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HOME EQUITY INSURANCE

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ABSTRACT

Home equity insurance policies, policies insuring homeowners against declines in the price of their homes, would bear some resemblance both to ordinary insurance and to financial hedging vehicles. A menu of choices for the design of such policies is presented here, and conceptual issues are discussed. Choices include pass-through futures and options, in which the insurance company in effect serves as a retailer to homeowners of short positions in real estate futures markets or of put options on real estate. Another choice is a life-event-triggered insurance policy, in which the homeowner pays regular fixed insurance premia and is entitled to a claim if both there is a sufficient decline in the real estate price index and a specified life event (such as a move beyond a certain geographical distance) occurs. Pricing of the premia to cover loss experience is derived, and tables of break-even policy premia are shown, based on estimated models of Los Angeles housing prices 1971-91.

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In this paper we describe insurance policies to enable individuals to protect themselves against the risks of declines in the price of their homes. As far as we have been able to determine, there is no precedent for true insurance policies on home price.[1] And yet, despite the neglect of such home equity insurance policies in the past, these policies could be extremely important. The risk of decline in the market value of homes is far greater than the risk of fire or other physical disaster; the potential significance of an insurance industry that protects market value of homes is much larger than that of the existing homeowners property insurance industry.

Since such insurance products have never really been attempted, there are some fundamental problems to be worked out. There are two basic categories of problems, which we will attempt to address here. The first is the economic problem: creating policies that serve the particular needs of homeowners well. We must make sure that the insurance policies cover as much of the homeowners' risk as possible without creating excessive moral hazard problems, and that the policies appropriately address the owners' uncertainties about selling the home or otherwise making use of the home equity. The second is the marketing problem, making the policies attractive to homeowners. Households may have difficulties in dealing with speculative markets, difficulties in confronting and managing speculative price movements. Policies that are attractive to homeowners could be designed to minimize these difficulties. We may also include under the category of marketing problems the preconceived notions among the general public and regulators as to what constitutes a credible insurance policy; the public will be more likely to buy a policy that resembles others that they have learned to accept.

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[1]There are innovative home equity assurance programs in the Chicago area, see below. There are also shared-appreciation mortgages and risk-sharing reverse mortgages.

At the time of this writing, derivative markets for real estate are being developed.[2] It is appropriate at this time to consider how such markets could be used to help insurance companies issue home equity insurance policies, by allowing the insurance companies to manage the risks that they incur by writing the policies. Still, we think that home equity insurance might well be an attractive product for insurance companies even if real estate derivative markets fail to develop.

We do not believe that it is possible to settle at this time on a single kind of insurance policy, and so we will here merely offer a menu of alternatives, listing the advantages and disadvantages of each. Indeed, ultimately, a number of different kinds of policies would likely be offered, to cater to the different preferences and situations of different homeowners.

I. Basic Conceptual Issues

The insurance industry and the securities (and derivatives) industry are essentially both in the same line of business — helping people manage risks. And yet the institutions are fundamentally different in these two industries. One important difference is in the payment structure of the risk-management contracts. The insurance contracts traditionally pay out only when an unexpected casualty is incurred, usually a rare event. In contrast, holders of securities contracts in effect see the value of their accounts change (positively and negatively) whenever the market price changes, in principle every minute of the day.

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[2]Some private risk management policies for real estate have been implemented. The London Futures and Options Exchange attempted to start a futures contract in residential and commercial real estate in 1991. Morgan Stanley & Co., Inc. and Aldrich, Eastman and Waltch, L.P., in 1993 completed a swap of commercial real estate appreciation for an interest rate. We are working with the Chicago Board of Trade to develop futures and options products in real estate.

Business events affecting the value of securities, such as shares in corporations, are usually not sudden and are not even objectively verifiable, and so traditional insurance contracts cannot be written on these events. Thus, risk management for owners of financial assets consists not of buying an insurance policy against business risks to the firms issuing the financial instruments, but of hedging in financial markets. The investor in a financial asset may take a short position in a futures market or buy a put option on the financial asset held. The price movements in the financial markets create an objectivity to the news, so that the owner of the financial asset can in effect receive payment on a "claim" whenever bad economic news reaches the market. Financial markets thus in effect insure against bad economic news even though the news itself is not objectively verifiable.

Most economic risks to the value of real estate, like the risks to values of shares in corporations, are everyday and hard-to-define events, and are inherently similar to these financial risks, rather than to risks that are traditionally handled by insurance companies. Depending on how the contracts are structured, home equity insurance claims might tend, in effect, to come every day, like returns on speculative assets.

Because of the tendency for house prices to change gradually, traditional insurance contracts cannot be written without some attention to the nature of the time-varying information about the likelihood of claims. Consider insurance policies insuring the risk of loss at time of next sale of the home for which the homeowner pays a regular insurance premium. Such policies must have some restrictions on the freedom of insurance companies to raise policy premiums on existing policies. If insurance companies could raise premiums on existing policies as much as they wanted whenever they wanted, then they could raise the premium to such levels as to force cancellation whenever aggregate real estate price indexes had declined enough to make claims appear likely. The potential for such behavior of insurance companies would be to negate the insurance function of the policies. Designers of insurance policies would have to impose some rigidity on policy premia or else abandon the concept of charging a regular premium for insuring the risk of loss on next sale of the home. Imposing such rigidity on the policy premium makes the insurance contract share some characteristics of a put option, in which the cost of insurance is settled at the beginning of the contract. As with the put option, the insurance policy gains and loses value as the home price falls or rises.

Even though risk management via home equity insurance has resemblance to risk management in financial markets, risk management for real estate is different from that of many other speculative assets, in that the market for real estate is very difficult to trade in, very illiquid. The result of this lack of liquidity is that the real estate market is not efficient; real estate prices are somewhat forecastable. A price decline in the real estate market may not be "news," since price changes are partly known in advance. If a price decline is already expected, then insurance companies cannot insure it.

Forecastablity of Real Estate Price Changes

For the purpose of clarifying the importance of the inefficiency of housing markets for risk management, we estimated a simple forecasting model for real estate prices using Los Angeles annual price index data for each year 1971–1991. The annual price index was the Case–Shiller quarterly price index for the first quarter of each year. The estimated regression model is:

$$\begin{array}{c} \Delta\ln(P_t) = \underset{(0.028)}{0.037} + \underset{(0.209)}{0.635}\,\Delta\ln(P_{t-1}) + \varepsilon_t \\ \sigma_\varepsilon = 0.068\ ,\quad R^2 = 0.758\ ,\quad n = 19 \end{array} \qquad (1)$$

Standard errors are shown in parentheses. Note that the coefficient of the lagged dependent variable is significantly above zero, indicating that this price series is not a random walk; rather, price changes tend to continue through time, therefore there is inertia in real estate prices. Such inertia in real estate prices has been confirmed by Case and Shiller [1989, 1990], Poterba [1991] and Kuo [1993] for the United States, and Ito and Hirono [1993] for Japan.

This simple model implies an unconditional mean annual log price increase of 10.14% (computed from the above model as 0.037/(1 – 0.635)). It implies that whenever the annual price change differs from that mean, then 0.635 (or nearly 2/3) of that difference is expected to continue for the next year. This autoregressive model can also be written in moving average form:[3]

$$\Delta\ln(P_t) - 0.1014 = \varepsilon_t + 0.635\varepsilon_{t-1} + 0.635^2\varepsilon_{t-2} + 0.635^3\varepsilon_{t-2} + \cdots \quad (2)$$

Since ε_t is in this model serially independent, the variance of $\Delta\ln P_t$ is the sum of the variances of the terms on the right hand side; this sum equals $(0.068^2/(1 - 0.635^2)$ or .0077. The one-year-ahead uncertainty about $\Delta\ln P_t$, however, is due only to uncertainty about ε_t, the lagged terms are already known. Thus, the variance of the one-year-ahead uncertainty about $\Delta\ln P_t$ is only $.068^2$, or .0046, only about 60% of the total uncertainty of 0.0077. For this reason, rolling over one-year risk management contracts may fail to insure a substantial part of the total risk, unless the quantity rolled over is grossed up, as described below. The situation is a little better with two-year contracts. At t–2, both ε_t and ε_{t-1} are unknown; the total variance of these two terms is .0066, or 86% of the variance of one-year price change. This is a substantial improvement in the fraction of the variance that is insured; there is in this sense an advantage to longer-horizon contracts.

With the particular stochastic process (1), it would still be possible for a homeowner to hedge, even with short-term hedging vehicles, all of the risk of

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[3]In using this model, we are disregarding measurement error in house price indices, an error that introduces an errors-in-variables problem in the above regression; see Case and Shiller [1989]. The annual changes in the Los Angeles price index here, however, are very well measured, with standard errors substantially less than one percent.

price changes in the home by grossing up the hedging, by hedging more than one home. Note that it follows from (2) that the innovation at time t in (natural) log price at time $t+n$, that is $E_t\ln(P_{t+n}) - E_{t-1}\ln(P_{t+n})$, equals $((1-\rho^n)/(1-\rho))\varepsilon_t$. Regardless of n, the innovation at time t is proportional to ε_t, but the larger n the higher the constant of proportionality. The change in the futures price between $t-1$ and t is by many models directly related to the innovation at time t in the price at the maturity of the contract. Thus, shorter horizon futures contracts could be used to hedge long horizon risk by just hedging more (according to the constant of proportionality) in the short contracts than one would in longer contracts. However, stochastic models of price other than (1) may not share this implication; if, for example, the model implied that prices were fully known one period ahead, then one-year futures contracts would be useless for hedging purposes.

The predictability of real estate prices has the potential to complicate the process of hedging real estate risk beyond the level of complexity hedgers already face in existing financial markets. This added complexity might also make it difficult for insurance companies to explain home equity insurance contracts, which are analogous to these financial hedging vehicles, to their public.

Liquidity and Time–Management Problems

A conventional futures market requires that contractors (both short and long) post margin, and see their margin accounts debited and credited on a daily basis in response to changes in the futures price. Many people will find it difficult to come up with the cash for a margin account under today's institutional arrangement. Moreover, the bother of having to deal with margin calls is probably onerous for ordinary households. Homeowners could escape frequent margin calls by posting a high initial margin, but posting large margin may be difficult for homeowners.

Effective use of conventional financial hedging vehicles for risk management requires concentration and attention. For example, conventional (American, exercisable on any date until the exercise date) put options have the problem that the owner of the option must deal with the fact that it may be advantageous to exercise early, and the same would be true with put options on real estate. In those times when real estate prices are expected to rise through time, since the strike price is fixed through time, the put is expected to move out of the money, and holding a put option to maturity will generally be a bad prospect; option holders must be prepared to exercise early. The ability to exercise early creates problems for households, as they must then monitor the put price and decide whether it is time to exercise early. The problem could be prevented by making the put options European, i.e., specifying that they cannot be exercised early as can American options. But this solution might not be a good one unless the options effectively are marketable, since a homeowner who decides to move will then want to get out of the option contract. And if the options are marketable, then the household begins to see problems that resemble those of other speculative assets; homeowners would feel the need to consider whether the option should be sold for speculative purposes; the option creates burdens of time and attention for households.

A household may not be able, in times of high risk to real estate prices, to afford the price of a put option initially, and would be forced to buy the put on margin. But this would then mean that the household would perhaps be unable to meet margin calls.

Ultimately, it must be recognized that homeowners are not likely to begin to behave like financial managers; they do not have the training or mental set to behave so. Any product that is sold to them must be in effect managed for them; the product must be designed so that little or no initiative is expected from the homeowner.

Because of the difficulty of managing hedging vehicles, it may be natural for households to buy or sell contracts only at the time of purchase or sale of the home, or at the time of refinancing of their mortgage. Given this, it would be desirable to limit the risk management problem to one that appears only at these times, and to combine the risk–management contracts with contracts that are entered into at these times. At these times, the homeowner has legal counsel and advice of others that would naturally be used to help make an informed decision about risk management contracts as well. There are two kinds of major contracts that a homeowner enters into at this time: the mortgage contract, and the homeowners insurance contract; either could be attached to a home equity insurance policy, or the policy could be a separate product that is marketed at this time. If home equity insurance is attached to mortgages, then it might serve marketing to sell only down-payment insurance on mortgages, rather than price insurance on homes. This could mean that an in-the-money put would have to be attached initially to the policy, and the put would grow increasingly out-of-the-money, if only the downpayment is to be insured, as the person pays off the mortgage. The homeowner would have only the initial downpayment protected, not the amortization of the mortgage. Restricting the policies in this way could bring down their cost, and facilitate the marketing as part of a mortgage.

Making Insurance Contracts Assumable or Transferable

In the public mind, there is a sharp distinction between speculative assets and insurance policies. A home equity insurance policy that too much resembles a speculative asset may not be accepted by the public, or regulators. And yet, we want to avoid policy provisions that lock the homeowner into an existing policy or home.

It is possible to make home equity insurance policies effectively marketable without turning them into speculative assets that the homeowner might feel the need to buy and sell often: make the policies assumable by the next purchaser of the home. If the insurance policy is assumable, then the new homeowner would not have to pay any additional or higher insurance premiums than were specified under the original policy. When home prices fall or are expected to fall, the existing insurance policy may become more valuable, and this extra value could become part of the package sold with the home.

Assumable fixed-rate conventional mortgages were widely available until a 1982 U.S. Supreme Court decision (Fidelity Federal Savings v. Dela Cuesta) ruled that lending institutions may enforce due-on-sale clauses. These mortgages became unavailable then, but they have since reappeared in 1993. Their attractiveness to homebuyers is certainly enhanced by the low current market interest rates, and this attractiveness is now beginning to be exploited.[4]

Assumable mortgages and assumable insurance contracts are effectively marketable by the homeowner only when the home is sold, and this feature of the mortgages intertwines the marketing of the mortgage or insurance contract with the marketing of the home. There is no appearance that any speculative asset (other than the home) is being sold, and yet the selling price of the home would generally be affected by the presence of an assumable policy, so that the policy is effectively marketable as part of the home sale. An issue that would arise, however, if these policies were marketable is that the new owner of the home would have to come up with the purchase price equal to the intrinsic value of the home plus the present value of the assumable policy. Therefore, the buyer would need to convince lenders of the value of the policy if it is to serve as part of the collateral for the loan.

The issue of assumability of home equity insurance policies mirrors that of the assumability of mortgages. Assumability prevents a locked-in effect, wherein a homeowner may sometimes feel that he or she cannot move without

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[4]DMR Financial Services in 1993 started offering assumable fixed-rate conventional mortgages for midwestern homebuyers.

losing a valuable contract. Making the policies assumable makes them serve the homeowners' needs better, but on the other hand, makes the policy premium higher. The public reception of the insurance policies might be maximized by offering both assumable and non-assumable policies (the former having a higher premium) and letting the homeowner choose between them.

An alternative to making the insurance policy assumable is to make it transferable when the homeowner moves. There would then have to be a mechanism, specified in the original policy, that determined the provisions of the transferred policy, so that the approximate value of the existing policy is transferred to the policy on the new home. This mechanism might be related to prices in futures or options markets for real estate; even though such a mechanism in the original policy connects the policy to speculative markets, the relation is probably not one that would cause most homeowners to see their policies as speculative assets.

Moral Hazard and Selection Bias Problems

In insuring the resale value of an individual home, the insurance company must confront the fact that the value is influenced by a number of factors under the control of the homeowner. Moreover, in insuring the value of an individual home, the insurance company must worry that an unrepresentative sample of homeowners will choose to become insured.

A homeowner who knows that all losses in value of the home are borne by the insurance company will have much reduced incentive to maintain the home properly; this is the moral hazard problem. To prevent this, there could be terms in the insurance contract that allow the insurance company to reduce payment on claims if there is evidence that the homeowner has not maintained the property properly. Still, much of the value-maintaining activities that should be undertaken by homeowners are not objectively verifiable. The dates when many maintenance activities (such as painting the home or replacing the roof) should be undertaken is a matter of judgment. Thus an insurance company may find it difficult to prove fault of the homeowner for not doing these prior to sale of the home, even though failing to do these may adversely affect the selling price of the home. A homeowner may redecorate or remodel the home to idiosyncratic tastes, without concern for the resale value of the home, and the loss of value on resale would be borne by the insurance company.

There is a selection bias problem in that a homeowner who feels that he or she paid too much for the home, and could not sell it for the same price, would have a special incentive to buy home equity insurance, thereby putting the expected loss onto the insurance company. The impact of this selection bias problem could be reduced if the insurance company were to require one or more independent appraisals of the home value at the time the insurance contract is initiated. However, the appraisers cannot completely solve the selection bias problem, since they do not know all the factors that contribute to home value. The appraisers mistakes will then tend to result in losses to the insurance company.

The combination of the moral hazard and selection bias problem could potentially make for very large losses to the insurance companies. Homeowners who have an incentive to take advantage of home equity insurance programs could seek out such policies, and then poorly maintain their homes. There could even be non-arms-length purchases and sales at nonmarket prices, to defraud the insurance companies. Vigilance would have to be maintained about all these potential problems, and such vigilance will impose costs on the insurance companies.

Both the moral hazard and selection bias problems can be reduced, though not eliminated, by coinsurance, by offering only policies in which the homeowner shares part of the loss. The selection bias problem can also be reduced somewhat by making sure that policies are evenly geographically distributed, and not concentrated in certain neighborhoods.

Another way of dealing with these problems is to offer insurance not on the change in price of the individual home, but on the change in a real estate index for the neighborhood in which the home is situated. The index could also be made specific to the type (e.g., whether house or condominium) or size of the home. This method ought to completely eliminate the moral hazard problem and, so long as even geographical and type distribution is maintained, the selection bias problem as well. Such policies would be very inexpensive to offer, as no appraisals and no monitoring of the homeowner's behavior, are needed. The insurance company might completely diversify risk in derivative markets cash settled based on the real estate price indices. A disadvantage of this method is that the geographical indices make some errors in predicting individual home price changes, so that the homeowner is not completely insured against losses on sale of the home.

The two methods of dealing with these problems could also be combined: there could be complete insurance of the price change that is due to aggregate market conditions and coinsurance for the deviation of the home price from the price change inferred by the index.

In what follows, we will assume that the home equity insurance policy is based on the change in the real estate price index, and not on the price of the individual home.

Cancelability of Policies

Conventional insurance policies can be cancelled at will by the purchaser. It would seem natural, therefore, to make the proposed new policies cancelable at any time too. However, making policies cancelable introduces a new element of uncertainty for insurance companies, that of predicting when policyholders will cancel. This uncertainty for insurance companies mirrors the uncertainty that mortgage lenders face in predicting when homeowners will prepay their mortgages. For mortgage lenders, prepayment uncertainty is a risk that cannot be hedged well on conventional interest rate futures or options markets. By the same token, cancellation uncertainty is a risk that cannot be hedged well by insurance companies on real estate price futures or options markets.

The uncertainty about cancellation of real estate price insurance policies may be especially difficult to deal with because it may reflect strategic behavior on the part of homeowners. Homeowners may cancel their policies just when real estate price indexes have risen a lot, suggesting that it is unlikely that they will have a claim under the original policy. They may also at times suspect that real estate prices will rise; since real estate markets are essentially inefficient, and since real estate prices show some inertial behavior as we have seen, there may be times when they have good reason to know that they should cancel. If insurance companies had previously contracted under assumptions that people would not cancel, they may suffer a serious loss.

Indexation of Policy Premiums and Floors

Ideally, policies should be fully indexed for inflation, as measured by a cost of living index such as the consumer price index. The policy should insure against *real*, not nominal loss in value of the home, and the insurance premium should be specified in real terms.

Now, most contracts today do not involve cost-of-living clauses, and so one might imagine that the market is not ready for such clauses. But, the importance of providing for changes in the cost of living is not so important for other kinds of insurance as it is for home price insurance. The most common risk that people face with their homes in an inflationary economy is not that nominal home prices will fall, but that the nominal home prices will not keep up with the cost of living. In, let us say, a period of 10% inflation as measured by the cost of living, a homeowner whose property did not increase would find that there were substantial real losses, that would not have been insured by a policy on nominal prices.

Ideally, the indexation of policy provisions should be made part of the first standard policy that is offered, and not be made just an option. The general public is likely to purchase the inflation protection only if it is presented as the recommended choice, not just as another option. At a time of major institutional change, we should try to get the initial contracts specified optimally, so that imitators will be more likely to follow this course. On the other hand, it may be harder to market indexed policies initially because they will tend to have higher policy premia in an inflationary economy.

The importance of indexation to the homeowner may depend in part on whether the homeowner has a fixed-rate or floating rate mortgage. With a fixed rate mortgage, the debt is defined in nominal terms, and so it may be more natural to insure the nominal value of the home. With floating rate mortgages, where the interest rate responds to news about inflation, the debt is more nearly defined in real terms, and then the homeowner may wish to have an insurance policy defined in real terms.

II. Antecedents of Home Equity Insurance

We have not heard of any prior attempts to create comprehensive insurance against declines home equity, but there have been attempts by local governments in the Chicago area to offer insurance against part of the risks to home equity.[5] In 1978 the village of Oak Park Illinois, a suburb of Chicago, created an "equity assurance" plan in which participating homeowners who have been enrolled for at least five years are reimbursed, when they sell their

[5] The shared-appreciation mortgages (see Ballew [1988]) and risk-sharing reverse mortgages (see Scholen [1993], Passell [1994]) have aspects of home equity insurance in them. Both are potentially important institutions for price risk management; neither has yet become a nationally significant institution.

home, for 80% of the loss incurred if the home was sold for less than the appraised value and if the loss was not due to an extended decline in the metropolitan area. The participating homeowner is not charged any insurance premium, and must pay only a $90.00 fee for the initial appraisal; the program is financed by a small tax levy on all property owners in the village. This program was created as part of a concerted effort by the village to prevent neighborhood decline at a time of racial change, an effort that also included such other measures as prohibition of for-sale signs, village inspections of exteriors of homes, and laws against realtors' steering of homebuyers, see Goodwin [1979].

A similar program, the "home equity assurance program" was created by a voter referendum in the city of Chicago in 1987 and began in 1990. It insures participating homeowners against all of the decline in value that is due to changes in neighborhood conditions. With this program, any precinct that voted to participate in the program has had an insurance fee, $6 to $25 depending on appraised value, added to the tax bill of each resident. However, only those homeowners in the precinct who have individually enrolled in the program and paid for an appraisal (at $150) are covered by the insurance. Those who enroll in the program have the right, after five years, to be reimbursed for any loss due to decline in neighborhood conditions. As with the Oak Park program, the program insures homeowners only against price declines due to changes that are isolated to that neighborhood. The law that created the program states that the program does not insure against any municipal-wide decline in value. In a sense, the Chicago program (like the Oak Park program) is the complement of, rather than substitute for, the index-based home equity insurance proposed here: the program explicitly excludes the risks that we propose to insure.

The Oak Park Program has never yet had a single claim; there has been no major price decline in Oak Park since the beginning of the program. Since the Chicago program has not existed for five years yet, there have been no claims there either. The experience of these programs thus does little to establish the viability of privately-issued home equity insurance.

The primary motivation for the Chicago area programs was to stem the outflow of responsible residents due to declining neighborhood quality. The hope was to break the vicious circle whereby an initial decline in neighborhood quality causes people to try to sell for fear of home price declines, thereby lowering the prices of homes, discouraging homeowner's investment in their own neighborhood, and therefore generating more declines in neighborhood quality. Such a vicious circle is widely held to be a mechanism whereby good neighborhoods are converted into slums.[6] As such, and with the very low premiums, the programs are more naturally city, rather than private, initiatives.

The Chicago experience, while innovative, does not appear to be a reliable model for private insurers to follow. Whether a home's price fell due to a decline in neighborhood quality is a very subjective notion; there will inevitably be disputes. The Chicago programs have not been tested enough to represent a valid precedent for other policies.

The Chicago programs have been a modest success in one sense: about three percent of eligible homeowners in Chicago have participated in the programs, about one to two percent of homeowners in Oak Park have participated. Still, while a few percent is enough of the population to make such programs worthwhile, we might hope for more participation. The Chicago area programs define the risks too narrowly, to exclude losses due to changes in market conditions. The programs were not managed by professional private insurance companies, and there are no financial incentives provided to realtors, lawyers or mortgage lenders to enroll homeowners in the program. The programs have no commission salesmen; homeowners must themselves take the

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[6] See Kelly [1991] for a discussion of these claims.

initiative to enroll. Many homeowners have been under the mistaken impression that they are automatically enrolled. Moreover, some homeowners have been deterred from taking action to enroll out of fear that having their home reappraised might result in a higher assessed value and therefore higher property taxes. The public demand for home equity insurance might be much greater with policies marketed well by private insurers.

III. Pass–Through Futures and Options

The home equity insurance products that offer the least risk to the insurance companies are those in which the insurance company is able to sell off the risk that they incur in writing the policies. If, as we expect will happen before too long, there are futures and options markets on real estate price indices, then an insurance company could create insurance products that are based on the contracts traded in such markets passed through to the homeowner. While at the present time there are likely to be regulatory obstacles to insurance companies serving as retailers of futures and options products, it is still important to consider the concept of such policies, leaving regulatory issues to later discussion.

The simple pass–through futures and options insurance policies would constitute the marketing, by the insurance companies, of the kinds of real estate contracts that we envision may shortly be trading at the Chicago Board of Trade. If the insurance companies are essentially selling market-traded contracts to the public, then they may completely hedge, in the options markets, their underwriting risks related to these insurance policies.

With the pass–through futures, homeowners will see their accounts debited or credited every day depending on the change in the real estate futures price on which their policy is based. Such insurance policies would get homeowners completely out of price risk on their homes, both on the upside and the down-side. Such insurance contracts are potentially useful to homeowners, but there may be some resistance among homeowners to giving up the upside potential of their homes, resistance to paying money to the insurance company if the values of their home increase. Such policies sound very unlike existing insurance policies.

With the pass–through options, homeowners keep the upside potential for appreciation of their homes, and are effectively insured against losses. Homeowners may be offered by their homeowners insurance company, or via their mortgage lender at the time that they buy their home, put options on real estate price indices in their city, in proportion to the purchase price of their home. Let us suppose that the put options have a maturity of two years. At the end of two years, the payout by the insurance company would be exactly the decline in value of their home (as inferred using the price of the home at the time the insurance policy was written and the city-wide index of home prices) below the exercise price, or floor, of the option. If the price of the home (inferred by the index) did not fall below the floor, the homeowner would not have a claim. The payment would be made ultimately by the writer of the option, not the insurance company, which only passes through the payment. Thus, the insurance company incurs no risk in writing these policies.

The two-year maturity for the option was suggested for this example because, as seen with our simple forecasting model equation (1), most of the two-year-ahead price change is unknown today. This time horizon also seemed a good choice for our example, since most people would not want to sell a home in much less than two years from the time of purchase, and two years represents something like the time frame for planning whether to move or not. Of course, there is no reason why they would not want a longer insurance horizon than their planning horizon, but the two-year (or perhaps three- or four-year) horizon may have a sort of intuitive attractiveness to it, we think, and this is what matters for marketing purposes. Many existing market-traded options are traded with two-year horizons.

The pricing of options on real estate price indices introduces some difficulties not encountered in pricing options on securities. We cannot use the conventional Black–Scholes [1973][7] option pricing formula or its analogues to price these, since these formulas rely on the fundamental assumption that the price of the underlying asset is a Markov process. With the Black–Scholes formula, the price of the option depends only on the current price, not lagged price, of the underlying asset, but clearly prices of options on real estate will depend also on the recent trend in prices. There is also another problem with the Black–Scholes analysis. The Black–Scholes formula also relies on the assumption that costless continuous arbitrage is possible between the option market and the market for the underlying asset: with real estate this assumption is obviously unacceptable; transactions costs in real estate are enormous.

The derivation of prices of options on assets whose returns are predictable here differs from that proposed by Lo and Wang [1994], who used an arbitrage pricing argument to derive their option prices. They noted that the original arbitrage pricing formulation of Black and Scholes [1973] still provides the same option price for given variance of returns even if expected returns are predictable; options prices are not affected by expected returns, or by lagged returns, once the underlying price is given. However, this conclusion follows from the assumption that the underlying asset price is costlessly tradable and is Markov. Under their assumptions, it follows that the option price is a simple nonlinear transformation of the price of the underlying (and time) and hence will generally tend to share, in a sense, any inefficiencies that are found in the underlying market. This conclusion is strongly at odds with our presumption that transactions costs are much lower in the options market than they are in the real estate market. The same inefficiencies should not be expected in both

[7]See also Ingersoll [1987].

markets. It is of course possible that the creation of a derivative market in real estate or of home equity insurance might alter the stochastic properties of home prices, and might make home prices more efficient.

To price the real estate options, we will use here, in the tradition of the early literature on options pricing of Sprenkle [1961], Boness [1964] and Samuelson [1967], the simple assumption that the value of the European option is just the present value of the expected payout and the assumption that prices are lognormally distributed. The formula we derive will also have an interpretation in terms of the more modern theory of options pricing out of equilibrium of Constantinides [1978] and McDonald and Siegel [1984].[8] To derive this present value, we use the expression for the truncated mean E(z; $z < a$) for the lognormal distribution f(z) where μ is the mean of ln(z) and σ^2 is the variance of ln(z):

$$\int_{-\infty}^{a} z f(z) dz = e^{\left(\mu + \frac{\sigma^2}{2}\right)} N\left[\frac{\ln(a) - \mu}{\sigma} - \sigma\right] \tag{3}$$

where N(·) is the cumulative normal distribution function. The present value of the expected payout of the put option is the present value of the exercise price times the probability of exercise minus the present value of the expected price of the underlying when the option is exercised. The probability of exercise is the probability that the price of the underlying is less than X; this probability can be calculated using the ordinary cumulative normal distribution function. The present value of the price of the underlying when the option is exercised is derived by substituting values for μ (the expected change in the log real estate price index between today and t periods from today) and σ^2 (the variance of the change in the log real estate price index between today and t

[8]A survey of the issues here, where the underlying market may not be efficient or in equilibrium, may be found in O'Brien and Selby [1986].

periods from today) into the above equation and using X, the strike price, for a, and premultiplying by the discount factor e^{-rt} where r is the discount rate and t is the time to maturity. This gives us our real estate put option price w:

$$w(t, X, P, \mu, \sigma, r) = Xe^{-rt}\mathrm{N}\left[\frac{\ln(X/P) - \mu}{\sigma}\right] - Pe^{\left(\mu + \frac{\sigma^2}{2} - rt\right)}\mathrm{N}\left[\frac{\ln(X/P) - \mu}{\sigma} - \sigma\right] \tag{4}$$

where P is the price of the underlying (here, the price of the home as inferred by the real estate price index) at the present time. A similar expression, based on a somewhat different time series model, appears in Sutton [1994]. Note that the formula (4) reduces to the usual Black–Scholes [1973] put option pricing formula in the case where the underlying asset is expected to earn the risk-free rate, $\mu = rt - \tilde{\sigma}^2 t/2$ and $\sigma^2 = \tilde{\sigma}^2 t$ where $\tilde{\sigma}^2$ is the variance in the Black–Scholes formula. As we shall apply this formula, however, we will take μ to be the expected log price change between now and t periods in the future according to an autoregressive model of the log real estate price index, as for example equation (1) above. The formula (4) also reduces to the McDonald and Siegel [1984] pricing formula for options whose underlying asset earns a below-equilibrium rate of return if their equilibrium rate of return equals the risk-free rate.

Let us now do pricing of one- and two-year options described above in terms of the information we have in lagged price changes, as well as the model, given in equation (1) above, of real estate price indices. In the auto-regressive model $\Delta\ln(P_t) = \rho\ln(P_{t-1}) + c + \varepsilon_t$ with error variance σ_ε^2, when we know the log price change over the preceding year then the expected total growth over the next year is $\mu = \rho\Delta\ln(P_{t-1}) + c$ and over the next two years is $\mu = (\rho + \rho^2)\Delta\ln(P_{t-1}) + (2 + \rho)c$, and variance of the log price change over one year is $\sigma^2 = \sigma_\varepsilon^2$ over two years is $\sigma^2 = (2 + 2\rho + \rho^2)\sigma_\varepsilon^2$.

Table 1 shows the one-year, and Table 2 the two-year put option prices at time t for various values of the just-observed price change $\Delta \ln(P_t)$. Note that a two-year put is not always more expensive than a one-year put with the same exercise price. These, or course, are European puts, that cannot be exercised until the exercise date, reflecting our assumption that homeowners will not be bothered with the problems of managing early exercise. With European options, extra time to exercise is not always a benefit, since the longer maturity may force one to postpone exercise until a less advantageous time.

Note that some of the option prices are quite high: when prices have been dropping and when the exercise price is very high, the price of the put must of course be high, since in these cases the purchaser of the option (homeowner) can expect to be paid a large sum in two-year's time. It would seem likely that marketing of options to the general public would be more successful with some of the less expensive options. Some of the options prices are quite low. For example, in a year when prices were unchanged, a two-year put option with an exercise price of $90,000 (corresponding to an insurance policy with a $10,000 deductible) need cost only $255 dollars at time of purchase, or, one might say, $128 per year of the two-year option. The insurance company could charge this price, plus an implicit fee, for expenses, which we disregard in our calculations here, and call it an insurance premium. Homeowners can have 'peace of mind' against price drops for a small sum.

Even an at-the-money two-year put option for a $100,000 home, corresponding to no deductible at all, would only cost, at a time when prices were unchanged, $1429 dollars, $715 per year for the two years of the option. This put price may seem low at first glance for insuring a $100,000 home against any price loss (due to aggregate market conditions). It should be remembered, however, that in terms of actual loss experience in Los Angeles losses of any substantial magnitude have been rare, and those losses that did occur tended to be preceded by prior price declines.

An insurance company might then function as a sort of portfolio manager for the puts, collecting from the homeowner each year an amount of money that guarantees the floor value for the home for the next two years. If they are to keep the homeowners as continuing customers, this means that the insurance company might suggest each subsequent year that the person pay an additional policy premium, and thereby extend the insurance for an additional year. After the first year has elapsed, the original two-year put has been reduced to a one-year put; the insurance company can charge for replacing this with a new two-year put.

Let us trace through a couple of scenarios. Suppose that after a year of unchanged prices a homeowner purchased a two-year put on a $100,000 home with a strike price of $90,000 for the $255 shown in Table 2. Now suppose that log house prices fell by 10%, so that the individual's home fell in value to $90,484. Then the two-year put turns into a nearly-at-the-money one-year put worth $2,971 (this number can be crudely approximated from Table 1 by multiplying $3,585 times .90484); the put is worth much more since it is now at-the-money; there is no longer a deductible when viewed from the new home price. In year 1 the price of an at-the-money two-year European put for a $90,484 home with strike price of $90,000 is $3,868. To extend the option from one year to two, the homeowner would need to pay $3,868 – $2,971 = $897, or $449 for each of the two years remaining. This kind of additional premium may be attractive to homeowners who have just seen the value of their homes fall by 10%.

Alternatively, suppose that, after the homeowner initially purchased the 10,000 deductible policy when the home was worth $100,000, log home prices increased the next year by 10%. The home, purchased originally for $100,000, is now worth, as inferred from aggregate price indices, $110,517. Then the market price of the two-year put for which the homeowner paid $255, now a one-year put, has fallen, from equation (4), to $0: the exercise price is now much further below the price of the home, and moreover, the price increases portend more price increases. The loss of the $255 of course represents the cost of insurance for the past year, when there was a gain rather than a loss on the home. The homeowner is now still insured for another year, but with prices rising, a fall below $90,000 is now extremely unlikely. In this case, it is plausible that an insurance salesman could contact the homeowner for some updating of the policy. At this time, the homeowner might find attractive trading in the old policy for a new policy insuring the $110,517 home against any decline below $110,000; the price of such a policy would be, by equation (4), $295. Again, of course, the insurance company would also collect a fee, to cover expenses, for this service, which we neglect in our calculations.

The scenarios we have just described depict the rolling-over of overlapping relatively short-term puts on the home price. We think that there is plausibly a market for such insurance policies, though only a market test could prove this.

Rolling over short-term puts, however, is not the same as purchasing a single put that expires on the date that the homeowner ultimately sells. The short-horizon insurance premia are as high as they are relative to longer-horizon premia in part because there is a chance that home prices will decline in the next two years, and then, beyond two years, rise back to the initial price before the individual sells. One who had followed the rolling-over of puts may receive a payment for loss after two years, even though there was no ultimate loss, and the initial premium must be high enough so that the insurance company can make these unnecessary payments for such losses. Homeowners may well want to purchase a put option whose exercise date coincides with some life event that relates to their purchase of sale of real estate: for example, they may want an option that matures when they ultimately sell the home and move a distance away. Unfortunately, they do not know when they will ultimately sell and move. But, to the extent that these life events are exogenous random events, the insurance company can pool the risk of uncertainty about exercise dates; this brings us to life–event–triggered insurance policies.

IV. Life–Event–Triggered Insurance Policies

With a life–event–triggered insurance policy, the homeowner will receive payment from the insurance company only when there is indeed a loss experienced by the homeowner. A loss is defined as a situation in which a life event (such as a move to another city) causes the homeowner to suffer from declining prices; normally price declines have no effect on homeowners who continue to live in the same homes. To the homeowner, such a policy is in effect a put option whose exercise date is contingent on this life event, although of course the insurance policies would not likely be called put options to the homeowner.

Insurance companies might be able to charge even lower premiums for life–event–triggered insurance policies than they would for the pass–through options described above, since the life events on which claims are contingent may be fairly rare. Consider a policy for which the life event is defined as the sale of the home. Insuring against losses on sale dates may not be very expensive for insurance companies, if sale dates are randomly distributed, since few people buy at the peak of the market and also sell at the trough.

To give some preliminary indication of the loss experience that insurance companies can expect, we have computed the average annual total claim per home sold twice for insurance policies on $100,000 homes in Los Angeles and New York, where the life event is defined as any sale of the house. We are assuming that the insurance company pays a claim to the homeowner when the homeowner experiences a loss between sales as defined by the index, and when the loss is beyond the deductible. The quarterly data set for both cities runs from 1985 first quarter to 1993 third quarter, a time period that includes some striking price drops in Los Angeles. From the peak in the Los Angeles market in the second quarter of 1990 until the end of the time period, the index declined 21.8%. (The peak to trough decline in the New York index in this sample was 10.3%). A homeowner who purchased a home in Los Angeles for $100,000 in the second quarter of 1990 and sold again in the third quarter of 1993 would have lost, according to this index, $21,800. A $10,000 deductible policy would pay a claim of $11,800 to this homeowner. And yet, the overall loss experience for an insurance company would be drastically smaller than this sale pair would suggest, since this time interval is only one of hundreds of possible time intervals between sales. Table 3 gives the annual average claim (loss beyond the deductible between sales when there is a loss, otherwise zero, divided by 4.17, the average interval between sales) on the assumption that all of the 378 possible sales intervals greater than or equal to two years that are contained within the range of 1985 first quarter to 1993 third quarter occur with equal frequency. The average claim for a $10,000 deductible policy is only $144 per year for Los Angeles and less than $1 per year for New York. The policy premiums could be indeed even lower given that many homes did not sell twice in this period. The policy premiums would be yet lower if the life event definition were to exclude some sales, as sales to buy a nearby home. This simple analysis is meant to be suggestive only; we now turn to formal modeling of the insurance costs.

We envision life–event–triggered insurance policies as resembling ordinary insurance policies in many details. The homeowner pays a fixed annual premium until the homeowner decides to cancel; the homeowner is free to cancel at any time. Coverage continues against losses until the homeowner cancels the policy. The policy has a deductible, which defines a floor below which the policy starts to pay out. The floor is the price of the homes at the time the insurance policy was taken out minus the deductible. If the price of the home, as inferred by the initial price corrected by an index of neighborhood real estate prices in that homes price tier, falls below the original price minus the deductible, and if the homeowner is eligible for a claim on that date, as when the homeowner must move and sell, then the insurance company pays the loss below the floor (as inferred from the price index) to the homeowner and the policy is cancelled. To the extent that the dates at which homeowners become eligible for claims (as by moving) are known, the insurance company, in writing the policies, is in effect writing a number of real estate put options with various exercise dates. The exercise dates would be the dates of eligibility for claims.

It was noted above that it would not make sense to create policies in which the insurance provider has unrestricted ability to change policy premia on existing policies; they would rationally raise premia whenever the real estate price index appeared to be approaching a level at which claims would be paid. We suppose here that the insurance company cannot change the policy premium after the policy is first issued.

Of course, homeowners choose when to sell, and might do so strategically, to take advantage of insurance companies; for the put option interpretation the exercise date may in effect be stochastic and influenced by market prices. But homeowners' willingness to sell for such a reason is likely to be limited, and the policy may be so written that they cannot use their insurance unless they have a real loss. For example, claims generated by home sales may be restricted to instances in which the individual moves more than some threshold distance, say 50 miles. Or, the policy may pay a claim only if the person moves to another area where real estate prices have not fallen as much; the claim could be based on the difference between the price behavior in the region of the insured property and the region to which the homeowner moves. Such restrictions on a policy makes it into a life–event–triggered insurance policy, in that it compensates only for actual losses, and at the same time may make it possible for insurance companies to offer the policies at a lower premium.

A concern is that, even if we try hard to define life events that appear to be beyond the control of policyholders, some policyholders may somehow still manage to influence the life events so that they can collect. For example, a homeowner might deliberately move more than the threshold distance to collect. Liquidity-constrained policyholders may be especially likely to do so. On the other hand, policy holders who are not liquidity constrained may feel no urgency to move in order to collect, knowing that they can do so at any future time. Realistically, we think that, although insurance companies must expect some losses due to policyholders' influencing life events, life events can be defined so that most homeowners will not alter the events in order to collect.

To the extent that life events are really exogenous and predictable for the average policyholder, and if puts of all the relevant maturities were traded in the options markets, then the insurance company that writes the policies could hedge its risk of losses by buying the puts whose expiration dates correspond to expected the life–event dates. Hedging the risk by buying puts eliminates all real estate price risk to the insurance company. It does not, of course, eliminate risks due to the uncertainty about the aggregate frequency of life events. Thus, hedging such insurance risk with real-estate put options is analogous to hedging mortgage portfolios in the treasury bond futures markets. In both case, a price risk is hedged, but a risk as to the cancellation behavior of homeowners is not hedged (in the mortgage case, this is prepayment risk).

In practice, while there has been talk of creating puts on residential real estate, long-horizon puts may not be traded soon. Other risk-management techniques can be used by issuers of the insurance policies: the insurance companies can try to diversify the geographic regions in which policies are issued, can limit the quantity of such policies. Moreover, dynamic hedging strategies involving real estate futures markets might be used to simulate the put options, or policies could be securitized and sold, or real estate swap agreements could be entered into.

In order to get a rough indication of the premiums required on such policies, and to get some idea how insurance companies should price such policies in the absence of real estate put option markets, which do not yet exist, we have computed break-even policy premiums using the assumption that the cost of providing the policies is given by the price of the portfolio of put options that the policy represents under the assumptions about eligibility of claims just described, and using our put pricing formula (4) and equation (1).

For this exercise, we suppose that a fixed proportion a of all policies are canceled by the policyholders each period, because of such factors as moves (whether beyond the threshold distance or not). Moreover, we assume that a proportion b of all policyholders at a given time become eligible for a claim each year (as by moving more than a threshold distance), and receive a claim if the price index has fallen enough to indicate that their home value is less than the floor, and cancel their policies. Clearly, under these assumptions b is less than a, since not all cancellations are incurred at times when the person is eligible for a claim. The insurance company would thus have b times the value initially insured in all homes for which policies were written in one-year puts, $(1-a)$ times b in two-year puts, $(1-a)^2$ times b in three-year puts, and so on. Let us suppose that the insurance company invests all policy premia in a riskless asset that pays the interest rate r. The total value of all the puts (relative to the value of the initially insured housing) can then be found by creating a weighted sum of the put prices with these portfolio values (b, $(1-a)b$, ...) as weights. Let us use C to denote this weighted sum generated using (4) above:

$$C = \sum_{t=1}^{\infty} b(1-a)^{t-1} w(t, X, P, \mu_t, \sigma_t, r) \tag{5}$$

where μ_t is generated recursively starting with $\mu_0 = 0$ by $\mu_t = \mu_{t-1} + \mu_{it}$ where $\mu_{it} = \rho\mu_{it-1} + c$ and $\mu_{i0} = \Delta \ln P$, and where σ_t^2 is also generated recursively starting with $\sigma_0^2 = 0$ by $\sigma_t^2 = \sigma_{t-1}^2 + \sigma_{it}^2$ where $\sigma_{it}^2 =$

$\sigma_\varepsilon^2((1-\rho^t)/(1-\rho))^2$.[9] The present value of a \$1 per year insurance premium, starting today and continuing each year until cancellation, is $V = 1/(1-(1-a)d)$ where d is the discount factor, $d = 1/(1+r)$ where r is the interest rate. The required annual premium for a single home, so that the insurance company can expect to break even in terms of loss experience with these policies, is then C/V.

As a way of getting some rough indication of the parameters a and b, we turn to U.S. Census data on population mobility. In 1992, the total U.S. population in owner-occupied units was 165.61 million persons, of these 14.79 million, 8.93% of the total, moved; a first guess at the parameter a would thus be 8.93%. To get an indication of the parameter b, we note that 5.87 million, 3.54% of the total population in owner-occupied units, moved to another county, and 2.81 million, 1.70% of the total population in owner-occupied units, moved to another state.[10] Thus, a first guess for the parameter a would be 3.54% or 1.70%, depending on the distance threshold the move that defines eligibility.

The cancellation rate a might differ from the 8.93% for several reasons. Notably, people may have reasons other than a move to cancel their insurance policy. This consideration suggests that the cancellation rate might be higher than 8.93%. Moreover, the census figures represent moves by individuals, not sales of homes. Some of the moves are the result of children growing up and moving out to live on their own; this consideration suggests that the cancellation rate might be less than 8.93%.

Eligibility for insurance claims should not be triggered by a move to

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[9] As above, these parameters refer to the autoregressive model $\Delta\ln(P_t) = \rho\ln(P_{t-1}) + c + \varepsilon_t$ with error variance σ_ε^2, as exemplified by equation (1).

[10] See Hansen [1993], Table B, page IX.

another county or state, since some people live on the border of counties or states, and such moves may be short-distance. Often, long-distance moves occur at times of family breakup, and in these times not all members of the family move far away; some work would have to be done defining more precisely how to define eligibility for insurance claims. Thus, we cannot translate the Census figures into any clear indication of the parameter a. For the purposes of our simulations, let us merely assume that the distance requirement is set at such a level that only 3% of households are eligible for claims each year. Moreover, let us assume that 9% of all households cancel each year. Table 4 shows the simulated break-even premia in markets in which the aggregate price change had various values in the preceding year.

Some of the estimated premiums may seem implausibly small. Note from Table 4 that even for a zero deductible, the fixed annual premium initiated in a period of stable prices to insure a $100,000 home forever is only $33 per year. How can the insurance company afford to insure a $100,000 home forever against price declines for only $33, when the standard deviation of the log price residual in the first-order autoregressive model (1) is 6.8% in the first year alone? The premium is so low since most homeowners will not actually sell within the time that home prices are likely to be low, and for most homeowners inflation will eventually push their home prices well above the floor price.

The assumption that the model (1) will continue to hold indefinitely might be questioned; many believe that we have entered a low-inflation monetary policy regime that will have permanently lower inflation rates. Moreover, some might question the assumption that only 9% of policyholders will cancel per year. Table 5 was produced in the same way as Table 4 but with the alternative assumption that the long-run inflation rate is only 3% per year and the cancellation rate was much higher, at 15% per year. That is, the constant term in equation (1) was lowered from .037 to $(1-0.635)*.03 = 0.011$, and the parameter a was raised to 15%; all other parameters were left unchanged. The break-even annual policy premiums look somewhat higher, but there are still some policies that are quite reasonably priced: for example, a zero-deductible policy issued in a time of stable prices is still only \$145 per year.

The annual policy premium calculations presented here are meant only to be illustrative; much further work remains to be done to refine the forecasting model for real estate prices and to estimate probabilities of cancellation.

V. Conclusion

The simple insurance policies that we called pass–through futures and options, but which need not be so described to the public, may well be attractive, easily marketed, and easy to risk-manage for insurance companies. On the other hand, our life–event–triggered insurance policies, that look more like conventional insurance policies, may be even more attractive to the public, albeit harder for insurance companies to hedge. We feel that the life–event–triggered insurance policy described above, in which the household sees itself insured against losses connected with defined life events, may be an important option for initiating home equity insurance, in terms of its general marketability, serviceability, and acceptability to insurance regulators. The life–event–triggered insurance policies will not cover households against all consequences of price declines in real estate, but the policies do significantly improve the households' ability to manage their risks.

Table 1

One-Year Put Option Prices for $100,000 Home
In terms of Actual Price Growth of Preceding Year

	X (Exercise Price)				
$\Delta\ln(P_t)$	$80,000	$90,000	$100,000	$110,000	$120,000
–20%	$45	$1,546	$7,714	$16,321	$25,184
–10%	$3	$321	$3,585	$11,088	$19,860
0%	0	$35	$1,075	$6,057	$14,225
10%	0	$2	$181	$2,304	$8,550
20%	0	0	$16	$526	$3,788

The parameter X is the strike price or exercise price of the option, the parameter $\Delta\ln(P_{t-1})$ is the actual change in log price over the preceding year. For these calculations, the interest rate r was 6% and the one-year-ahead standard deviation of price was 6.78%.

Source: These calculations depend on the first-order autoregressive model for changes in log price, equation (1) in the text as well as the options pricing formula, equation (4).

Table 2

Two-Year Put Option Prices for $100,000 Home
In terms of Actual Price Growth of Preceding Year

	X (Exercise Price)				
$\Delta \ln(P_t)$	$80,000	$90,000	$100,000	$110,000	$120,000
–20%	$929	$4,009	$9,939	$17,771	$26,374
–10%	$176	$1,261	$4,518	$10,366	$18,029
0%	$20	$255	$1,429	$4,590	$10,124
10%	$1	$31	$291	$1,404	$4,428
20%	0	$2	$36	$275	$1,215

The parameter X is the strike price or exercise price of the option, the parameter $\Delta \ln(P_{t-1})$ is the actual change in log price over the preceding year. For these calculations, the interest rate r was 6% and the one-year-ahead standard deviation of price was 6.78%.

Source: These calculations depend on the first-order autoregressive model for changes in log price, equation (1) in the text as well as the options pricing formula, equation (4).

Table 3

Break-Even Analysis on Loss Experience
for Selected Markets

	Annual Costs for a $100,000 Home Deductible		
	$5,000	$10,000	$20,000
Metropolitan Areas Using Actual Indices			
Los Angeles 1985–93	$292	$144	$3
New York 1985–93	$158	0	0

Note: Figures give average claim per home sold twice assuming a claim is paid whenever a home is sold at a loss beyond the deductible after two or more years, assuming all possible intervals greater than two years are equally represented. The price indices are the quarterly Case Shiller Home Price Indices for the metropolitan areas.

Table 4

Calculations of Annual Premium for
Life–Event–Triggered Home Equity Insurance
Initial Home Price \$100,000
As Function of Log Price Change over Previous Year
Using Price Model Estimated Using Historical Los Angeles Data

	X (Home Price Minus Deductible)				
$\Delta\ln(P_t)$	\$80,000	\$85,000	\$90,000	\$95,000	\$100,000
–20%	\$34	\$56	\$89	\$136	\$196
–10%	\$12	\$20	\$34	\$57	\$92
0%	\$4	\$6	\$11	\$19	\$33
10%	\$1	\$2	\$3	\$5	\$9
20%	0	0	\$1	\$1	\$2

Notes: These figures were produced using equation (5) shown in the text using equations (1) and (4) to produce C, and dividing by V, the expected present value of policy premiums, under the assumption that 9% of homeowners move (and then cancel) and that 3% of homeowners are eligible for a claim by virtue of life event, each year. The figures give the annual premium such that the insurance company will expect to break even, in consideration of loss experience only, on this policy.

Table 5

Calculations of Annual Premium for
Life–Event–Triggered Home Equity Insurance
Initial Home Price $100,000
As Function of Log Price Change over Previous Year
Moderate Inflation Regime

	X (Home Price Minus Deductible)				
$\Delta\ln(P_t)$	$80,000	$85,000	$90,000	$95,000	$100,000
–20%	$143	$200	$276	$369	$475
–10%	$72	$103	$147	$207	$285
0%	$33	$49	$70	$100	$145
10%	$15	$22	$31	$44	$64
20%	$7	$9	$13	$19	$27

Notes: These figures were produced as in Table 4 except that here the constant term in equation (1) was changed to 0.011 (reflecting a lower, 3%, assumed steady-state inflation rate) and the cancellation rate was increased from 9% per year to 15% per year (reflecting an assumed faster defection of policyholders).

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