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ABSTRACT

Home equity conversion as presently constituted or proposed usually does not deal well with the potential problem of moral hazard. Once home-owners know that the risk of poor market performance of their homes is borne by investors, they have an incentive to neglect to take steps to maintain the homes' values. They may thus create serious future losses for the investors. A calibrated model for assessing this moral hazard risk is presented that is suitable for a number of home equity conversion forms: 1) reverse mortgages, 2) home equity insurance, 3) shared appreciation mortgages, 4) housing partnerships, 5) shared equity mortgages and 6) sale of remainder interest. Modifications of these forms involving real estate price indices are proposed that might deal better with the problem of moral hazard.

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MORAL HAZARD IN HOME EQUITY CONVERSION

Many of the forms of home equity conversion, both those forms that have already been implemented in some places and those that are just in the proposal stage, may result in some serious future losses for the investors. Participating homeowners may fail to take steps to maintain the value of their homes once they know that others are bearing some of the risk of poor home resale value. The risk of such future problems with home equity conversion might be reduced if the contracts are redesigned so that the settlements in the contracts are determined by real estate price indices, rather than in terms of the sale price of the home itself.

We will refer to the failure on the part of the homeowner to take steps to maintain the value of the property when it is sold as "moral hazard," in keeping with conventional use of that term, although in fact the word "moral" may be misplaced. Homeowners are presumed to be acting in their own self interest generally within the limits set by the law, though probably not quite the way that investors in home equity conversion forms would like.

We use the term home equity conversion to refer to the objective of a number of plans that enable homeowners to convert their illiquid and risky investments in their own homes to other uses, and/or reduce their exposure to real estate risk. We will consider a number of home equity conversion institutions that can achieve risk reduction for homeowners, some of which have actually been implemented (though not on a large scale): 1) reverse mortgages, 2) home equity insurance, 3) shared appreciation mortgages, 4) housing market partnerships, 5) sale of remainder interest, and 6) shared equity mortgages.

Reverse mortgages are contracts providing regular payments and/or a lump sum to the homeowner, the debt to be repaid only when the home is sold, the owner no longer lives in the home, or the owner dies. They are the "reverse" of conventional mortgages in the sense that, for many of them, the homeowner receives a monthly payment from the mortgage lender rather than makes a monthly payment to the bank, but their essential feature for us is that they involve some partial home price risk sharing for the homeowner. These reverse mortgages involve partial risk sharing for the homeowner because if the loan balance turns out to be greater than the value of the home when it is sold, the homeowner need not pay the difference. Reverse mortgages are loans against home equity only; they are subject to a non-recourse limit. They differ fundamentally from conventional mortgages or home equity loans for which loan applicants are required to show proof of income, and where the home is technically collateral. With reverse mortgages, no proof of income or wealth beyond the home is required, because the mortgagee has no claim on these.

The Federal Housing Administration sponsors a reverse mortgage program called the Home Equity Conversion Mortgage Insurance Demonstration Program, begun in 1989. Since this is a demonstration program only, there is a national limit of only 50,000 of these Home Equity Conversion Mortgages (HECMs). With the demonstration program, the risk that the mortgagee will have to absorb negative equity is ultimately borne by the government. There are also some private reverse mortgages, not insured by the government, such as the Home Keeper for Home Purchase program recently begun by Fannie Mae, and with these the homeowner's price risk is shared with other investors. With conventional mortgages, in contrast to reverse mortgages, there is usually not the same risk sharing for the homeowner, since the homeowner is usually still required to repay the mortgage even if the home value falls below the mortgage balance.

Home equity insurance is a policy that insures the price of a home on resale. We have proposed various forms of home equity insurance, see Shiller and Weiss (1994). The insurance might be a stand-alone insurance policy that a homeowner may buy at any time, or, more plausibly, it would be an add-on to the homeowners insurance policy or mortgage policy. In some forms, home equity insurance may be essentially a sort of option, a put, on the home. In its simplest form, the policy could be settled on the actual sales price of the home, or, alternatively, as we proposed it, it could be settled on an index of home prices. Today there is not, and never has been as far as we know, any home equity insurance program, but some insurance companies have expressed some interest in our proposals, and we believe that home equity insurance may be a real possibility in the not too distant future.

Shared appreciation mortgages (SAMs) are mortgages in which the lender shares some of the home appreciation with the borrower, but does not share in any possible home depreciation. The new Bank of Scotland SAMs are an example. In these, the homeowner receives an interest-free or low-rate loan with no repayment date, in exchange for turning over a fraction of the appreciation of the home from the time of application at the time of sale or death. (The homeowner does not receive money from the lender if the appreciation is negative.) In the Bank of Scotland interest-free version, one pays no interest at all, but turns over as much as 75% of the appreciation of the home.

Housing market partnerships are partnership contracts involving the homeowner and another investor in which the investor is the limited partner, the homeowner the managing partner. Caplin, Chan, Freeman and Tracy (1997) have been advocating these for the United States. Since the investor is the limited partner, the investor has no personal liability from ownership of the property, and so limited partnerships can be readily sold, even securitized.

Shared Equity Mortgages (SEMs) are similar in effect to the housing partnerships. SEMs are occasionally arranged among family members and sometimes with outside investors. With SEMs, there are three parties to the mortgage contract, the homeowner, an investor, and a mortgage lender. In effect, both the homeowner and the investor buy shares in the home. In some cases the investor and mortgage lender may be the same.

Sale of remainder interest is a pure sale of the home (or portion thereof) to investors who will acquire the (share of the) home after the owner dies or moves out of the home, until which time the owner has a contract allowing him or her to occupy the home. With the Lifetime Security Plan in California, see Goren et al. (1996), sale of remainder is marketed to elderly homeowners who are in need of income. In this sale of remainder interest contract, the homeowner agrees to turn over basic maintenance of the home to the plan sponsors, thus reducing the moral hazard problem.

Reverse mortgages and sale of remainder interest are contracts with special interest to elderly people, who have equity in their home but perhaps little spendable income. In contrast, the other forms of home equity insurance are likely to be of interest to young to middle age homeowners, who wish to hedge some of the risk attendant on buying a home.

For all of the above contracts, the homeowners may not always perceive the advantages of the contracts in terms of risk reduction. Those who choose reverse mortgages may, for example, perceive these as merely a way to get liquidity from their homes. Those who choose shared appreciation mortgages may say that they do this just to get a lower mortgage rate. But these consequences in fact are related to the risk reduction that the contract entails, since the risk reduction is related to the costs and benefits of the contract to both the borrower and the lender, and thus also affects the terms the borrower and lender will agree upon. For example, the very fact that reverse mortgages offer a fixed income for life to elderly homeowners is proof that some risk management is an essential part of the contract.

We believe that many of these contracts that base settlements exclusively on the selling price of the homes are likely to reveal in many cases, at a later date, serious costs for the lender, costs that might have been avoided if the contracts had been written differently. With reverse mortgages, the contract could be restructured so that the homeowner maintains an interest in the home at all times, by rewarding/penalizing for departures of home price from the index value. With home equity insurance, the policy can be settled in terms of an index. With shared appreciation mortgages, the contract should be settled, at least in part, on a real estate price index for the region and housing type, rather than just on the selling price of the home. For housing market partnerships, the partnership contract should have special provisions so that the occupant of the home, the limited partner, benefits if the selling price of the home on sale is high relative to the selling price predicted by an index.

These contract provisions are critical because they encourage the homeowner to take steps to increase the value of the property, while not affecting the aggregate risk management properties of the contract. Without such provisions, we feel that, over long periods of time, there could be serious decrements to property value caused by the bad incentives. Many observers seem to think that the moral hazard problem is essentially "solved" if homeowners retain a fractional interest in the home. Our analysis suggests otherwise.

We consider here first some examples of the ways homeowners influence the sales value of their home, and of the likely incentive effects of home equity conversion. We then turn to a formal model of the effects of home equity conversion on incentives for all these different forms of conversion. Finally, we summarize the importance of alternative institutions that use index numbers in such a way that incentives are better maintained for homeowners.

Maintenance of Home

The basic theme we are developing here concerns the nature of incentive effects caused when homeowners share the changes in value of their home with other investors. Consider a case where a homeowner shares half of a house's value with an investor. Suppose the homeowner has the house on the market, but the house needs exterior paint which would cost $3000. Suppose the value for the house is $200,000 if the homeowner had kept up with painting the exterior. If the homeowner has not, the house will bring only $195,000 on the market. Therefore, the homeowner would rather not pay the $3000, since it yields to the homeowner only $2500. In contrast, if the contract were settled on the index rather than on the home price itself, then the homeowner would have a $2000 incentive to do the painting. To the investor, settling the contract on an index instead of the selling price of the house here entails half of a $5000 difference in return.

Now, many risk-sharing contracts with homeowners specify that the maintenance should be kept up for the contract, and the homeowners are subject to penalties if it is not. In practice, it may be very difficult to enforce such contract provisions. Consider further the house painting issue. The cost of hiring painters to paint a house varies considerably, often by a factor of two or more from lowest to highest price. One can hire high school students to paint the house, and not supervise them. This may result in a disaster-in-waiting, such a peeling paint if it is applied improperly. Or, it may result in spattered paint on roofing, floors, windows, and elsewhere, that may detract from the resale value of the house. Many houses have high resale value because they have been maintained exceptionally well, and this value may be easily lost even if the homeowner is technically in compliance with maintenance provisions of the contract.

The contract might have provisions that an appraiser inspects the maintenance, and the homeowner is penalized if maintenance is inadequate. Such provisions might go part way, but not fully, to solving the problem. For clear-cut tasks like fixing the roof when it has a hole in it, the appraiser can evaluate easily whether the homeowner is complying properly. But, there is a vast gray area in most maintenance. Is it time to replace the entire roof, and not just fix the hole? Is it time to replace the kitchen stove? Is it time to remove slightly fading wallpaper? Should the homeowner have the old in-ground swimming pool removed and relandscape the yard? Even if most people will agree that these changes would be value-increasing, it will be largely impossible prove this well enough to exact penalties from homeowners for failing to do these things. Of course, one might ask the appraiser not to pass on the individual improvements, but to just give an estimate of the value of the home. But these appraisals of the real value of a home are subject to substantial errors, 10%, 20% or even more are common, so that the effects of maintenance will be easily lost in the noise. Also, there will be agency problems in getting appraisers to give unbiased appraisals when they know that their appraisal feeds directly into a penalty for the homeowner. Moreover, imposing penalties against homeowners for ambiguously defined noncompliance is an expensive proposition: dealing with litigation and other homeowner resistance are likely expenses. They would have to expect to impose penalties on a high proportion of homeowners if the penalties are to be effective.

Improvements in the Home

Let us consider another example of likely homeowner behavior when the owners of the home have a risksharing contract such that they have in effect ownership of only half the value of the home. Suppose again that the home is currently worth $200,000. The homeowners would like to upgrade the kitchen for $10,000. The investment would increase the value of the home by $6000. If the homeowners did not have the risk-sharing contract, they would lose $4000 but gain the benefit of a better kitchen until the home is sold. Without the risk-sharing contract this might seem like a good tradeoff. However, with a risksharing contract, the homeowners regain not $6000 but only $3000 on resale (their share of the $6000) and so the effective cost of the renovation would be $7,000, not $4,000, and so the homeowners might well decide not to make the improvement.

Of course, risk-sharing contract provisions could be written in order to take account of such improvements. But, again, there is a problem, a difficulty defining the value of the improvements. What if the homeowners want to renovate the kitchen themselves, as an amateur job? How much should the homeowners be compensated for this? Moreover, with renovation jobs, whether amateur or professional, there is a substantial possibility that the renovation will detract from the value of the home, rather than add to it. What if the renovations are done in unconventional taste? What if the renovations are done for idiosyncratic needs (a home doctor's office with waiting room, or an elevator for a disabled person)? Homeowners largely know that such renovations may not increase home value, and therefore have an incentive to stay with conventional improvements and with professional renovators to keep resale value up. But, if they bear little risk in the contract, then homeowners will have less incentive to do so.

Selling of Home

Consider a home that is currently actually worth $200,000 and the value as measured by the index is also $200,000. The homeowners have already relocated to another city due to a job change and must cover all carrying costs themselves. Suppose the carrying costs of the home are $2000 a month. Suppose the homeowners are offered $190,000 for the home. They would figure that with a 50% equity interest in the home, this lowball bid would cost only $5000. They would compare this loss against the possibility of having to wait two and a half months to get a bid of $200,000. They might take the lowball $190,000 bid and thereby cost the investor $5000. If the contract had been settled on the indexed value of $200,000, the investor would not be subject to this loss.

There are other agency problems in selling home as well that might cause the outcome to be bad with some of these risk-sharing contracts. There is an incentive with the risk-sharing contracts for the homeowners to sell the property themselves. Moreover, there is an incentive for the homeowners to negotiate a lower fee with the real estate broker, on the understanding that the homeowners will accept an earlier offer than they otherwise would.

There are many studies that bear on the question whether impatience to sell does in fact have a substantial impact on selling price. Many studies have studied the effect of time on the market on selling price, see for example, Asabere and Huffman (1993) and Haurin (1988), and Zuehlke (1987). But these studies are not very meaningful since a longer time on the market could equally well signal that the homeowners were patient to sell (implying a higher price) or that the home was worth less than expected (implying a lower price). Springer (1996) ran hedonic regressions of log housing price on a number of characteristics variables with also variables reflecting the seller's eagerness to sell or the seller's reporting being relocated. Eagerness and relocation were found each to have about a 2% reduction in selling value. In fact his measures of these variables were likely to be poor, and so the effects of urgency to sell are probably larger than this. Genesove and Mayer (1997) found that Boston condominiums with 100% loan to value ratio sold at prices 4% higher, after controlling for characteristics, than condominiums with 80% loan to value ratio, and stayed on the market 15% longer. Since homeowners with higher loan to value ratio have more incentive to get a good price, this appears to be evidence of the effect of incentives on selling behavior. Glower, Haurin and Hendershott (1997) find that people who say that their job has changed, thereby suggesting an urgency to sell, tend to sell for 11% less than do others.

New kinds of real estate brokerage arrangements are currently being developed: in addition to the traditional broker as representative of the home sellers, there are also buyers' brokers and dual brokers. Law governing real estate brokers is being changed. We can never be sure that new seller-broker contract forms will be developed that may enable sellers to accept lower offers on their homes. For example, a new arrangement in which the buyers pay the broker's fee, rather than the sellers, could cause the selling price to go down by the amount of the broker's fee. Sellers involved in risk-sharing contracts may have an incentive to make such new arrangements. Arrangements can be made that make payments to brokers difficult to untangle.

Under-the-Table Transactions

With existing home equity conversion contract forms, the homeowners have a powerful incentive to hide some of the value of the home. There are very many ways that this can be done. The simplest thing to do is just to sell the home to friends or relatives at a below-market price. There could be an secret buydown from the buyers or a party connected with the buyers. Another way is to remove some advantage that the home has before selling it, such as replacing unique antique chandeliers with common reproductions.

Contract provisions requiring an appraisal of the property can prevent some of the most egregious examples of this. Still, there are potential problems, since appraisal is not an entirely objective science.

Homeowners can sell separately items that they might otherwise have included for sale, and they can refuse concessions such as homeowner warranties, redecorating allowances, or points or buydowns, or seller-offered financing, which would otherwise have boosted the price. There are very many different things that the seller can do to affect the selling price of the home, and all of these things would have to be addressed in a contract, lest they become serious costs for the investors who bear real estate risk.[1]

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[1]Another issue for lenders, which does not fit into our model of homeowner investments in value, deserves mention. This is the problem of selection bias for those who choose to take part in home equity conversion schemes. Some people know that their homes are headed for a decline in value. This may happen because cracks are developing in the foundation, termite damage has been discovered, or a drug dealer has moved in next door. These people have a special incentive to try to shift their home equity risk to others before the loss is discovered.

Dealing with all of these problems creates costs for providers of home equity conversion.

Do These Moral Hazard Costs Really Matter?

Some providers of experimental forms of home equity conversion express blithe optimism that basing the contracts partly on an appraisal and making sure the homeowners have a fractional interest in the resale value of the home are adequate measures to deal with moral hazard problems.

In evaluating these claims, it should be borne in mind that the experience to date with experimental home equity conversion programs may not be a reliable guide to future losses. Firstly, with many of these forms losses take many years to develop, since home values change slowly. Secondly, the home equity conversion market is still in its infancy, and is not highly competitive. Profit margins have not been bid down to low levels, as can be expected to happen eventually. In a competitive market for home equity conversion contracts, small differences in revenues can spell the difference between success and failure for lenders or investors. Thirdly, the experience with the experimental forms of these contracts to date may not reflect the experience in the future when conditions change, when the pool of participating homeowners changes, when the national inflation rate changes, when homeowners learn more about how to play games against the investors. Thus, it is important to model the moral hazard in the abstract, to help us gauge its potential future significance.

Graphical Representations of the Various Home Equity Conversion Forms

For the purpose of understanding the incentives for moral hazard created by the various home equity conversion forms, we will summarize the incentives created for the homeowners by each of the various forms of home equity conversion described above in terms of their implied functional form relating the homeowners' expected terminal portfolio value to the value of the home when it is finally sold. The date at which the home is sold depends of course on random factors: marriage, divorce, job changes, death, etc. For illustrative purposes, we disregard the uncertainty about date of sale, and assume that it is known, let us say, eight years in the future. Let us call $g(V)$ the homeowners' portfolio value as a function of the sales value V of the home on this date. In each example the portfolio is assumed to consist of the homeowners' equity in the home (home value minus debt) plus any transfers created by the home equity conversion program. We assume that the homeowners are concerned about heirs, and so it is immaterial whether the sale is caused by death of an owner or for other reasons.

Figures 1 through 4 show hypothetical forms for the $g(V)$ function for each of four situations: 1) conventional mortgage, 2) reverse mortgage and conventional mortgage with home equity insurance, 3) shared appreciation mortgage, and 4) limited partnership, shared equity mortgage, or sale of remainder interest. In all four figures the horizontal axis shows the value of the home when it is finally sold divided by the value when the home is purchased, and so the point 1.00 on the horizontal axis represents a situation in which the final value of the home equals the initial value of the home. In all four diagrams the homeowners have just purchased a home by borrowing an amount so that the loan to value ratio, that is the loan balance on the date when the house will be sold divided by the value of the house today, is $L > 0$. The initial loan to value ratio would be higher than L if the homeowners are not making regular interest payments on the loan, as for example, with reverse mortgages, since the loan balance would grow as interest accumulates. The initial loan to value ratio might be essentially the same as

L if mortgage payments are being made about equal to interest, as might be the case with conventional or shared equity mortgages for the first eight years of a longer-term mortgage. On all four figures, we take $L = 0.8$.

Figure 1, showing the case of a conventional mortgage, is very simple since we assume no bankruptcy. The $g(V)$ function is just a straight line with a slope of one, and passes through the horizontal axis at point L. If the final value of the home when it is sold equals L, then the homeowners get nothing at time of sale; the sales price is just enough to pay off the mortgage. If the value of the home should become less than the loan balance, then the homeowners have negative equity. In fact, some homeowners will declare bankruptcy under this circumstance, and so one might show the line as having a slope of less than one where V is less than L. Moreover, in non-recourse states such as California homeowners can walk away from negative equity without bankruptcy. We disregard this complication here to provide a simpler contrast between the different risk management forms.

Figure 2 shows the case of a reverse mortgage in which the homeowners are loaned an amount which will be, when it is sold, 80% of the value of the home today. A reasonable story to tell about this case is that the homeowners are elderly, already own the home, and are using the proceeds of the loan to buy a lifetime annuity which will be consumed. The elderly homeowners will stay in the home until death, and the proceeds of the final sale, if any, will go to heirs. If the home is worth at the time of final sale less than 80% of the initial value of the home, then the heirs get nothing, hence the horizontal slope of the $g(V)$ to the left of L. Otherwise, they receive the value of the home minus the loan balance, and so the $g(V)$ curve attains a slope of 1 to the right of L.

Note that Figure 2 is identical to the familiar plot, from elementary finance textbooks, of the payout of a call option on the exercise date as a function of the price of the underlying. Indeed, a home with a reverse mortgage does work out to be essentially such a call option.

The same diagram Figure 2 applies to the situation of homeowners who have taken out home equity insurance on their home, to create a floor of value on the home. Doing this is the same as buying a put option on the home with a strike price equal to 80% of home value at the initial date, and borrowing 80% of the value of the home. That a portfolio of a home, a put option and a debt is the same as a call option on the home is due to the put-call parity relation in finance.

Figure 3 shows the case of a shared appreciation mortgage in which 75% of the mortgage value above the initial home value is paid to the mortgage lender, but all of the losses for the homeowner if the value of the home on resale is less than the initial value. This $g(V)$ curve is a broken straight line with a slope of one to the left of $V_0 = 1$, and a slope of .25 to the right of V_0.

Figure 4 shows the case of a limited partnership in which the 'homeowners' (the residents of the home) actually own only 25% of the home and the other partner 75%. Now, the $g(V)$ curve is just a straight line with slope of 0.25. This figure also shows the case of a shared equity mortgage and a sale of remainder interest where the homeowners retain only a 25% interest in the home.

In viewing the variety of patterns of risk management shown in Figures 1 through 4, one wonders what accounts for the simultaneous existence in the market of all these different forms. Is there some good reason why some homeowners would want one of these forms and other homeowners want another? This question is analogous to the question, in finance, why different people want different portfolios of options and other derivatives. The answer is probably sufficiently complex that there is no simple answer. The answer has probably to do with differing opinions about future price movements, differing information sets, differing asset positions and income flows, differing worries and concerns, differing ways of framing the issues. Our concern here, however, is not with reasons for these different contracts, but with the moral hazard associated with them. Fortunately, as we shall see now, the moral hazards created by all these different home equity conversion contracts have a certain family resemblance.

A Model of Moral Hazard for These Home Equity Conversion Forms

Let us now suppose that there is a production function $f(I)$ that converts investment expenditure I into home value.[2] We interpret the term I very broadly as representing all costly activities that increase home value, not only the maintenance and improvements but also the efforts to get a good price at resale and the moral effort to refrain from under-the-table transactions. The homeowners attach weight a, $0 \leq a \leq 1$ to the resale value, and $(1 - a)$ to the value in use to the homeowners before sale.[3] The expected profit for the homeowners in the absence of any risk sharing is given by:

$$\Pi = a(E\tilde{V} - D + f(I)) + (1 - a)f(I) - I \qquad (1)$$

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[2]We assume that the function $f(I)$ is the same for all risk sharing arrangements. In fact, this may not be so. Certain of these arrangements will tend to attract elderly homeowners, for whom the human costs of investing in upkeep may be higher; see Reshcovsky and Newman (1991).

[3]If real interest rates are 3% per year, then for a consol, 79% of the value today consists of the present value of the consol in 8 years, and 21% of the value is the present value of intervening dividends. This might suggest that a is in the vicinity of 0.8. We suspect, however, given human psychology and attitudes toward risk, a somewhat lower value of a might be appropriate.

where $\tilde{V}$ is the random (unknown when the investment I is made) value of the home if there is no depreciation in it, random due to changing market conditions, D is the depreciation on the home that would occur if there were no investment made at all in value-preserving or value-increasing activities, and E is the expectations operator. We will assume the usual properties for the production function, that $f'(0) = \infty$, and that $f'(I) > 0$ and $f''(I) < 0$ for $I > 0$. Profit maximizing homeowners will set the derivative of the profit function to zero, and so:

$$f'(I) = 1. \tag{2}$$

Suppose now that the homeowners enter into a risk-sharing contract so that the homeowners receive on sale instead $g(\tilde{V} - D + f(I))$ of the resale value of the home, where g is one of the functions shown in Figures 1 through 4. Then the profit function to the homeowners is:

$$\begin{aligned} \Pi &= aEg(\tilde{V} - D + f(I)) + (1 - a)f(I) - I \\ &= ah(I) + (1 - a)f(I) - I \end{aligned} \tag{3}$$

where $h(I)$, the expected homeowner portfolio value on resale as a function of I, equals $Eg(\tilde{V} - D + f(I))$ and E is the expectations operator. The function $h(I)$ will be central to our analysis below. The differences between the home equity conversion forms, both for homeowner investment incentives and for expected losses to investors, can be summarized in terms of differences in the $h(I)$ functions. The first order condition for maximal profit is then:

$$ah'(I) + (1 - a)f'(I) - 1. \tag{4}$$

We now derive expressions for $h(I)$ to allow us to use equation (4) to gain some perspectives on the effects of the home equity conversion on the investments that homeowners make in their homes. To do this, we make use of the functional forms for g that are shown in Figures 1 through 4. We need also to make some assumptions about the distribution of $\tilde{V}$ and about the production function $f(I)$.

Since our model uses a lognormality assumption for $\tilde{V}$, it is straightforward to derive expressions for $h(I)$. The function $g(\cdot)$ shown in the figures has the simple form of a straight line or a broken straight line, with a break at $V = L = 0.8$ (the loan to initial value ratio) for the reverse mortgage (home equity insurance) example (Figure 2) and with a break at $V = V_0 = 1$ (the price from which appreciation is measured as a fraction of initial value) for the shared appreciation mortgage example (Figure 3). We derive that the expression for a conventional mortgage, corresponding to Figure 1, is:

$$h(I) = e^{\mu+\sigma^2/2} + f(I) - D - L. \tag{5}$$

The expression for a reverse mortgage or home insured by home equity insurance, corresponding to Figure 2, is, if $f(I) - D$ is less than L:

$$\begin{aligned} h(I) = {} & N\left(\frac{\mu + \sigma^2 - \ln(L - f(I) + D)}{\sigma}\right) e^{\mu+\sigma^2/2} \\ & + N\left(\frac{\mu - \ln(L - f(I) + D)}{\sigma}\right) (f(I) - D - L) \end{aligned} \tag{6}$$

where $N(\cdot)$ is the cumulative normal distribution function. If $f(I) - D$ is greater than or equal to L, then expression (5) applies.[4]

[4]The same expressions might seem to apply to conventional mortgages in nonrecourse states. However, in this case we should also consider the cost of default there. Even in nonrecourse states, homeowners must consider the costs of default, especially since they must consider the difficulty of getting a mortgage on their next

The expression for a shared appreciation mortgage where the homeowner receives a fraction α of appreciation, corresponding to Figure 3, is, if $f(I) - D$ is less than V_0:

$$h(I) = e^{\mu+\sigma^2/2} + f(I) - D - L - (1-\alpha)\left(N\left(\frac{\mu + \sigma^2 - \ln(V_0 - f(I) + D)}{\sigma}\right) + N\left(\frac{\mu - \ln(V_0 - f(I) + D)}{\sigma}\right)(f(I) - D - V_0)\right) \tag{7}$$

and if $f(I) - D$ is greater than or equal to V_0, then

$$h(I) = V_0 - L + \alpha(e^{\mu+\sigma^2/2} + f(I) - V_0). \tag{8}$$

Finally, for the limited partnerships, shared equity mortgage and sale of remainder interest, corresponding to Figure 4, $h(I)$ is given by:

$$h(I) = \alpha(e^{\mu+\sigma^2/2} + f(I) - D - L). \tag{9}$$

Finally, to compute the effects of the moral hazard on the investor, note that the sum of $h(I)$ and the expected receipts $\Pi_f(I)$ to the investor from loan balance and or sale of (share of) home is always equal to the expected value of the home $\exp(\mu + \sigma^2/2) + f(I) - D$, and so $\Pi_f(I) = \exp(\mu + \sigma^2/2) + f(I) - D - h(I)$. Thus, the expected shortfall s to the investor due to moral hazard as a function of the amount I that the homeowners choose to invest, as a fraction of the initial value of the home, is:

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home. In practice, even in non-recourse states, defaults are rather rare. With reverse mortgages, in contrast, the homeowner has no reason to give any thought to resale value below the loan balance.

$$s = \Pi_I(I_n) - \Pi_I(I) - f(I_n) - h(I_n) - f(I) + h(I) \qquad (10)$$

where I_n is the investment that the homeowner would make in the home if there were no moral hazard. After computing the amount I that the rational homeowner will invest in the home, we can use this expression to compute the expected shortfall. To translate this into a fraction of the amount invested, we must divide s by L for reverse mortgages, by the amounted loaned for shared appreciation mortgages, and by $(1 - \alpha)$ for housing partnerships, shared equity mortgages and sale of remainder.

Calibration of Model

For purpose of simulating our model, we must calibrate the parameters. For the distribution of $\tilde{V}$, we use the model of home prices presented in Case and Shiller (1987, 1988), and the assumption that the home sale is 8 years after purchase. The Case–Shiller model of home prices was that home prices are driven by three factors, city-wide factors, home specific (including neighborhood factors) and a time of sale noise factor. The first of these two factors were assumed to be lognormal random walks, and the third was assumed to be a serially independent lognormal variable. Averaging over the four cities, we found that average standard deviation of the quarterly change in the citywide variation in log price indices was $\sigma_c = 2.52\%$. Again averaging over the four cities, we found that the estimated standard deviation of the quarterly change in the home-specific or neighborhood variation in log price was 3.31% per quarter. The standard deviation of the time of sale noise was $\sigma_N = 6.37\%$. For sales 8 years (32 quarters) apart, this implies that the standard deviation σ of the change in log price is $((32)(\sigma_c^2 + \sigma_H^2) + 2\sigma_N^2)^{.5}$ $= 25.20\%$. We assume that the mean change in log price μ equals zero for this calibration, reflecting a low inflation environment, though clearly other assumptions could be entertained.

For the production function for I, gross investment as a fraction of the initial home value, we assume that $f(I) = I^{.5}$. This choice of investment function is admittedly arbitrary, but it is roughly plausible, and seems suitable for calibrating the model for illustrative purposes. With this investment function, we would see that in the absence of any risk sharing arrangement the homeowner would, maximizing profits, set $I = 0.25$. This means that over an 8 year period the homeowner would invest about 3% of the value of the home per year. It also means that if the homeowner were to consider an additional improvement of 10% of the initial value of the home, beyond the improvements optimally made under a conventional mortgage, then the additional improvement would be mapped into approximately a 9% additional improvement in the resale value of the home, substantial, but not quite worth making as an investment. We assume a value for D equal to 0.5. This implies that if the homeowner lives in the home but makes absolutely no investment at all in value-maintaining or value-improving activity of any kind (including not resisting the impulse to remove value from the home and sell at below market price) then the home would lose half its value in eight years. We will not normally observe such sharp declines in value because there are usually some incentives to maintain value. With this value of D, a profit-maximizing homeowner, who maximizes equation (1) in the absence of any risk management contract distortions, will, by investing 25% of the home's initial value, cause the home value to remain unchanged after eight years at 1.00 times the initial value.

The $h(I)$ curves corresponding to Figures 1–4, computed using expressions (5) through (9), are shown in Figures 1a–4a. On each figure a 45 degree line is also shown, a line with a slope of one.

Note that for all four figures, the $h(I)$ curves are smooth, even though the $g(V)$ function that was used to derive them had a kink in it in two cases. The smoothness of the $h(I)$ curves reflects the presence of uncertainty: the homeowner does not know which section of the broken straight line will be relevant after the final value of the home is discovered. Thus, one might say that all four curves look basically similar in overall appearance, despite their different derivations. They all show an upward slope and a negative second derivative. But, this similarity obscures important differences to the homeowners in terms of the implied profit maximizing behavior.

If $a = 1$, profit maximization means finding the value I at which the $h(I)$ curve is as high as possible relative to this 45 degree line, that is, where it has the same slope. From Figure 1a, it is apparent that the point of maximum corresponds to 0.25 in the conventional mortgage case. This is the case where, as shown above, the homeowner will invest a quarter of the value of the home in 8 years, thereby maintaining the home at its original value. Note that at this point there still appears to be negative profits in this calibration exercise. This fact merely reflects the fact that we have ignored the service benefits that the homeowner obtains from the basic home, before investment, in calculating profit.

For the other three situations, the situations shown in Figures 2 through 4 and for which the $h(I)$ schedules are shown in Figures 2a through 4a, the incentives for the homeowner are very different.

In fact, the maximized profit for Figure 2a if $a = 1$, the case of a reverse mortgage or home equity insurance, occurs where the homeowners invest only 2% of the value of the home, and the losses to the home will be catastrophic. The reader can check this result visually by noting the level of I in

Figure 2a where the slope of the $h(I)$ schedule matches that of the 45 degree line shown there. This point on the figure is very close to the origin. In this case, the home will lose 36% of its value due to moral hazard. The lender faces an expected shortfall per dollar loaned, s/L, using expression (10), of 20.7% of the amount loaned. In other words, the lender who made a loan so that loan value on the final date was 80% of the initial value of the home would face expected losses due to moral hazard alone of 20.7% of all loans, not just defaulting loans. The figure can be this high because the probability is 70.5% that the home value will be inadequate to cover the loan balance fully, even though the loan to value ratio was 0.8. The reason for this catastrophic shortfall with the reverse mortgage is that if the home value $\tilde{V}$ is sufficiently low the homeowners are protected against losses, and so do not care about them. While the homeowners do not know what $\tilde{V}$ will be, they know at the time the investment I is made that it stands a good chance of being sufficiently low. While the $h(I)$ curve in Figure 2a resembles that of Figure 1a for high I, it is critically different for the relevant regions, low values of I.

Of course, assuming $a = 1$, that the homeowners care only about resale value and not at all about value in use before sale, was rather extreme. If we instead take $a = 0.5$, meaning that the homeowners give equal weight to both, then we find that, except for conventional mortgages, they will invest more in the home. For reverse mortgages, our calibrated model shows that the homeowners will invest 18% of the value of the home, and thus, the home will lose 8% of its value on resale. One can visually verify, very roughly, this level of investment for $a = 0.5$ by using both Figures 1a and 2a, by finding the level of investment where the average of the slopes of the two $h(I)$ curves equals the slope of the 45 degree line. With this method, one can see visually why lowering a to 0.5 has such an effect on I: while the $h(I)$ curve shown in Figure 2a is fairly linear and with slope less than one except at very low levels of I, the $h(I)$ schedule shown in Figure 1a has a slope that is much greater than one even at levels of I approaching the optimal level of 0.25. With our assumption of an initial loan to value ratio of 0.8, and an eight-year standard deviation of housing prices of 25.2%, then expression (10) implies that lenders will, in our model, face an expected shortfall per dollar loaned, s/L, due to moral hazard of 2%. This shortfall may seem fairly small, but recall that it is an actual loss, on average, for each mortgage written, and this moral hazard loss is on top of all other losses. This loss will still have to be made up for by a higher mortgage rate, or other charge, if the lender is to break even, but such a higher rate may make the lender uncompetitive.

Whether the $a = 1$ case or the $a = 0.5$ case considered above is relevant is a matter of judgment. We think that it is plausible that the true value of a lies between these two extremes, and so our estimated expected shortfall lies between the two cases illustrated.

In the case of a shared appreciation mortgage, Figure 3a, when $a = 1$ the homeowners optimally invest 14% of the value of the home, so that the home loses only about 13% of its value. Note that the $h(I)$ curve in Figure 3a resembles that of the conventional mortgage in the low region, Figure 1a, so there is much less incentive to allow home value to drop sharply than there was in Figure 2a. Failing to invest in the home will, in the shared appreciation mortgage case, push homeowners into a region of I where they are bearing almost all of the expected losses for failing to invest more. This explains why there is so much more investment in the $a = 1$ case for shared appreciation mortgages than for reverse mortgages. Lenders face a shortfall

s as a fraction of the value of the home, from equation (10), of 4%. When $a = .5$, then the homeowners invest 18% in the home, just as in the case of reverse mortgages, and from equation (10), the shortfall s as a fraction of the value of the home is 2%. Again, not knowing a, we think it is plausible that it lies somewhere between 0.5 and 1.0, and so the expected shortfall should lie between 2% and 4% of the value of the home.

In the case of the partnership, shared equity mortgage and sale of remainder interest, Figure 4a, the incentives to invest are reduced over the entire range of I. The slope of the $h(I)$ schedule in Figure 4a is scaled down, in comparison with Figure 1a, by the factor α. When $a = 1$, as was the case with the reverse mortgage, the profit maximizing homeowners will invest only 2% of the initial value of the home. Losses to investors are catastrophic; $s/(1 - \alpha)$ is, using equation (10), 36%. If $a = 0.5$, then the homeowners will invest 10% in the value of the home, and the investors thus face an expected shortfall $s/(1 - \alpha)$ of 18% of their investment.

The declines in home value suggested by our calibration are often quite large. Moreover, even declines of home value that are among the smaller of those predicted by our model for our examples may be an important issue for the mortgage lenders or other parties who are the ultimate bearers of the losses, to them losses multiplied by the thousands or millions of homes that they cover. Our model illustrates how a number of different factors conspire to produce widely varying amounts of homeowner investment, and, given the uncertainty about some of imposed parameter values, there is perhaps some substantial uncertainty about the likely long-run outcomes to home equity insurance forms. While our model is only a calibrated model, it is illustrative of the kinds of calculations that must be pursued very carefully before investing in any home equity conversion form.

It is important to make a final word about general inflation. In all of our calculations, we conditioned on L, the final loan balance as a fraction of initial home value, setting it to 0.8 in both the conventional and reverse mortgage case. But general inflation has different kinds of expected effects on L for the different forms of home equity conversion. In an inflationary period, with nonindexed conventional mortgages, mortgagors are forced to pay down the real mortgage rapidly, so that the mortgage balance tends to decline quickly relative to home value. Lenders accustomed to conventional mortgages may thus learn a sort of complacency about the risks to them of declining home values. With reverse mortgages, there is no such pay down of the mortgage balance when inflation is high. Investors should be cautious not to let the experience with default losses on conventional mortgages cause them to underestimate the risks of the alternatives to it that we have considered. Moreover, inflation tends to reduce the moral hazard advantage we saw in the shared appreciation mortgage form relative to the other home equity conversion forms, by pushing the homeowners into a region of the $h(I)$ curve where all the benefits of investing accrue to investors.

Implications of this Analysis for Contract Design

Let us consider the kinds of modifications that could be made in the home equity conversion contracts analyzed to reduce or eliminate the moral hazard problem created by the contracts, and consider how well these modifications are likely to work.

1. Reverse mortgages. As discussed above, the reverse mortgage contracts might specify that the homeowner is penalized for deviations of the home selling price from the value predicted by the index and the original selling price. This penalty provision can be made operative merely by in-

dexing the debt to the real estate price index. Even if we do not change the loan to value ratio, keeping it at 80% say, such indexation of debt in reverse mortgages may drastically reduce moral hazard by reducing the probability that the price of the home will fall below the *indexed* loan value. At the same time, indexing the debt to the real estate price index yields the additional benefit to the homeowner that the reverse mortgage policy achieves a risk management objective for the homeowner, protecting the homeowner against any impact from aggregate real estate market fluctuations.

To analyze the effects of indexing the loan balance to the real estate price index, we can use the same framework as shown above, and merely reducing the estimate of σ, so that it reflects only relative-price noise of the house, not the full noise. Of course, moral hazard risk is not completely eliminated unless there is no chance that the market value with perfect maintenance, $\tilde{v}$, can fall below the indexed loan value.

2. Home equity insurance. Here, the contract could merely specify that the policy covers the decline in the real estate price index for the region and kind of home, and not at all the decline in price of the home itself. That was, in fact, our original proposal, Shiller and Weiss (1994). This indexing would completely eliminate the moral hazard problem.

3. Shared appreciation mortgages. With these mortgages, it is clear again that the amount owed for appreciation to the lender could be measured by a real estate price index. Obviously, the moral hazard problem is eliminated since the amount owed has nothing to do with the value of the home.

4. Housing partnerships and shared equity mortgages. The advice that is suggested by our analysis of moral hazard is that the limited partner should share in the index risk only, the risk of the selling price of the home entirely borne by the homeowner.

5. Sale of remainder interest. The situation here is much the same as with reverse mortgages. The contracts are again likely to be signed with elderly homeowners with little other assets. It is advisable to provide to the homeowners somewhat less than the entire value of the home, keeping some fraction of the value of the home in escrow for penalties if the value of the home does not keep up with the index.

All of the above changed contracts should make the home equity conversion investments more marketable to other investors and more securitizable. Investors in the securities need not trouble themselves with investigating how well the manager of the home equity conversion contracts is dealing with the myriads of moral hazard issues that we have described.

Basic Measurement Issues

Our calibrated model is only rough indicator of outcomes. A couple of issues that appear to be particularly salient to interpreting its relevance are whether there is substantial basis risk in home price indices and whether we have modeled moral hazard behavior accurately. We will leave these issues for further research, after describing them.

We define basis risk as the risk that fluctuations in the home price index will not match well fluctuations in the price of the home that are beyond the homeowners' control. The term basis risk is borrowed from futures market practitioners, who refer to basis risk as the risk that the futures price will not converge on the cash price that is being hedged. If the futures price does not correlate well with the cash price, then the futures market does not allow good hedging. By analogy, if home price indices do not track the individual home prices well, apart from changes that the homeowner deliberately makes in the value, then the various home equity conversion forms will not manage the homeowners' risk well.

The basis risk for our purposes is fundamentally difficult to measure, since we must measure changes in home prices that are beyond the owners' control. Thus, measuring basis risk entails measuring price changes that are identified with characteristics of the homes. The problem is that any characteristics of the home that are beyond the control of the homeowner that we also can measure for the purposes of measuring basis risk could by the very fact that we measure them be used to condition the price index, so that they become part of the settlement itself. We suspect that this basis risk, properly measured, is small. Why, after all, should home prices vary very much beyond the control of the homeowner due to factors beyond the measurable ones of location, size, age, etc.? Still, further work might be done to try to learn something about the basis risk before launching contract forms. Research can also be done developing finely defined price indices, for homes of specific characteristics, to serve as the basis of settlement of home equity conversion contracts.

The actual moral hazard risk we will experience with home equity conversion forms is, despite our modeling efforts, hard to measure. We have assumed in our model that individuals always behave optimally in their own self interest with full knowledge. While the model is a useful start, we should not always assume that individual homeowners are accurately described by it. One issue not addressed in our model is the process of learning. We think that the ultimate moral hazard is likely to build with time after the contracts become commonplace. The homeowner's ability to exploit weaknesses in the contract definition may tend to grow over the years, as these weaknesses become more apparent. There is likely to be a process of social learning after large sums are committed to these contracts, when homeowners with such contracts will have a great deal of incentive and time to communicate with each other and with their lawyers about the best methods to beat the system. While creators of new home equity conversion forms may tend to view past experience with experimental home equity conversion forms as a good guide to the future, perhaps future research should instead consider carefully some blend of the evidence from past experience and the evidence from models like that we have presented here.

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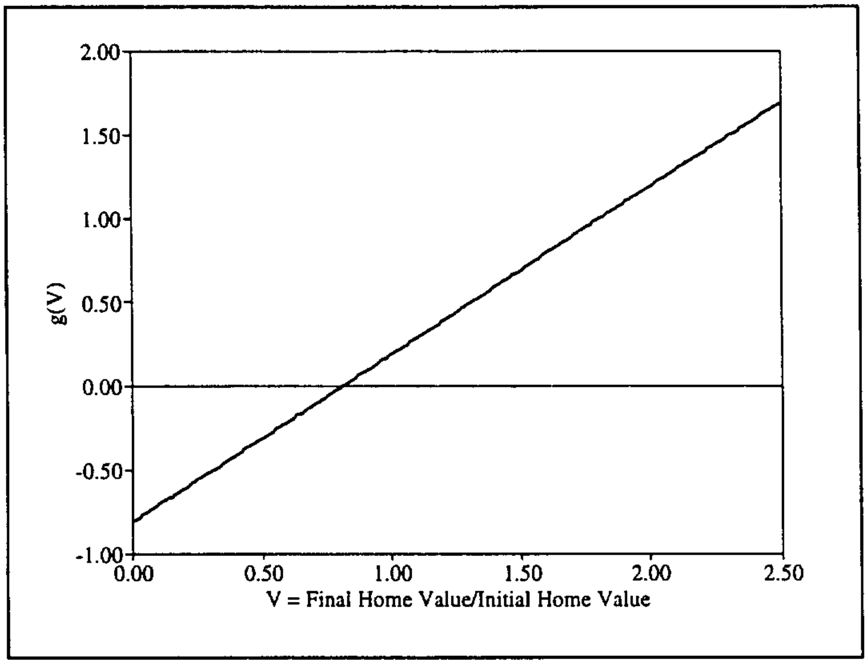

Figure 1 Function $g(V)$ giving value of portfolio in terms of the sales price V of house, house with conventional mortgage.

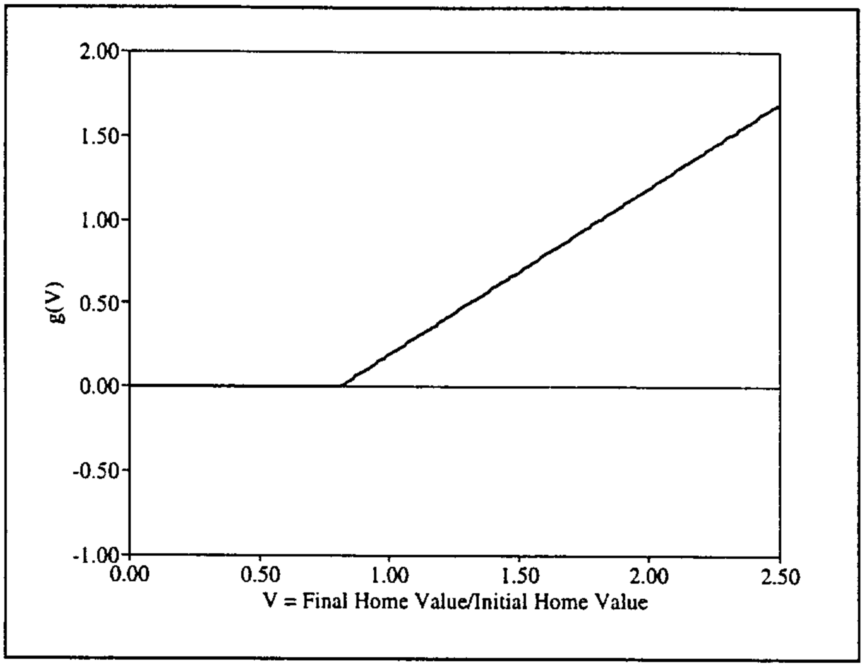

Figure 2 Function $g(V)$ giving value of portfolio in terms of the sales price V of house, house with reverse mortgage or house with home equity insurance.

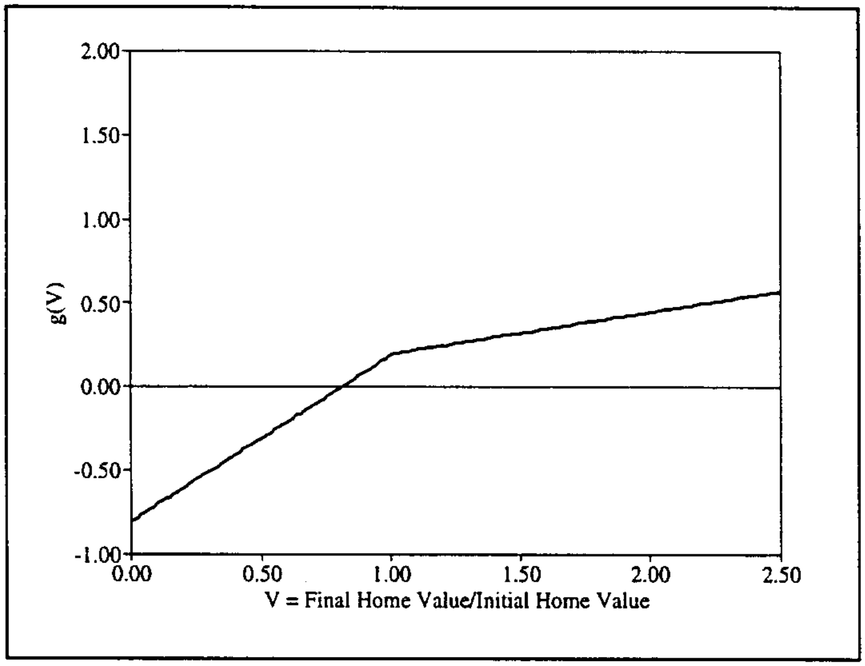

Figure 3 Function $g(V)$ giving value of portfolio in terms of the sales price V of house, house with shared appreciation mortgage.

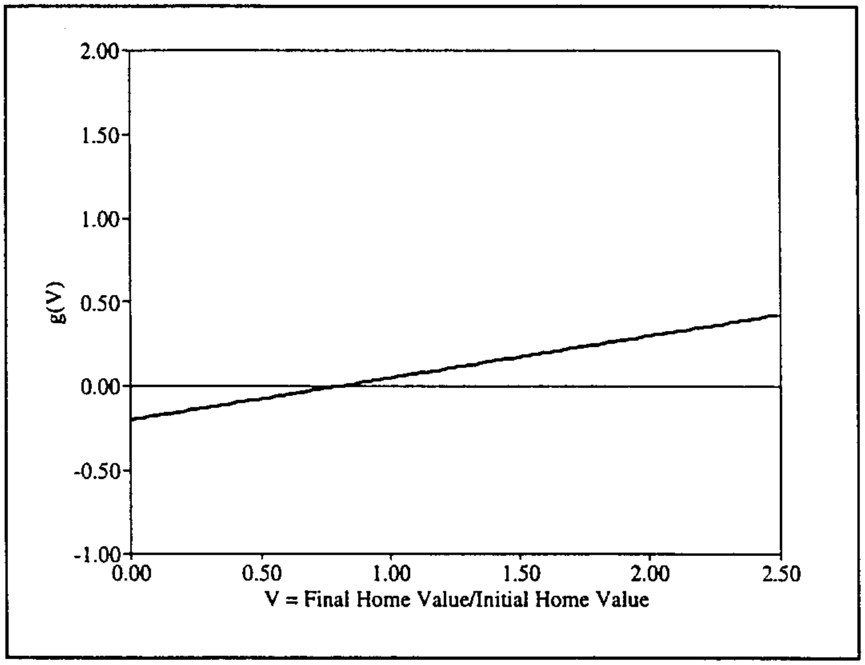

Figure 4 Function $g(V)$ giving value of portfolio in terms of the sales price V of house, house with partnership, shared equity mortgage or sale of remainder.

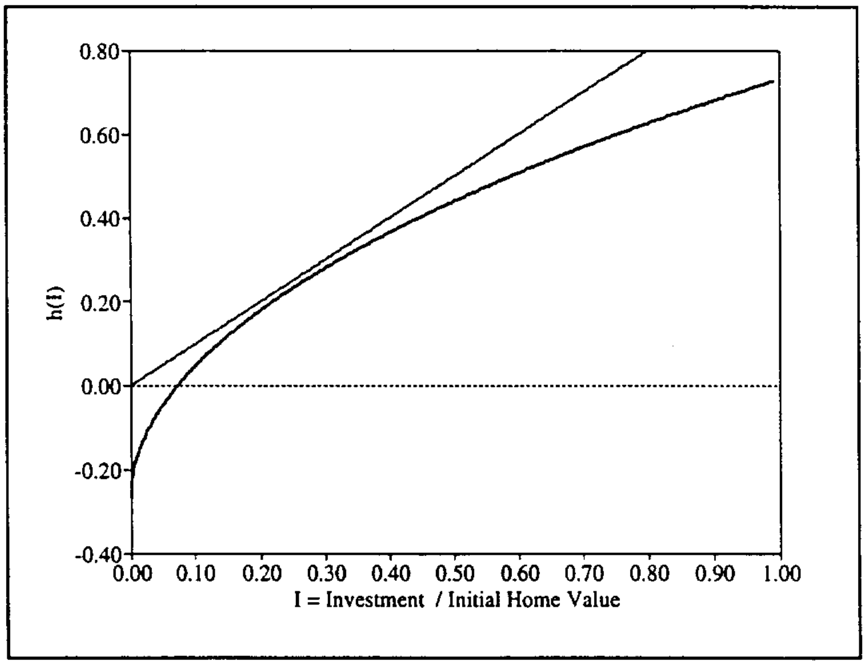

Figure 1a Function *h*(*I*) giving expected portfolio value increment after investing *I* in the house, conventional mortgage (see Figure 1).

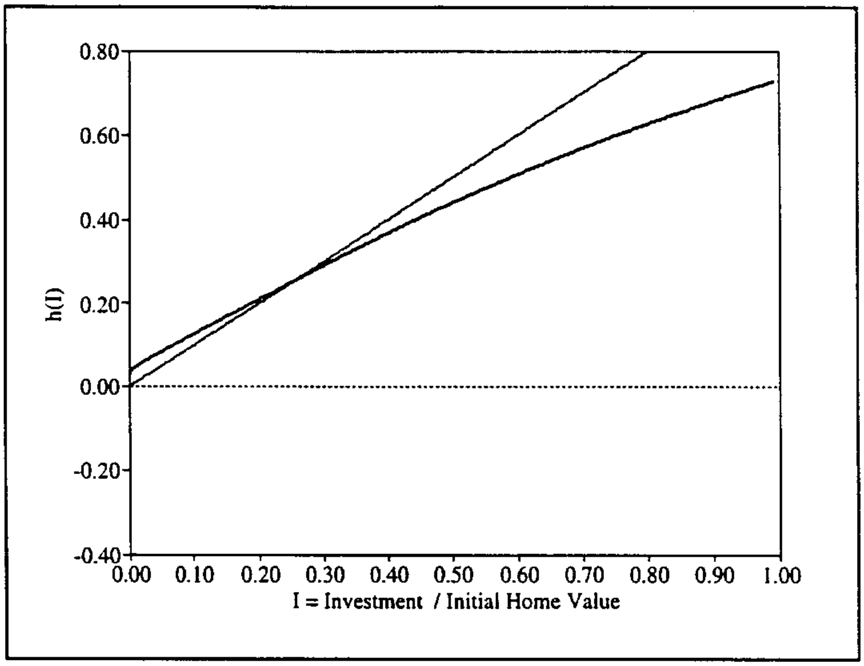

Figure 2a Function $h(I)$ giving expected portfolio value increment after investing I in the house, house with reverse mortgage or home equity insurance (see Figure 2).

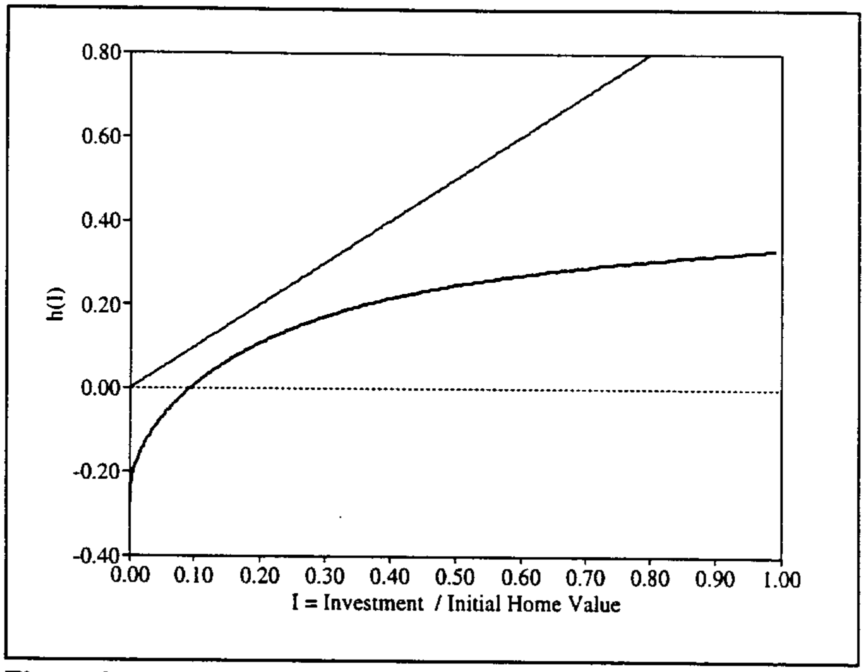

Figure 3a Function $h(I)$ giving expected portfolio value increment after investing I in the house, house with shared appreciation mortgage (see Figure 3).

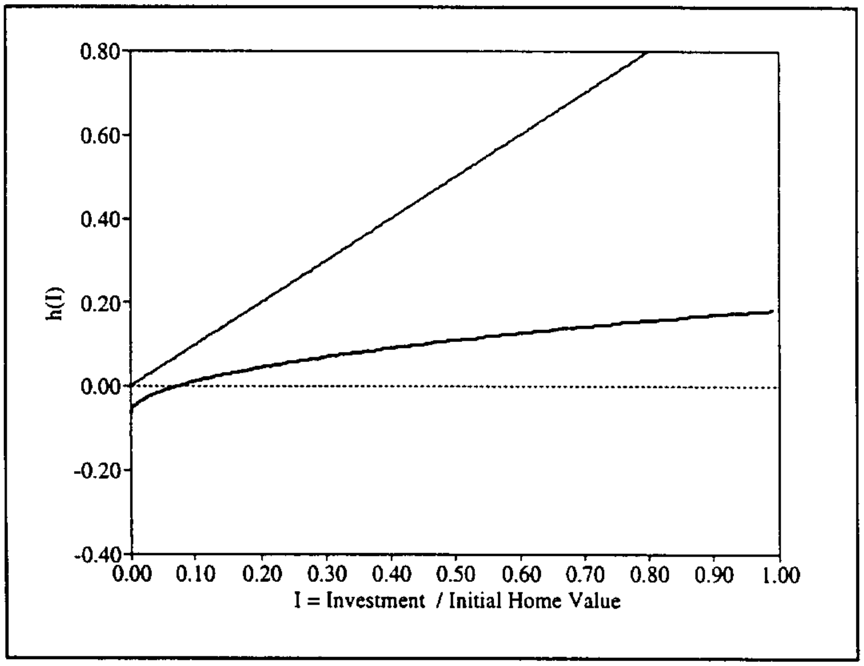

Figure 4a Function $h(I)$ giving expected portfolio value increment after investing I in the house, house with partnership, shared equity mortgage or sale of remainder.