MORAL HAZARD IN HOME EQUITY CONVERSION

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Moral Hazard in Home Equity Conversion

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Home equity conversion as presently constituted or proposed usually does not deal well with the problem of moral hazard. Once homeowners 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 indexes are proposed that might deal better with the problem of moral hazard.

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 were redesigned so that the settlements in them were determined at least in part by real estate price indexes, rather than only 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 reduce their exposure to real estate risk.

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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. We will present a calibrated model of moral hazard, which allows us to reach some tentative conclusions about the magnitude of moral-hazard losses in each of these forms of home equity conversion.

All of these home equity conversion forms are potentially very significant, given the importance of housing in national wealth. According to the Balance Sheets for the American Economy produced by the Board of Governors of the Federal Reserve System, owner-occupied residential structures and land accounted for 25.9% of household wealth in 1994. For lower-wealth people, housing wealth figures even more prominently in their total wealth as they approach retirement [see Gustman and Steinmeier (1999) and Venti and Wise (1997)] and is often almost their entire wealth at retirement other than social security. One would think that institutions that help people to manage the risk of such holdings would be very important. And yet, as of this date, none of these home equity conversion forms is very important in the United States or anywhere else in the world. While there are many reasons offered for their failure to thrive (see Mayer and Simonds 1994), concerns about moral hazard may be an important factor inhibiting their growth.

We shall propose modifications of the home equity conversion forms in which the risk reduction for the homeowner is achieved by tying payments, at least in part, to a home price index rather than to the value of the homeowner's own home. By tying payments to an index, the moral-hazard problem disappears, since homeowners have no control over the index as they do of their own home value.

Unfortunately, once index numbers are used, a new problem appears, that of basis risk. 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 is borrowed from futures market practitioners, who mean by it 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 indexes 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. In the concluding sections of the paper we will offer some proposals for modifying home equity conversion contracts to take account both of moral hazard and of basis risk.

Types of Home Equity Conversion

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. That is so 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 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 (1999). The insurance might be a stand alone policy that a homeowner might buy at any time, or, more plausibly, it might be an add-on to the homeowner's 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 pays 75% of the appreciation of the entire home in lieu of interest for a loan equal to 25% of the initial value 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. There may also be a third party, a mortgage lender. Caplin, Chan, Freeman and Tracy (1997) have been advocating these partnerships for the U.S. 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 equity. In some cases the investor and the 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 homeowners die or move out of the home, until which time the owner has a contract allowing them to occupy the home. If the sale involves a mortgage, then again a mortgage lender is also involved. With the Lifetime Security Plan in California (see Goren, Jacobs and Rosenbaum 1996), sale of remainder is marketed to elderly homeowners who are in need of income. In this contract, the homeowner agrees to turn over basic maintenance of the home to the plan sponsors, thus reducing the moral hazard. For the elderly homeowners targeted by their plan, who may have less energy to pursue proper maintenance, provision of such home maintenance may be efficient. It is less likely to be attractive to younger homeowners, because they lose some control over the house and because such maintenance costs more than their own maintenance.

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-aged homeowners who wish to hedge some of the risk attendant on buying a home.

Risk Reduction and Moral Hazard with These Types of Home Equity Conversion

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, for those contracts that base settlements exclusively on the selling price of the homes, this risk reduction comes at serious potential moral-hazard costs to 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 managing 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 shows badly because it needs exterior paint, which would cost \$3,000. Suppose the value for the house would be \$200,000 if the homeowner had kept up with painting the exterior. Since the homeowner has not, the house will bring only \$195,000 on the market. Therefore, the homeowner would rather not pay the \$3,000, since it yields to the homeowner only \$2,500. In contrast, if the contract were settled on the index rather than on the home price itself, then the homeowner would have a \$2,000 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 \$5,000 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 as improperly applied paint that eventually peels. Or it may result in spattered paint on roofing, floors, windows, etc., which may detract from the resale value of the house. While contract provisions could try to specify that homeowners must use an approved list of professional painters, it will be very costly and difficult to try to enforce such provisions. There is no licensure for painters, and painters that have the most established reputations tend also to charge very high prices. Many houses have high resale value because they have been maintained exceptionally well due to the owners' own diligence and motivation, 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 inspector examines 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 inspector 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 to prove this well enough to exact penalties from homeowners for failing to make them. 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 appraisals of the real value of a home are subject to substantial errors (10%, 20% and 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 on homeowners for ambiguously defined non-compliance is an expensive proposition: litigation and other homeowner resistance are likely expenses. Investors would have to expect to impose penalties on a substantial proportion of homeowners if the penalties were to be effective.

Improvements in the Home

Let us consider another example of likely homeowner behavior when the owners of the home have a risk-sharing 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 $6,000. If the homeowners did not have the risk-sharing contract, they would lose $4,000 but gain the benefit of a better kitchen until the home is sold. Without the risk-sharing contract this might seem like a good trade-off. However, with a risk-sharing contract, the homeowners would regain not \$6,000 but only \$3,000 on resale (their share of the \$6,000), 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? What if the homeowners renovate the kitchen in a number of stages, extending over years? Will it be feasible and cost-effective for the investor to review all of these improvements and reach an agreement on their value? 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.

Sale of Home

Consider a home that is currently actually worth \$200,000 and whose 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 \$2,000 a month. Suppose the homeowners are offered \$190,000 for the home. They will figure that with a 50% equity interest in the home, this lowball bid would cost only \$5,000. They will 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 \$5,000. 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 a home 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.

Home equity conversion contracts might deal with these problems by giving the investor a right of first refusal on the house, as proposed for example by Caplin, Chan, Freeman and Tracy (1997), so that if a homeowner wishes to accept a lowball bid, the investor can then buy the house. There is a problem with such contract provisions, however, in that the investor has no easy way of discovering whether the bid is really lowball, since there is no precise way to measure market value, particularly for an investor from outside the neighborhood. Appraisers' opinions and automated valuation models (AVMs) have a substantial margin for error. The investor would have to worry about buying the houses too often and then incurring substantial transaction costs in trying to sell them. Moreover, both conventional wisdom and hedonic regression results (Springer 1996) show that selling a vacant house tends to bring lower value.

There are many studies that bear on the question whether impatience to sell does in fact have a substantial influence on selling price. Many studies have considered the effect of time on the market on selling price; see for example Asabere and Huffman (1993), 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 characteristic variables and on variables reflecting the seller's eagerness to sell or the seller's reporting being relocated. Eagerness and relocation were found each to yield 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.

The moral hazard in home equity conversion may occur not only when the home is sold, but also when it is first purchased. Buyers of a home may, due to impatience or unwillingness to consider alternative homes, buy an overpriced home, if they think that the expected loss on subsequent resale can be transferred to someone else via home equity conversion. In this respect, the potential loss is really twice as big as might be indicated by the above analysis. Of course, egregious overpaying will tend to be caught by appraisers, but it is unlikely that they will catch modest overpaying. Paying 5% too much on purchase and selling for 5% too little on sale will result in a 10% loss as a fraction of the purchase price of the home, on top of all the other potential losses discussed above.

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 not be developed that may encourage sellers to accept lower offers on their homes or buyers to take higher offers. 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.

Disguise or Complexity of Sales

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 is just to sell the home to friends or relatives at a below-market price. There can be a secret or disguised buydown from the buyers or a party connected with the buyers. While some of these methods constitute fraud, they may still happen. And there are more subtle things that can also be done that have the same effect. Homeowners may remove some advantage that the home has before selling it, such as replacing unique antique chandeliers with cheap modern lighting fixtures, and then argue, if asked about it, that this was done as part of routine remodeling.

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. They can ask the buyer to accept the house "as is" rather than make corrections before sale, in exchange for a lower selling price. They can refuse concessions such as homeowner warranties, redecorating allowances, 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] 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 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.

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, or 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 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 home equity to the value of the home when it is finally sold. The date at which the home is sold depends of course on random

[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.

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, 8 years in the future. Let us denote $e(V)$ the homeowners' equity as a function of the sales value V of the home on that date. In each example the equity is assumed to consist of the usual 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 other reasons.

Figures 1 through 4 show hypothetical forms for the function $e(V)$ 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 its value when purchased, and so the point 1.00 on the horizontal axis represents a situation in which the final value of the home equals its initial value. In all four diagrams the homeowners have just purchased a home by borrowing an amount such that

Figure 1 ■ Conventional mortgages: home equity $e(V)$ versus the value V of the home, both as fractions of initial purchase price.

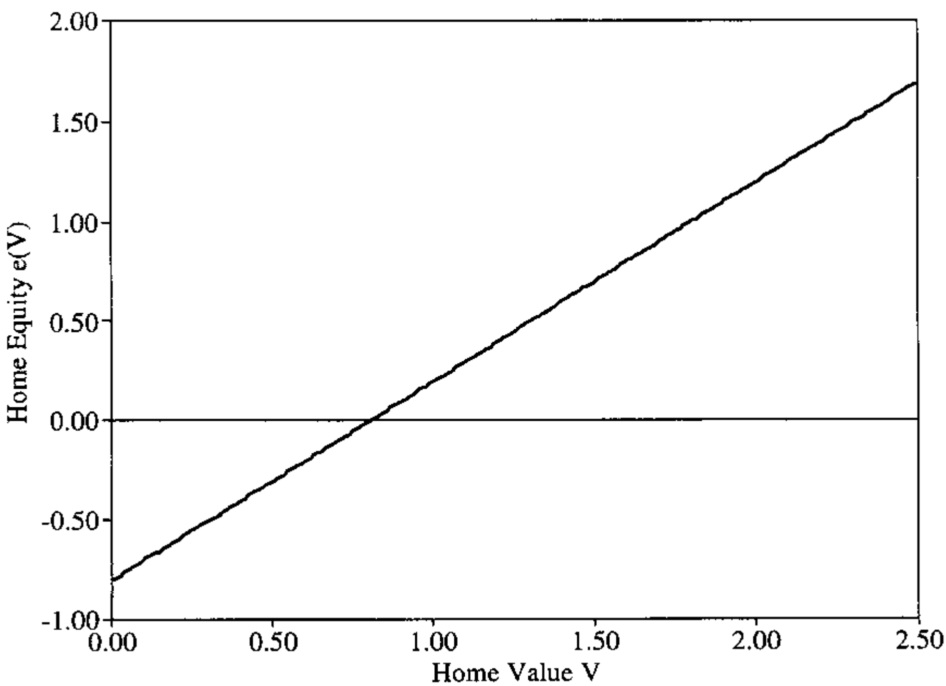
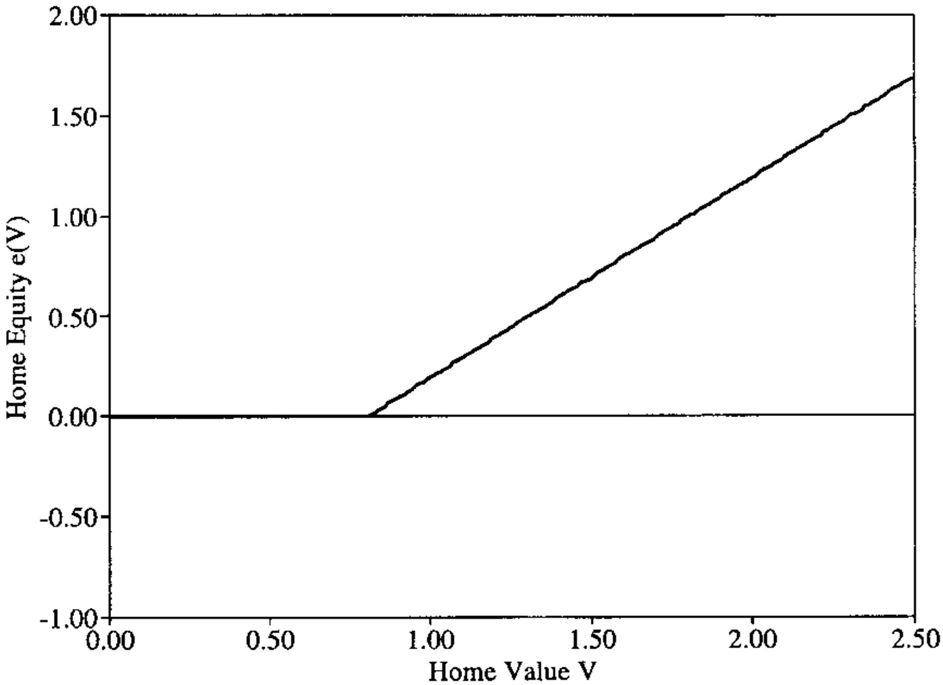


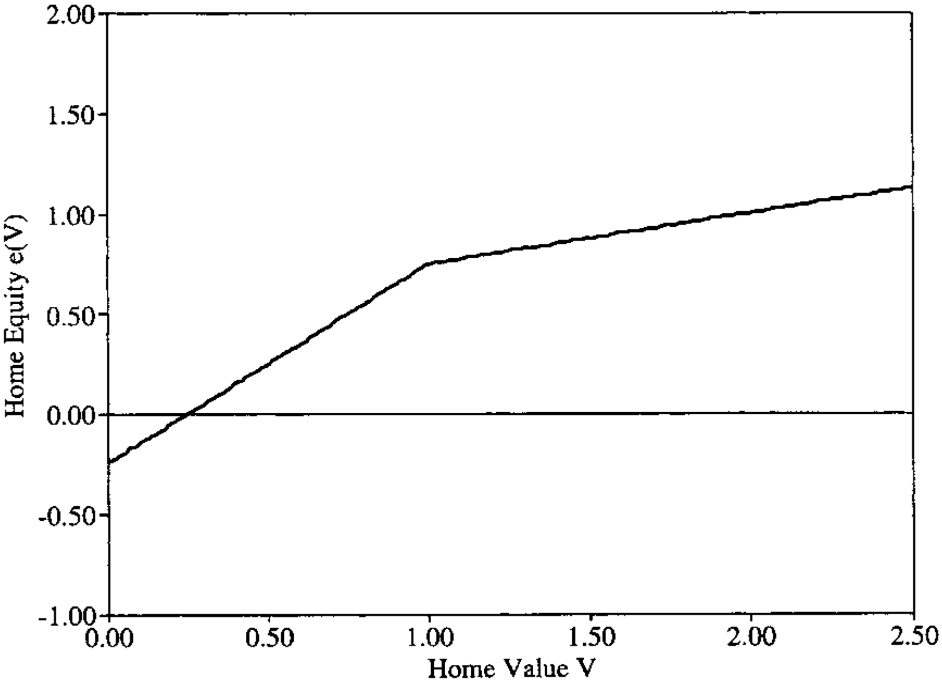
Figure 2 ■ Reverse mortgage or home equity insurance: home equity $e(V)$ versus the value V of the home, both as fractions of initial purchase price.



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 will 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 will then grow as interest accumulates. The initial loan-to-value ratio may be essentially the same as L if mortgage payments are being made about equal to interest, as may be the case with conventional or shared equity mortgages for the first 8 years of a longer-term mortgage. In 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 function $e(V)$ 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 the time of sale; the sales price is just enough to pay off the mortgage. If the value of the home becomes 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-

Figure 3 ■ Shared appreciation mortgage: home equity $e(V)$ versus the value V of the home, both as fractions of initial purchase price.

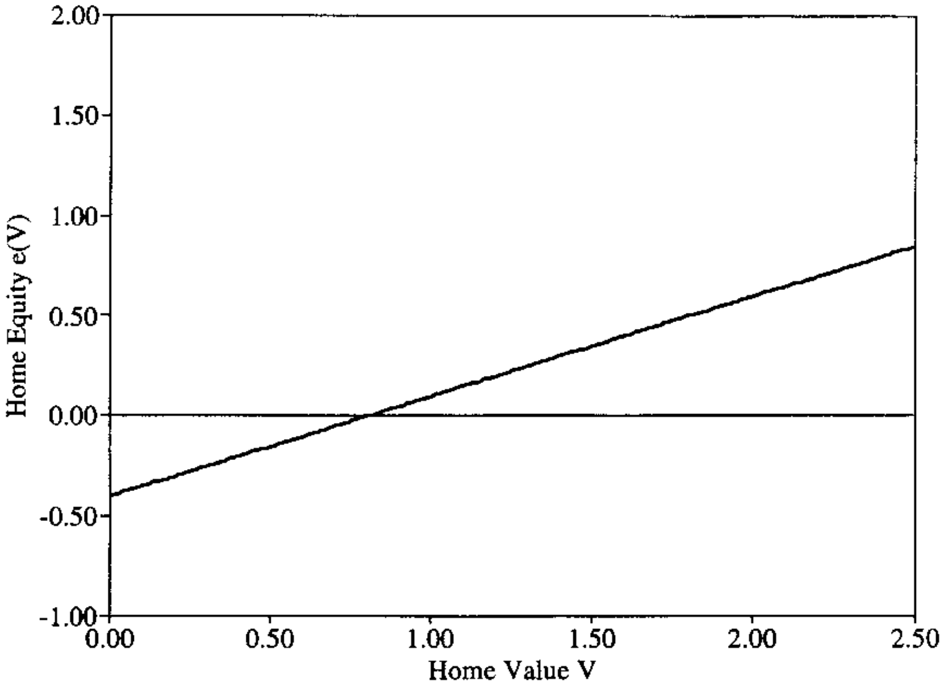


recourse states such as California, homeowners can walk away from negative equity without bankruptcy. We disregard this complication here to provide a simpler contrast between the different risk management forms.

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 at the time of final sale is worth less than 80% of its initial value, then the heirs get nothing, whence the horizontal slope of $e(V)$ to the left of L. Otherwise, they receive the value of the home minus the loan balance, and so the $e(V)$ 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 asset. Indeed, a home with a reverse mortgage does work out to be essentially such a call option.

Figure 4 ■ Housing partnership, shared equity mortgage or sale of remainder: home equity $e(V)$ versus the value V of the home, both as fractions of initial purchase price.



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 zero on their home equity. 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 home value above the initial value is paid to the mortgage lender, but all of the losses fall on the homeowner if the value of the home on resale is less than the initial value. This $e(V)$ curve is a broken straight line with a slope of one to the left of $V_0 = 1$ and a slope of 0.25 to the right of V_0. The case shown in the figure is the Bank of Scotland example with $L = 0.25$.

Figure 4 shows the case of a limited partnership in which the "homeowners" (the residents of the home) actually own only 50% of the home equity and the other partner 50%, and where there is a conventional mortgage L of 80%

of the value of the home. Now, the $e(V)$ curve is just a straight line with a slope of 0.5 through $V = 0.8$. This figure also shows the case of a shared equity mortgage and a sale of remainder interest with the same parameters.

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 complex, having to do with differing opinions about future price movements, differing information sets, differing asset positions and income flows, differing worries and concerns, and 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 gross investment expenditure I into home value.[2] We interpret the argument I very broadly as representing all costly activities that increase home value—not only the maintenance and improvements, but also the efforts to decorate the house in conventional tastes and to get a good price at resale, as well as 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. The expected profit for the homeowners in the absence of any risk sharing is given by

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

where $\tilde{V}$ is the random (unknown when the investment I is made, due to changing market conditions) value of the home if there is no depreciation in it, D is the depreciation on the home that would occur if no investment were made at all in value-preserving or value-increasing activities, and E is the expectation operator. We will assume that $f'(0) = \infty$, and that $f'(I) > 0$

[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.

and $f''(I) < 0$ for $I > 0$. Profit-maximizing homeowners will set the derivative of the profit function equal 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 $e(\tilde{V} - D + f(I))$ of the resale value of the home, where e is one of the functions shown in Figures 1 through 4. Then the profit function to the homeowners is

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

where $h(I)$, the expected home equity on resale as a function of I, equals $\mathrm{E}e(\tilde{V} - D + f(I))$, 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 functions $h(I)$. 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 perspective 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 e 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 $\tilde{V}$ (with mean $\ln \tilde{V} = \mu$ and var $\ln \tilde{V} = \sigma^2$), it is straightforward to derive expressions for $h(I) = \mathrm{E}e(\tilde{V} - D + f(I))$. The function $e(\cdot)$ 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, $e(V) = V - L$, corresponding to Figure 1, is[3]

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

The expression for a reverse mortgage or a home insured by home equity insurance, corresponding to Figure 2 [$e(V) = V - L$ if positive, otherwise $e(V) = 0$], is, if $f(I) - D$ is less than L,

$$h(I) = N\left(\frac{\mu + \sigma^2 - \ln[L - f(I) + D]}{\sigma}\right) \exp\left(\mu + \frac{\sigma^2}{2}\right) + N\left(\frac{\mu - \ln[L - f(I) + D]}{\sigma}\right)[f(I) - D - L] \tag{6}$$

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

The expression for a shared-appreciation mortgage where the homeowner receives a fraction α of appreciation, [$e(V) = V - L$ for $V < V_0$, $e(V) = V_0 - L + \alpha(V - V_0)$ otherwise, corresponding to Figure 3], is, if $f(I) - D$ is less than V_0,

$$\begin{aligned} h(I) &= \exp(\mu + \sigma^2/2) + f(I) - D - L \\ &\quad - (1 - \alpha)\left[N\left(\frac{\mu + \sigma^2 - \ln[V_0 - f(I) + D]}{\sigma}\right) \exp\left(\mu + \frac{\sigma^2}{2}\right) \right. \\ &\quad \left. + N\left(\frac{\mu - \ln[V_0 - f(I) + D]}{\sigma}\right)[f(I) - D - V_0]\right], \end{aligned} \tag{7}$$

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

[3] Use the fact that if $f(x)$ is the normal density with mean μ and variance σ^2, then $\int(-\infty,a)\exp(x)\, dx = N((a - \mu - \sigma^2)/\sigma) \exp(\mu + \sigma^2/2)$, where $N(\cdot)$ is the standardized normal distribution function.

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

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

For limited partnerships, shared-equity mortgages and sale of remainder interest, corresponding to Figure 4, $h(I)$ is given by

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

Finally, to compute the effects of the moral hazard on the investor, note that the sum of $h(I)$ and the expected receipts $\Pi_I(I)$ 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 $\Pi_I(I) = \exp(\mu + \sigma^2/2) + f(I) - D - h(I)$. 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

$$s = \Pi_I(I_n) - \Pi_I(I) = f(I_n) - h(I_n) - f(I) + h(I) \tag{10}$$

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 committed by the investor, we must divide s by L for reverse mortgages and shared-appreciation mortgages, and by $1 - L$ for housing partnerships, shared-equity mortgages and sale of remainder. For the latter, where there are three parties involved—the homeowner, investor (or limited partner) and mortgage lender—we divide by $1 - L$ rather than by L because the party bearing the moral hazard risk is the investor, not the mortgage lender.

Calibration of Model

For the purpose of simulating our model, we must calibrate the parameters.[5] For the distribution of $\tilde{V}$, we use the model of home prices presented in Case and Shiller (1987, 1989) 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 kinds of factors: city-wide factors, home-specific (including neighborhood) factors and a time-of-sale noise factor. The first two were assumed to be lognormal random walks, and the third was assumed

[5] In our working-paper version of this paper, we made assumptions about the parameters of $f(I)$ and D which resulted in rather higher moral-hazard costs. We still believe that the earlier parameters are reasonable too.

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 indexes 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 $[32(\sigma_c^2 + \sigma_H^2) + 2\sigma_N^2]^{0.5} = 25.20\%$. 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.

There appears to be no precise way to infer our production function $f(I)$ and our depreciation rate D from parameters shown in existing literature. The observed data on housing investment do not cover all of the expenditures of money, effort and inconvenience that we would include in I. The conventional measures of depreciation do not attempt to measure the decline in value that would occur if none of these expenditures were made. Existing hedonic regression methodology, regressing price on characteristics, does not allow us to infer the production function, because it does not represent the individual as solving a maximization problem like that described here. If all individuals have been maximizing, then I has been chosen so that $f'(I)$ has always equaled one, so in our model all individuals would have the same I at all times. Regressions cannot be run unless I shows variation, but this variation would have to reflect factors not in our model, such as heterogeneity across individuals in $f(I)$.

To calibrate $f(I)$ we use the assumption that the historical representative value for I satisfies $f'(I) = 1$. Moreover, if we also assume as an approximation that there has been no long-term trend in the real value of existing houses, then $f(I)$ equals the long-run average depreciation rate D. Assuming a two-parameter power-function form $f(I) = bI^c$ allows us to infer, given historical representative values for I and D, the function $f(I)$ from these two relations, which, solved, give $c = I/D$ and then $b = I^{1-c}/c$.

Thus, we need only find representative historical values for I and D to calibrate $f(I)$. There are some data on the normal component of investment in homes: the U.S. Census data on expenditures on maintenance, repair and improvement. Their figures include expenditures on repairs as well as improvements such as additions, remodeled kitchens, remodeled bathrooms, storm windows and insulation. The Census figures exclude the value of the labor that the homeowner puts in. Peek and Wilcox (1991) create estimates of the value of the homeowner labor associated with these expenditures and, using the Census data, report that the average investment as a fraction of the value of the home from 1948 to 1989 was 2.39% per annum.[6] This may underestimate the amount of effort that homeowners put in, but, to be conservative for our simulation, we will use approximately this number.

The U.S. Department of Commerce, for computing a net stock of residential structures from data on investment in real estate, assumes a depreciation rate of 1.25% per year, or 10% in 8 years, but this value is just based on an assumed 80-year life for housing and straight-line depreciation. Statistical estimates of annual depreciation rates for homes and apartment buildings, such as those based on coefficients of an age variable in hedonic regressions, tend to range from 0.3% to 0.8% per year, or about 2% to 6% in 8 years. [See Randolph (1988) for a survey of depreciation estimates in the literature.] These depreciation rates are not appropriate for our purposes, in that they do not control for normal maintenance and other efforts to maintain value—for example, for negligence in attending to problems, for failure to maintain conventional tastes and use patterns, or for failure to make efforts to obtain a good selling price. Our experience with the automatic valuation models for individual homes suggests that mismanagement of the home may cause far more than 10% declines in value within 8 years.

From these facts, we decided to assume a historical value for the 8-year I of 0.16 and for the 8-year depreciation D of 0.25. The value of I corresponds to homeowner investment of 2% a year of the value of the home for 8 years. The value of D implies that if the homeowner lives in the home but makes absolutely no investment in value-maintaining or value-improving activity of any kind (including not resisting the impulse to buy above market value, remove value from the home and sell below market value), then the home would lose a quarter of its value in 8 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 16% of the home's initial value, cause the home value to remain unchanged after 8 years at 1.00 times the initial value. These values of I and D give us $f(I) = 0.81 \times I^{0.64}$ for our simulation.

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, suggesting that the

[6] This is the sum of their average annual growth rate of quality plus their assumed depreciation rate of 1.25%.

parameter a, the weight that the homeowner gives to resale value, is about 0.8. If there is a risk or impatience premium, however, we might expect a higher real interest rate and hence a lower a. We will report simulations with $a = 1$ and with $a = \frac{1}{2}$.

Simulation Results

The $h(I)$ curves (homeowners' expected home equity if they make gross investment I in the home) corresponding to Figures 1–4, computed using the expressions (5) through (9) for the calibrated parameter values, are shown in Figures 5–8. On each figure a 45-degree line is also shown, a line with a slope of one. Simulation results are presented in Table 1 for the two values of a.

Note that for all four figures, the $h(I)$ curves are smooth, even though the function $e(V)$ 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 until after the final value of the home is discovered. Thus, one might

Figure 5 ■ Conventional mortgage: expected home equity $h(I)$ versus homeowners' gross investment I in home maintenance etc. (cf. Figure 1). A 45-degree line is also shown.

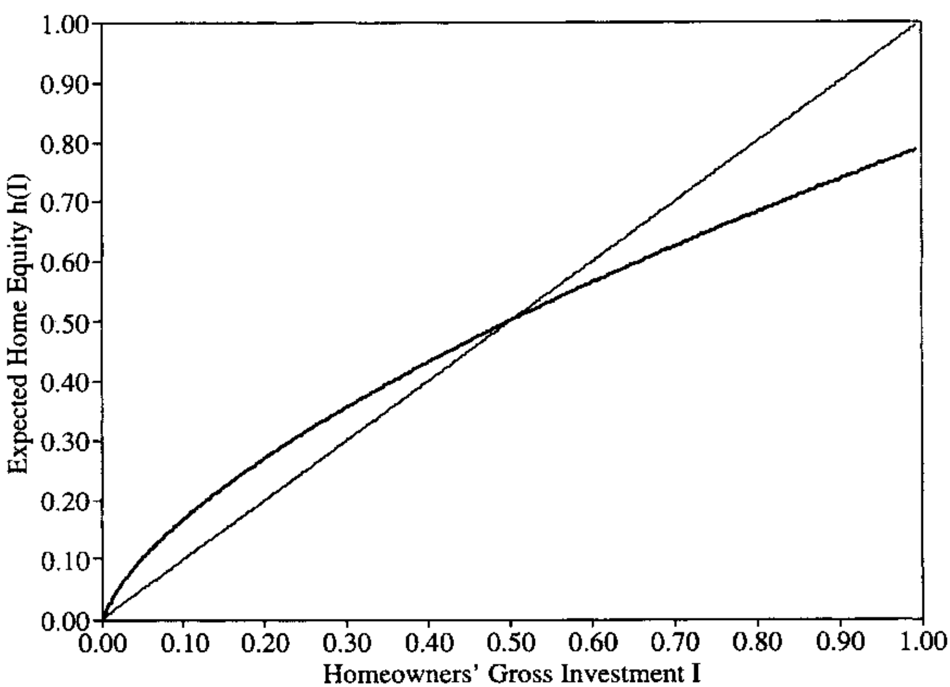
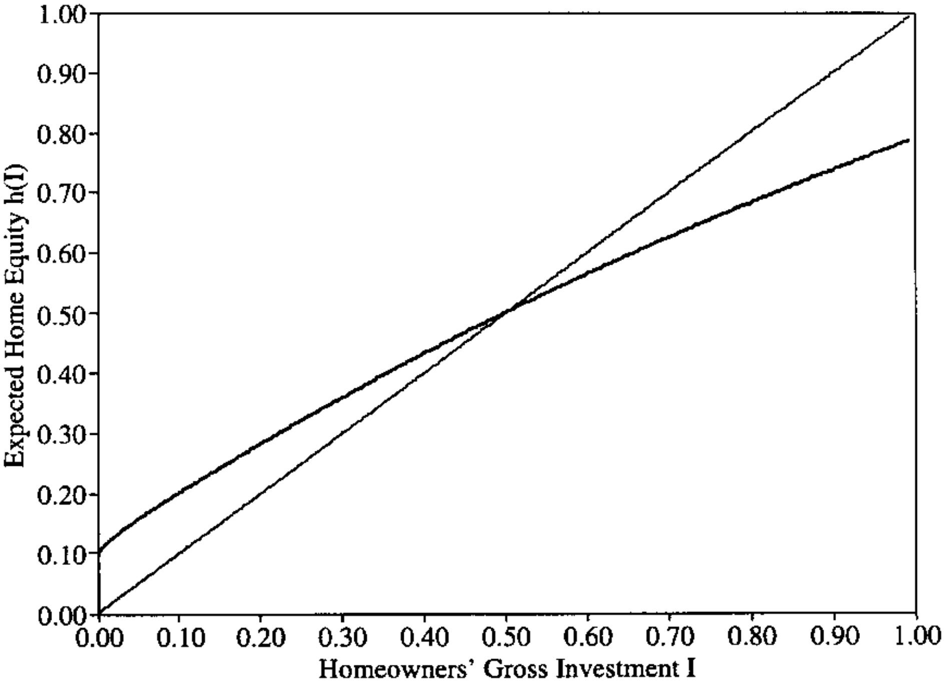


Figure 6 ■ Reverse mortgage or home equity insurance: expected home equity $h(I)$ versus homeowners' gross investment I (cf. Figure 2).

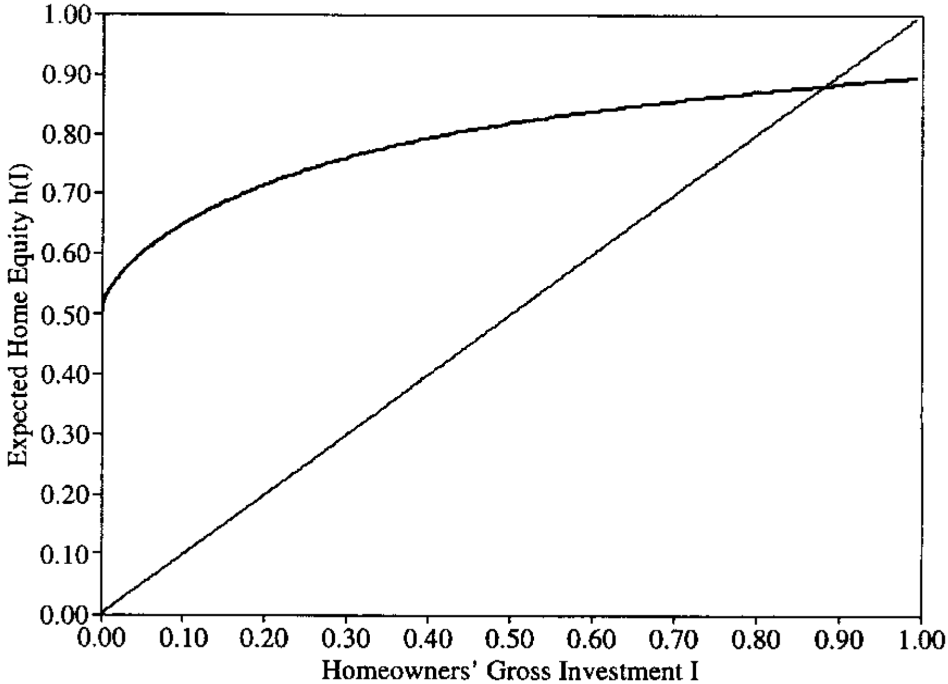


say that all four curves look basically similar in overall appearance, despite their different derivations. They all show an upward slope and a negative second derivative. But this similarity obscures important differences to the homeowners in terms of the implied profit-maximizing behavior.

If $a = 1$, profit maximization means finding the value I at which the $h(I)$ curve is as high as possible relative to the 45-degree line, that is, where it has the same slope. From Figure 5, it is apparent that the point of maximum corresponds to 0.16 in the conventional-mortgage case (as also given in Table 1). This is the case where, as shown above, the homeowner will invest 16% of the value of the home in 8 years, thereby maintaining the home at its original value.

For the other three situations—the situations shown in Figures 2 through 4 and for which the $h(I)$ schedules are shown in Figures 6 through 8—the incentives for the homeowner are very different. In fact, the maximized profit for Figure 6 if $a = 1$ (the case of a reverse mortgage or home equity insurance) occurs where the homeowners invest only 3% of the value of the home in 8 years, and the losses to the home will be large. The reader can check this result visually by noting the level of I in Figure 6, where the

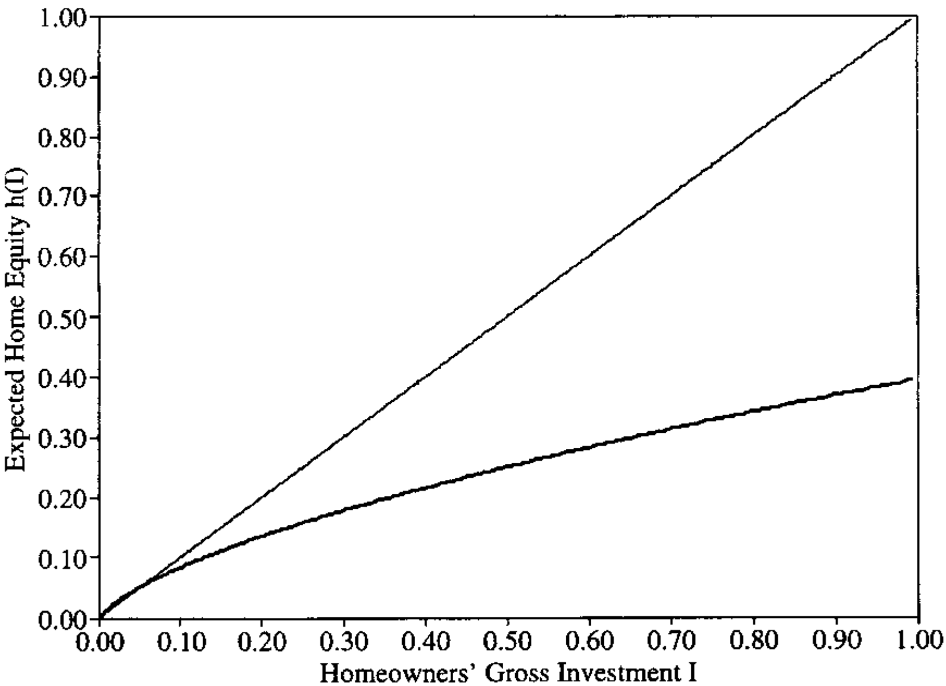
Figure 7 ■ Shared-appreciation mortgage: expected home equity $h(I)$ versus homeowners' gross investment I (cf. Figure 3).



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 16% of its value due to moral hazard. The lender faces an expected shortfall s of 5% of the value of the house (Table 1), and s/L, using (10), of 6% of the amount loaned. The reason for the 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 6 resembles that of Figure 5 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 11% of the value of the home (Table 1), and thus the home will lose 6% of its value on resale. One can visually verify, very roughly, this level of investment for $a = 0.5$ by using both Figures 5

Figure 8 ■ Housing partnership, shared-equity mortgage or sale of remainder: expected home equity $h(I)$ versus homeowners' gross investment I (cf. Figure 4).



and 6, 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 6 is fairly linear and with slope less than

Table 1 ■ Simulation results.

Assumption	$a = 1.0$		$a = 0.5$	
	I	s	I	s
Conventional mortgage	0.16	0.00	0.16	0.00
Reverse mortgage	0.03	0.05	0.11	0.01
Shared-appreciation mortgage	0.07	0.01	0.10	0.01
Partnership etc.	0.02	0.09	0.07	0.05

Note: Table shows the profit-maximizing investment I in maintenance, improvements etc. for the homeowner, and the expected shortfall in value s to the investor due to moral hazard as a fraction of the value of the house for each of two assumptions about the parameter a.
Source: Authors' calculations from simulation described in text.

one except at very low I, the $h(I)$ schedule shown in Figure 5 has a slope that is much greater than one even for I approaching the optimal level of 0.16.

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.

As shown in the table, in the case of a shared appreciation mortgage with $\alpha = 0.25$ (Figure 7), when $a = 1$ the homeowners optimally invest 7% of the value of the home, so that the home loses only about 10% of its value. Note that the $h(I)$ curve in Figure 7 resembles that of the conventional mortgage in the low region (Figure 5), so there is much less incentive to allow the home value to drop sharply than there was in Figure 6. 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. In the case of the partnership, shared-equity mortgage and sale of remainder interest with $\alpha = 0.5$ (Figure 8), the incentives to invest are reduced over the entire range of I. The slope of the $h(I)$ schedule in Figure 8 is scaled down, in comparison with Figure 5, by the factor α. If $a = 0.5$, then the homeowners will invest 7% in the value of the home, and the investors thus face an expected shortfall s of 0.05, so that $s/(1 - L)$ is 25% of their investment. These losses appear very large, of course, since we assume an 80% mortgage for both homeowner and investor. The losses as a fraction of the investor's outlay would be of course much lower if the investor did not borrow.

The declines in home value suggested by our calibration are sometimes quite large, but in other examples they are small. This shows that superficially similar alternative forms of home equity conversion may have very different moral-hazard effects. Moreover, the uncertainty we face in estimated moral hazard may be large, since we have made a lot of assumptions to get these results.

For example, we have made an assumption about inflation over the life of the home equity conversion contracts. In an inflationary period, with non-indexed 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 paydown 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.

In sum, we believe that our simulations using the calibrated model are indicative of the potential moral-hazard costs caused by home equity conversion, and of the kinds of factors that determine these costs. Still, the precise numbers we have produced for specific forms of home equity conversion have to be interpreted with great caution.

Implications of this Analysis for Contract Design

Let us consider the kinds of modifications, involving home price indexes, that could be made in the home equity conversion contracts analyzed to reduce or eliminate the moral hazard posed by the contracts, and consider how well these modifications are likely to work. In all cases, we must weigh the moral-hazard costs of settling contracts on the price of the individual homes against the basis-risk costs of settling the contract on an index.

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 indexing, wholly or in part, the debt to the real estate price index. Indexing partially rather than wholly would help with basis-risk problems, while being less effective against moral-hazard problems. 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 one of his or her risk management objectives: protecting him or her against any effect of aggregate real estate market fluctuations. To analyze the effects of such indexing, we can use the same framework as above, merely reducing the estimate of σ, so that it reflects only the relative-price noise of the house, not the full noise. Of course, moral hazard 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 1999). This indexing would completely eliminate the moral-hazard problem. Since it reintroduces a basis-risk problem, we might also consider home equity insurance that settles partly on the home's own value.
3. *Shared-appreciation mortgages.* With these mortgages, it is clear again that the amount owed for appreciation to the lender could be measured all or in part by a real estate price index. If the amount is determined entirely by the index, then 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.* To reduce moral hazard, the investor might avoid buying too high a fraction of the home, and homeowners can pursue other means of reducing the risk of the remainder of their home, such as home equity insurance settled on an index. Or the partnership contract can be specified so that it settles partly on an index. There can be a formula specifying that the managing partner benefits if the selling price is high relative to the index.
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 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

To appreciate the measurement difficulties that we have been dealing with, consider the analogous issue of estimating the effects of rent control on maintenance of apartments. Rent control has potential moral-hazard effects analogous to those studied here, and there are decades of data available about the experience with rent control. And yet, after surveying the substantial empirical literature on the effects of rent control on maintenance, and pointing out fundamental problems with the data and estimation, Arnott (1995, pp. 114–115) concludes that

> The rather depressing conclusion is that little has been learned to date about the positive effects of second-generation rent controls in North America. . . . Direct econometric estimation of the effects of second-generation controls is fraught with difficulty. Consequently, little confidence should be placed in forecasts based on such regressions. Simulation may offer a more promising approach to forecasting the effects of second-generation rent controls since it permits the integration of empirical knowledge and *a priori* reasoning.

We have attempted such a simulation here for the effects of home equity conversion on moral hazard, and believe that it indicates a range of plausible 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 indexes and whether we have modeled moral-hazard behavior accurately. We will leave these issues for further research, after describing them.

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, while we observe only actual prices that are influenced deliberately by the homeowner. 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, we cannot rule out basis risk as a problem, and so perhaps consideration should be given to hybrid home equity conversion forms that depend both on actual home value and on price indexes. Research can also be done developing finely defined price indexes, for homes of specific characteristics, to reduce basis risk and serve as the basis of settlement of home equity conversion contracts.

The actual moral hazard we will experience with home equity conversion forms is, despite our modelling efforts, hard to measure. We have assumed a form for the investment function that translates investments into home value, and assumed as well that individuals always behave optimally in their own self-interest with full knowledge of this functional form. 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 might be smaller at first than predicted by our model and then 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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