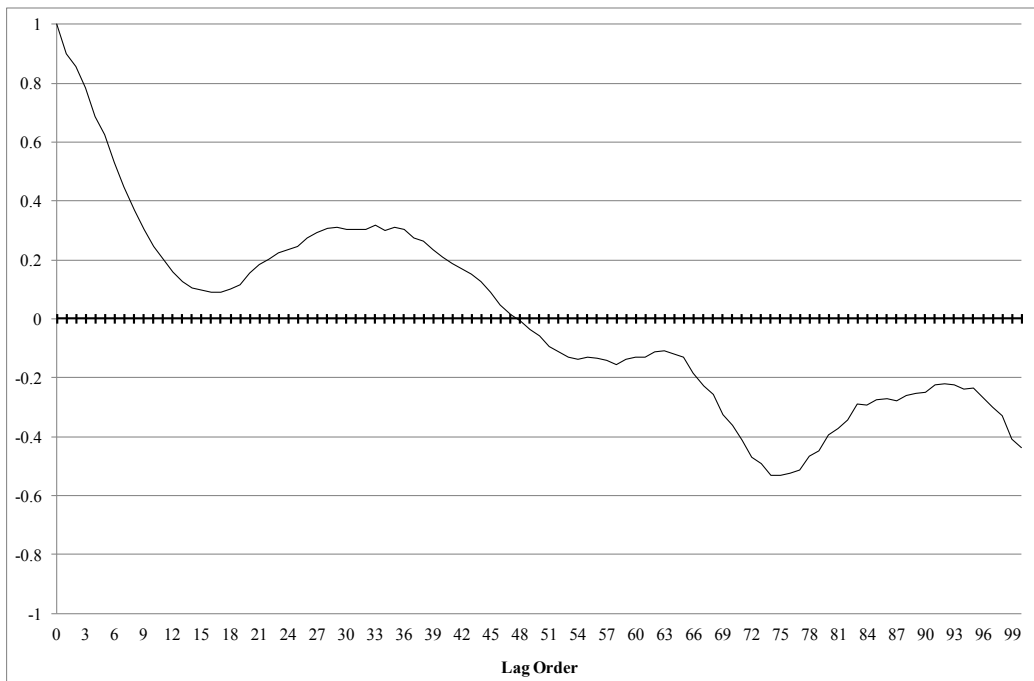


Figure 5(b). Autocorrelation in monthly HPI returns



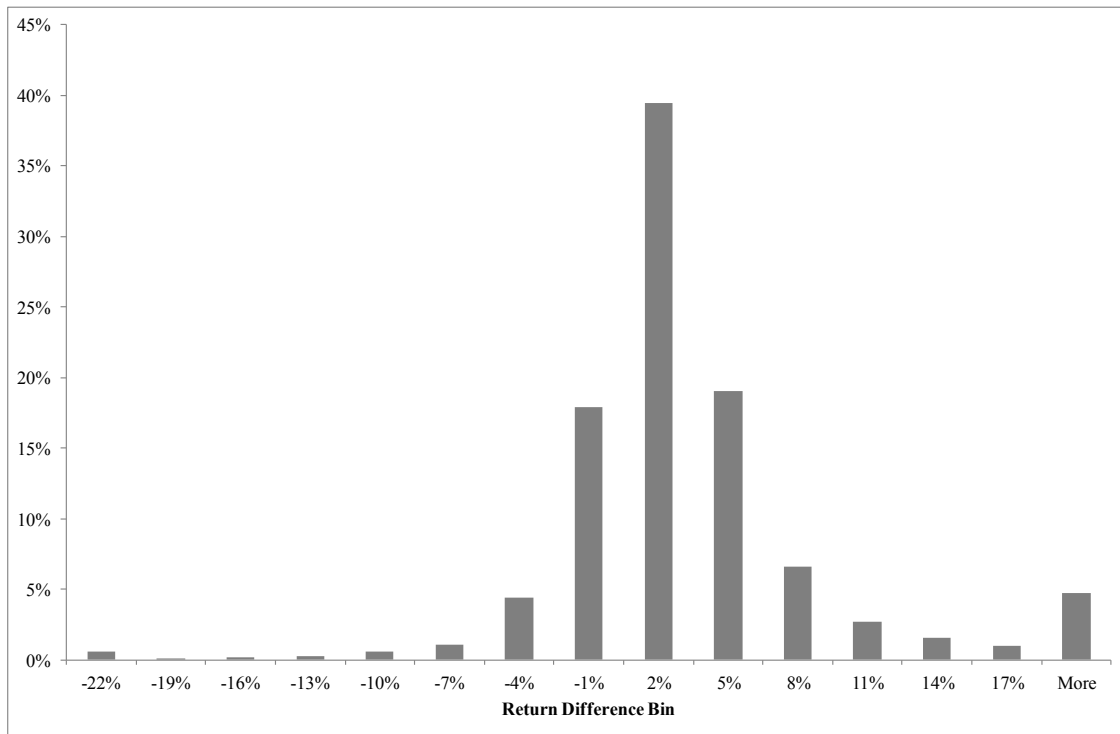
It is also noteworthy that monthly HPI shows significantly persistent autocorrelation as shown in Figure 5(b) (see Kuo 1994 for results from a different time period and region). This may prove challenging for individuals using models that are not based on historical data. The ARCH or GARCH models used by other authors (e.g., Li *et al.*, 2010) will have to account for autocorrelation for long periods, well in excess of 3 years. Our non-parametric

approach calculates the price of the NNEG based on the actual matched sample data over a long period of time. Furthermore, the autocorrelation shown in Figure 5(b) is more persistent than noted by Li *et al.* (2010). They used the Nationwide Price Index and found that a strong autocorrelation effect lasts for approximately 2 years. Hosty *et al.* (2008) also analysed the Nationwide Index and found that the autocorrelation and volatility vary by region. They do not cite figures separately for the county of Kent so we are not able to make further comparisons to their work.

We then compared the difference in annualized returns between the individual house price inflation to the HPI between transaction dates. The transaction data has exact dates, but the HPI is calculated at month ends. We used linear interpolation between consecutive HPI values to be able to match the period between transaction dates. We decided to remove the most extreme values of the differences in annualized returns between individual house price inflation and HPI from the subsequent analysis. For the highest 5 per cent of the annualized return differences (i.e., above the 95th percentile) we substituted the value for the 95th percentile and for lowest 0.5 per cent of the annualized return differences we substituted the value for the 0.5th percentile, i.e., we winsorized both tails, but were more conservative about substituting extreme negative observations than extreme positive ones.

The results of the winsorization process are evident in the size of the extreme left and right hand bins of Figure 6. From the shape of the histogram it can be seen that the return differences have a positive median. Although we cannot be certain of the reason for this effect, we suspect that it is due to our data being in respect of sales in relatively desirable urban centres in the county, whereas the HPI is calculated based on all sales within the county.

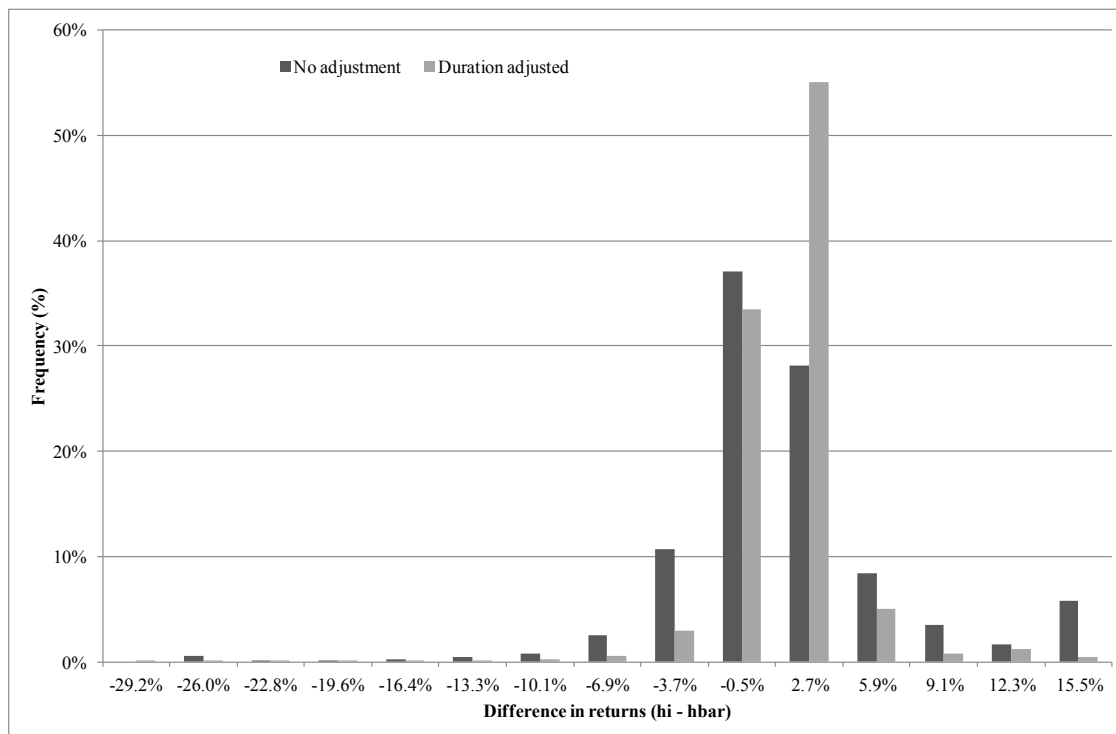
Figure 6. Histogram of winsorized return differences between individual homes and HPI



To remove the impact on pricing of having a positive mean, we recalculated the distribution of return differences by subtracting the mean difference from the data underlying Figure 6. This resulted in the distribution shown in Figure 7, which we used to price the NNEG. Note the long left tail.

Figure 7. De-meaned differences, both raw and maintaining duration

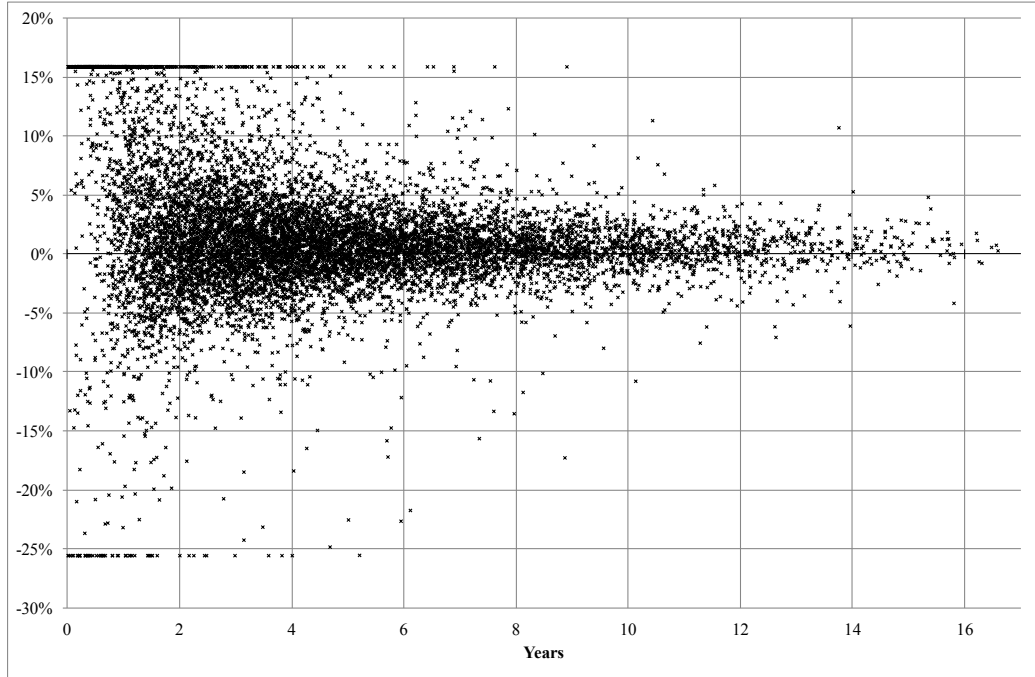
We present the histogram of demeaned differences between individual house price returns and HPI returns over the same period based on all available matched repeat sales transactions in the dataset. We also include a ‘duration adjusted’ histogram that shows the distribution that would arise if we observed the return changes at the time of exit of a contract. This duration effect reflects the increased mass in the centre of the distribution from a longer duration of LTC borrower tenure than average market tenure implied by our sample.



In our analysis of the data of annualized return differences we noted a duration effect as shown in Figure 8, which is based on the data underlying Figure 6. The bolder horizontal lines at the top and bottom of the Figure 8 result from the winsorization of the data. It is particularly interesting to note that as the time between transactions increases the variability of return differences reduces. However, it takes at least 10 years before it might be considered stable. In the United States, the Federal Housing Finance Administration (FHFA) publishes estimates of the dispersion of house prices around the index by modelling the house prices as a diffusion whose variance naturally grows over time, but at a decreasing rate. This is consistent with our findings that the annualized deviations fall over time, though the effect is more pronounced for our sample. Our approach, instead is nonparametric, so we do not estimate the dispersion as a smoothed function of time. Instead, we use randomly drawn returns with matched holding periods in our simulation, thereby avoiding the need to model this duration effect. Figure 9 presents a comparison of duration-based dispersion in our data with FHFA estimates of volatility for the state of Rhode Island. Rhode Island

has a small population and so may provide an appropriate comparison to the data for the communities in Kent County on which this paper is based.

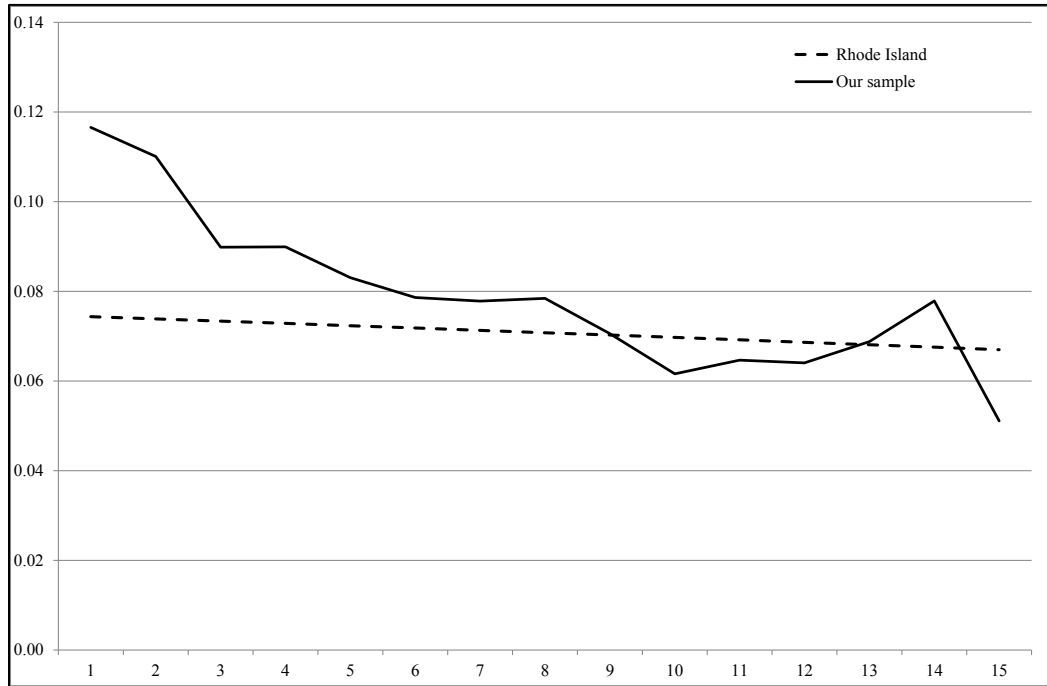
Figure 8. Annualized return differences by time between transactions



Since our data is in respect of HPI in a county in England, it would be desirable to have information for England regarding incidence rates of entry into care and duration in care once entered. We could not find any publicly available sources that provided this information for the local population. However, the Intercompany Study Report (Gagne *et al.*, 2011) published by the Society of Actuaries is an important source of data on LTC incidence for developed western countries. Figure 5a of that report shows the ratio of female to male incidence with respect to care requirement to be 149% for ages 65-69. Accordingly we assumed that 60 per cent of the applicants would be a couple with a healthy male and a female requiring care expenditures and that 40 per cent of the applicants would be a couple with a healthy female and a male requiring care expenditures. To evaluate the probabilities of a person requiring care at later ages, we used the incidence rates shown in Figure 4 of the same report (for Unlimited Benefit Period), modified by the rates by gender.

Figure 9. Annualized standard deviation of individual house prices around the index: Comparison with model estimates from Rhode Island, United States

We plot the Federal Housing Finance Administration’s estimates for volatility (annualized) over a fifteen year horizon based on a diffusion model alongside the estimates from our data for Canterbury and Medway. The standard deviation in our sample is higher and falls faster than the experience in Rhode Island implied by FHFA estimates.



3.3 Simulation Steps

To calculate the premium we used one million simulations. For each simulation a path for the original status was followed until an exit resulting in a house sale arose (based on Equation 2). At the point of exit and house sale a random drawing from the winsorized data of annualized return differences of individual house price inflation and HPI is made.

In a particular simulation path, if the exit happens in year t , we restrict the pool of return differences from which we draw to those that were based on t -period returns. However, practical limitations are that our data only covers a 17 year time period and the number of data points for longer durations is much smaller (because of the time period and the approach of using repeat transactions that occurred within this period). Hence, for durations of 15 years or longer we draw a return difference from the combined bin of 15 or more years.

The accumulated premiums and the losses on house sales where price appreciation was less than the accumulated loan were discounted to the date of loan in order to calculate the required NNEG. Three different interest rates

ranging from 1.5 per cent to 7.5 per cent were used to show the sensitivity of the NNEG to different rate environments.

We used an iterative process to derive the annual NNEG charge. We normalize the initial house value to 1. We set m on a grid of 100 basis point steps, ranging from 0 to 400 basis points. We further add an administration charge of 20 basis points. For each value of m , we vary c along a grid of points, and for each value of m and c , we first determine the initial loan based on Equation 1 above. We then determine the charge c that will result in the discounted value of future cash flows being equal to zero, i.e., the breakeven point. The above calculations then allow us to back out the maximum initial loan that is feasible under fair pricing in our data sample.

The foregoing was based on the assumption of the maximum loan being made at initiation. Both the lender and the borrower might prefer to have the loan payable in instalments. In this way the borrower would only borrow as required and would not pay interest on unrequired amounts. Also there would be less initial outlay of funds by the lender increasing its lending capacity. Given the greater variability in house price returns relative to HPI over shorter durations, this also reduces the basis risk of the NNEG. We thus consider the case when 10 equal instalments are made, following the same steps as above in all other respects.

4. Results

Table 3(a) presents the payoffs to the PPP for three different interest rates when the loan is disbursed as a lump sum at loan initiation. The lowest level of c for each m that results in a non-negative payoff is highlighted in bold. The farthest column to the right is the backed out maximum loan value as a percentage of initial property value.

First of all, the loan allowed in this setting is found to range from 89% at the higher end to 41% at the lower end. The breakeven outcomes occur for an annual NNEG charge of approximately 65 basis points when m equals 20 basis points to a range of 140 - 170 basis points when m equals 420 basis points. An increase in the size of m (a fixed component) makes the charge more sensitive to the interest rate.

Still on Table 3(a), we can see that the loan value is relatively insensitive to the interest rate level at loan initiation. Also, as expected, when m increases, c increases as well. This is consistent with m being fixed for the tenure of the loan and thus reflecting greater HPI risk and longevity risk.

In Table 3(b) we present the case when the loan is disbursed in 10 equal annual instalments. The break-even range for c shifts down to the region between 13 and 37 basis points per annum. When m is at 20 basis points, c is 13 basis points, and the possible loan ratio rises to 95%.

Table 3(a). Payoffs to the PPP used to determine breakeven NNEG c for each value of m and r when the loan is advanced as a *lump sum*

For three different interest rate environments, we calculate the payoff to the PPP for a range of values of m and c . The number in bold is the first level of c at which the payoff is positive. The corresponding breakeven proportion of house value that may be loaned is in the far right column. m is in *percentage points* while c is in *basis points*. The value for loan allowed has been calculated as per Equation 1, including a 20 basis point administration charge per year in addition to the m shown.

$r = 1.5\%$		<i>NNEG charge c</i>											Loan Allowed
m	20	35	50	65	80	95	110	125	140	155	170	185	
0	-0.15	-0.08	-0.03	0.03	0.09	0.14	0.19	0.24	0.29	0.34	0.39	0.44	89%
1	-0.21	-0.15	-0.09	-0.03	0.02	0.08	0.13	0.18	0.23	0.28	0.32	0.37	74%
2	-0.30	-0.24	-0.18	-0.12	-0.06	-0.01	0.04	0.09	0.14	0.19	0.24	0.29	62%
3	-0.41	-0.35	-0.29	-0.23	-0.17	-0.12	-0.06	-0.01	0.04	0.09	0.14	0.19	50%
4	-0.55	-0.49	-0.43	-0.36	-0.30	-0.25	-0.19	-0.14	-0.08	-0.03	0.02	0.07	41%

$r = 4.5\%$		<i>NNEG charge c</i>											Loan Allowed
m	20	35	50	65	80	95	110	125	140	155	170	185	
0	-0.08	-0.05	-0.01	0.02	0.05	0.08	0.11	0.14	0.17	0.20	0.22	0.25	89%
1	-0.11	-0.07	-0.04	-0.01	0.02	0.05	0.08	0.11	0.14	0.17	0.19	0.22	75%
2	-0.15	-0.11	-0.08	-0.05	-0.02	0.01	0.04	0.07	0.10	0.13	0.15	0.18	62%
3	-0.20	-0.17	-0.13	-0.10	-0.07	-0.04	-0.01	0.02	0.05	0.08	0.11	0.13	51%
4	-0.26	-0.23	-0.20	-0.16	-0.13	-0.10	-0.07	-0.04	-0.01	0.02	0.05	0.08	42%

$r = 7.5\%$		<i>NNEG charge c</i>											Loan Allowed
m	20	35	50	65	80	95	110	125	140	155	170	185	
0	-0.05	-0.03	-0.01	0.01	0.03	0.05	0.07	0.08	0.10	0.12	0.13	0.15	89%
1	-0.06	-0.04	-0.02	0.00	0.02	0.04	0.05	0.07	0.09	0.10	0.12	0.13	75%
2	-0.07	-0.05	-0.04	-0.02	0.00	0.02	0.03	0.05	0.07	0.08	0.10	0.11	63%
3	-0.10	-0.08	-0.06	-0.04	-0.02	-0.01	0.01	0.03	0.04	0.06	0.07	0.09	53%
4	-0.13	-0.11	-0.09	-0.07	-0.05	-0.04	-0.02	0.00	0.02	0.03	0.05	0.06	43%

Table 3(b). Payoffs to the PPP used to determine breakeven NNEG c for each value of m and r when the loan is advanced in 10 equal instalments

For three different interest rate environments, we calculate the payoff to the PPP for a range of values of m and c . The number in bold is the first level of c at which the payoff is positive. The corresponding breakeven proportion of house value that may be loaned is in the far right column. m is in percentage points while c is in basis points. The value for loan allowed has been calculated as per Equation 1, including a 20 basis point charge per year in addition to the m shown.

$r = 1.5\%$		NNEG charge c											Loan Allowed
m	10	13	16	19	22	25	28	31	34	37	40	43	
0	-0.01	0.00	0.01	0.02	0.02	0.03	0.04	0.05	0.06	0.06	0.07	0.08	95%
1	-0.01	-0.01	0.00	0.01	0.02	0.02	0.03	0.04	0.05	0.05	0.06	0.07	81%
2	-0.03	-0.02	-0.01	-0.01	0.00	0.01	0.02	0.02	0.03	0.04	0.05	0.06	69%
3	-0.05	-0.04	-0.04	-0.03	-0.02	-0.01	0.00	0.00	0.01	0.02	0.03	0.03	59%
4	-0.08	-0.07	-0.07	-0.06	-0.05	-0.04	-0.03	-0.03	-0.02	-0.01	0.00	0.01	49%

$r = 4.5\%$		NNEG charge c											Loan Allowed
m	10	13	16	19	22	25	28	31	34	37	40	43	
0	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	95%
1	-0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.04	81%
2	-0.01	-0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	69%
3	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	59%
4	-0.03	-0.03	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01	50%

$r = 7.5\%$		NNEG charge c											Loan Allowed
m	10	13	16	19	22	25	28	31	34	37	40	43	
0	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	95%
1	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	82%
2	-0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	70%
3	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	59%
4	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	50%

Note that the maximum loan allowed is about 50% when the annual fixed charge in excess of the NNEG charge is 420 basis points, leading to a total charge exceeding 450 basis points per annum. This result suggests why consumers may find the HER loan pricing unattractive. 420 basis points is a considerable annual charge in excess of the NNEG fee for such a financial product.

These results are significant for a number of reasons. First, the results are consistent with those reported by Li *et al.* (2010) who used a model and very different assumptions for interest and mortality. Second, the results show that the

maximum loan values available to borrowers could be made attractive through an efficient pricing and administration mechanism under which the loans were based on a floating rate. This is undoubtedly a factor in explaining the low take-up rates for HER loans. Third, even greater loan amounts could be made if the loan is disbursed in instalments.

5. Discussion and Further Possibilities

In this section we discuss some further issues with the design of the loan structure and its wider applicability. One of the concerns for which our data is inadequate is a question of whether the risk of under-maintenance of the homes discussed in Section 2 has been completely accounted for. Our baseline model assumes that the maintenance is carried out by the homeowner because of the incentive effects of tying the repayment rate to the index; although, elderly or partially disabled homeowners may find this difficult or expensive. In some cases, the PPP may choose to raise the administrative fees to account for maintenance expenditures carried out by the PPP itself. More complexity can be introduced into contracts based on standards and costs of maintenance in different regions. This could be priced by our model, but is not the focus of this paper.

There is also a question of wider applicability of the proposed structure. Our focus in this paper is on the provision of financing for LTC, as the issue will increasingly challenge policymakers. This focus allows us to suggest government involvement, a specific funding structure and policy response. Moreover, in the context of LTC considerations, it is more reasonable to model the behaviour of homeowners as seeking equity release in order to age in place and manage daily expenses, including care costs, and not for the purpose of seeking an additional way to invest in the future variability of house prices and of differences in their individual house's price and the index.

However, the potential for a similar lending and securitization structure open to a wider class of borrowers is worth evaluating carefully. A more generally available HER product based on our proposed structure may not be appealing to policymakers and would thus require a different level of market co-ordination and more complex rules and modelling considerations that are beyond the scope of this paper.

Also, products such as home reversion agreements currently allow investors to purchase equity in individual homes, and to that extent they are similar to our proposals. In home reversion agreements, individual homeowners effectively sell a certain amount of equity in their home at a deeply discounted price that reflects their life expectancy and house price forecasts. The high discounts again reflect the idiosyncratic risks from individual properties and the combined risks built into the NNEG that affect traditional fixed rate HER products. Any alternative structure that would match our proposal would be based on the principle of unbundling and reallocation of risks, thereby attracting funders wishing to be exposed to residential real estate as an asset class.

Finally, a further possibility exists for policymakers to lay off more risk. In the United States, the FHFA has recently made successful efforts to pass some credit risk to private parties (Goodman *et al.*, 2013). This shows that it may be further possible for the state to pass some risk from an NNEG to the private sector through the PPP's residual account.

A second securitisation of the residual account (in the PPP) is possible in order that private investors could share the risk of the NNEG. Income to the residual account occurs from:

- NNEG premiums incorporated into the loans,
- the fee charged for administrative, maintenance and servicing included in the loans; and
- settlement payments when the residual account is negative.

Payments from the residual account occur from:

- payments required by the NNEG when the loan value exceeds the house value on sale;
- expenses incurred by the PPP for administration, maintenance and servicing; and
- dividends to investors to share any profits in the residual account.

The payments on the NNEG arise because the loan value exceeds the house value on sale. The date at which this comparison takes place is on the sale of the house due to either institutionalization or on death. Hence, the risk associated with the NNEG includes both morbidity and mortality. Where the house price at sale exceeds the value of the loan, the homeowner would have the option to receive the excess on sale or to seek a mortgage for the loan amount and retain the home. If the expected sale price is close to the loan value, and if the property were deemed suitable for social housing, the homeowner might agree to transfer ownership to the PPP and reduce sale related costs, so that the home could be used for social housing.

Andrews (2012) discusses this type of product design and proposes that differences between the expected date of entry into care and the actual date of entry into care could be handled by a swap. If this were done then the securitization of the residual account would be a pure play on the efficiency of the loan process and deviations in actual house price improvement from the HPI. Some financial institutions might prefer such a 'purer' securitization; hence, the available market for participation in these financial transactions might be broadened by having both a swap and a securitization, which could lead to greater efficiency. In the absence of such a swap, any differences between expected and actual date of entry into care would be part of the residual account.

6. Conclusion

We have shown that disbursing the loan in instalments decreases the required NNEG premium and could be used as a way to increase the maximum loan value, potentially resulting in loan values of up to 95 per cent of appraised

value. It is important for authorities or private institutions to organise the collection of more data that would allow for greater precision in pricing, and reduce the range of uncertainty. However, the results are so strikingly different from the pricing that appears to be available in the market today that greater consideration regarding how the HER loan is structured is warranted.

Our findings have implications for HER products in general and especially for HER products related to LTC. Davidson (2009) suggests that HER may affect demand for LTC insurance and is a substitute for such insurance. Our proposed structure may also be generalized and widened to offer an alternative approach to the challenges recognized by Shiller and Weiss (1999) in terms of offering home equity insurance to homeowners.

Population aging is increasing the interest in LTC provision. Various reports (e.g., Sutherland, 1999) have recommended that England provide a better organised system of LTC provision, but their recommendations have not been implemented fully because they have been judged too costly, among reasons given. Following the most recent commission's report (Dilnot *et al.*, 2011), the government has proposed legislation that revises the available financial support regarding LTC. In view of this, the paper has a practical application. It proposes a specific HER loan in respect of LTC costs that might be provided by a PPP, where the loan administration would be highly efficient and the NNEG risk could be borne by private investors through a securitization. This would support the government's proposed legislation and help address increasing concerns about long-term care financing for the elderly.

The market associated with the provision of the NNEG exhibits unfulfilled potential. If the market structure demonstrated in this paper were adopted, we expect that a more competitive market in HER loans would be available.

Acknowledgements

We are very grateful to Jim Griffin and Pradip Tapadar for helpful discussions and comments. We are also grateful for a Faculty of Sciences Research Grant from the University of Kent for assistance with purchasing the housing data required for the study. We acknowledge the useful comments received from two anonymous referees that provided guidance on how to improve this paper.

References

- Andrews, D. (2009). *Requirements to Make the Housing Asset a Viable Retirement Asset*. SOA Monograph M-F109, Society of Actuaries, Schaumburg, USA.
- Andrews, D. (2012). Using housing wealth to fund long term care. Paper presented at the International Actuarial Association Colloquium on The Actuarial Profession and Social and Economic Development, Hong Kong, May.

- Bailey, M. J., Muth, R. F., & Nourse, H. O. (1963). A regression method for real estate price index construction. *Journal of the American Statistical Association*, **58**, 933-942.
- Burgess, G., Monk, S., & Williams, P. (2013). *Equity Release Amongst Older Homeowners*. Cambridge Centre for Housing and Planning Research, Cambridge.
- Calnea Analytics (2007). Land Registry House Price Index Methodology. www.calnea.com [accessed June 2013].
- Case, K. E., & Shiller, R. J. (1987). Prices of single-family homes since 1970: New indexes for four cities. *New England Economic Review*, September, 45-56.
- Case, K. E., & Shiller, R. J. (1989). The efficiency of the market for single-family homes. *American Economic Review*, **79**, 125-137.
- Castle Trust (2014). July 2014 Income House Product Termsheet. <http://castletrust.co.uk/downloads/income/2014/07/Termsheet/Income House - Termsheet July 2014.pdf> [accessed September 2014].
- Davidoff, T. (2004). Maintenance and the home equity of the elderly. Working Paper, Fisher Center for Real Estate and Urban Economics, University of California Berkeley.
- Davidoff, T. (2010). Home equity commitment and long term care insurance demand. *Journal of Public Economics*, **94**, pp. 44-49.
- Dilnot, A., Warner, N. & Williams, J. (2011). *Fairer Care Funding: The Report of the Commission on Funding of Care and Support*. United Kingdom.
- Dorling, D., & Cornford, J. (1995). Who has negative equity? How house price falls in Britain have hit different groups of home buyers, *Housing Studies*, **10**, pp. 151-178.
- Fabozzi, F.J., Shiller, R.J. & Tunaru, R.S. (2012). A pricing framework for real estate derivatives. *Journal of European Financial Management*, **18**, 762-789.
- Gagne, R., Corliss, G., Campbell, K., Ho, C., Koklefsky, B., Lucas, R., Oberman-Smith, S., Perry, E., Purushotham, M. & Shaughnessy, M. (2011). *Long-Term Care Experience Committee Intercompany Study Report 6 1984 – 2007*. Society of Actuaries, Schaumburg, USA.
- Goodman, L. S., Yang, L., and Landy, B. (2013). The first GSE risk-sharing deal: An effective risk transfer mechanism?, *The Journal of Structured Finance*, **19**, 33-42.
- Hancock, R. (2000). Estimating the housing wealth of older home owners in Britain. *Housing Studies*, **15**, 561-579.
- Hosty, G.M., Groves, S.J., Murray, C.A. & Shah, M. (2008). Pricing and risk capital on the equity release market. *British Actuarial Journal*, **14**, 41 – 91.
- Jagger, C. (2012). *Longevity Bulletin 04*. Institute and Faculty of Actuaries, London.
- Ji, M., Hardy, M. & Li, J.S-H. (2011). Markovian approaches to joint-life mortality, *North American Actuarial Journal*, **15**, 357 – 376.
- Ji, M., Hardy, M. & Li, J.S-H. (2012). A Semi-Markov multiple state model for reverse mortgage terminations, *Annals of Actuarial Science*, **6**, 235 – 257.

- Kuo, C-L. (1994). Serial correlation and seasonality in the real estate market, *Journal of Real Estate Finance and Economics*, **12**, 139-162.
- Land Registry: Search the index. Online Resource.
<http://www.landregistry.gov.uk/public/house-prices-and-sales/search-the-index> [accessed January 2013].
- Li, J.S-H., Hardy, M.R. & Tan, K.S. (2010). On pricing and hedging the no-negative-equity-guarantee in equity release mechanisms. *Journal of Risk and Insurance*, **77**, 499-522.
- Northern Ireland Housing Executive (2010). *Research into the Future Housing and Support Needs of Older People: Assessment of the Potential of Equity Release for Older Owner – Occupiers*. Northern Ireland Housing Executive.
- Ong, R. (2009). House price appreciation in old age: Analysis and issues for the use of reverse mortgages as a retirement funding strategy in Australia. *Population Ageing*, **2**, 139 – 160.
- Overton, L. (2010). *Housing and Finance in Later Life: A Study of UK Equity Release Customers*. Age UK.
- Shiller, R.J. & Weiss, A.N. (1999). Home equity insurance. *Journal of Real Estate Finance and Economics*, **19**, 21-47.
- Shiller, R.J. & Weiss, A.N. (2000). Moral hazard in home equity conversion. *Real Estate Economics*, **28**, 1-31.
- Sutherland, S. (1999). *With Respect to Old Age: Long Term Care – Rights and Responsibilities: A Report by The Royal Commission on Long Term Care*. Stationary Office, UK.