5-1-1995

Mortgage Default Risk and Real Estate Prices: The Use of Index-Based Futures and Options in Real Estate

Robert J. Shiller

Karl E. Case

Allan N. Weiss

COWLES FOUNDATION FOR RESEARCH IN ECONOMICS
AT YALE UNIVERSITY

Box 2125, Yale Station
New Haven, Connecticut 06520

COWLES FOUNDATION DISCUSSION PAPER NO. 1098

MORTGAGE DEFAULT RISK AND REAL ESTATE PRICES: THE USE OF INDEX-BASED FUTURES AND OPTIONS IN REAL ESTATE

Karl E. Case, Robert J. Shiller and Allan N. Weiss

May 1995

Mortgage Default Risk and Real Estate Prices: The Use of Index-Based Futures and Options in Real Estate

by

Karl E. Case, Robert J. Shiller and Allan N. Weiss*

Abstract

Evidence is shown, using US foreclosure data by state 1975–93, that periods of high default rates on home mortgages strongly tend to follow real estate price declines or interruptions in real estate price increase. The relation between price decline and foreclosure rates is modelled using a distributed lag. Using this model, holders of residential mortgage portfolios could hedge some of the risk of default by taking positions in futures or options markets for residential real estate prices, were such markets to be established.

In a previous paper (Case, Shiller and Weiss, 1993) we argued that there is a need for a liquid, national hedging market in real estate prices. We proposed futures and options markets that are cash settled based on indices of city or region residential real estate prices.

Individual homeowners are the largest bearers of residential real estate risk, and they have the most to gain from hedging in such markets. Homeowners are for the most part highly leveraged and undiversified. However, while hedging would provide great benefits to homeowners, most are unsophisticated financial managers, certainly unaccustomed to using derivative markets.

The likely reluctance of homeowners to make use of hedging markets represents an obstacle to their establishment. It is more likely that homeowners would use risk-management services that were offered to them by retailers who present the services in attractive packages and who market them appropriately. If liquid markets for real estate risk existed, then one might expect to see eventual development of such retailers who would then

*The authors would like to thank Gregory Sutton and Diane Whitmore for excellent research assistance. Michael Goldberg of Fannie Mae and Shantaram Hegde of the University of Connecticut provided helpful comments.

use the futures and options markets to lay off the risk they acquire from selling these services. Some possible retail institutions, and their relation to hedging markets, are described in Shiller and Weiss (1994).

Unfortunately, the development of such a symbiotic relationship between retailers of market hedging services and futures markets may be slow to develop, since each party in the relationship needs to see the other already developed before rapid growth can occur. But this obstacle to the establishment of futures markets may not be serious if there are yet others who stand individually ready to use the futures markets now, so that the markets could gain an initial foothold serving them.

One group that may be ready now to use hedging markets in real estate price risk is holders of portfolios of mortgages. The values of their portfolios depend on collateral values, that is, on the current price of the mortgaged real estate.

In this paper we will present evidence that the value of mortgage portfolios does depend importantly on risks of price change in real estate markets, so that mortgage holders ought to have a strong incentive to hedge. Risks are negligible when aggregate prices are increasing rapidly, become substantial when aggregate prices level off for a few years, and become severe when aggregate prices fall.

To accomplish this, we first develop a model of the relation of mortgage defaults to citywide real estate prices. Next, after a brief review of the empirical literature, we examine foreclosure data (for the fifty states) and house price indexes, as well as other economic variables, in an effort to produce a predictive model of losses due to mortgage default. The results give some suggestions about how holders of mortgage portfolios might hedge in the proposed real estate futures and options markets.

Mortgage Holders as Option Writers

Those who invest in mortgages are in effect writers of two kinds of options, call options on long-term debt and put options on real estate prices. The call option on long-term debt arises from the prepayment option in the mortgage contract, which the mortgagor has an incentive to exercise should interest rates fall (long-term bond prices rise). The put option on real estate arises from the option the mortgagor has to default altogether on the mortgage. In non-recourse states, like California and Texas, this option is guaranteed by law. In other states, the mortgagor does not technically have this option, but in practice lawsuits seeking deficiency judgments against non-real estate assets of defaulting mortgagors are few in number. By comparison with options on, say, corporate stocks, these options are somewhat unconventional, but they are fundamentally no different.

One might think that investors who hold mortgages should eliminate the risk of the option investment by purchasing interest rate call options and real estate put options. Doing this would seem to cancel out the risk that they incurred in writing the options. However, the matter is not so simple since the owner of a portfolio of mortgages holds in effect a portfolio of options with different strike prices; a portfolio of options is not the same thing as an option. Moreover, the mortgagors will not exercise their options with anything like the predictability of holders of financial options. So, there is no natural reason for hedgers to favor the options market for hedging over the futures market. They could use a dynamic hedging strategy, adjusting their hedges in either the futures or options markets in ways that will be discussed below.

Because of the nature of the prepayment option, a mortgage is an option with not a single strike price and single exercise date, but a schedule of strike prices and exercise dates, that schedule determined by the schedule of amortization of the mortgage (see Chinloy, 1991). This option is related to interest rate risk, rather than real estate price risk, since prepayments occur primarily when interest rates decline. However, the option is not as simple as an option on an interest-bearing vehicle. Because of liquidity constraints, those mortgagors who are liquidity constrained due to a fall in the value of their property may find themselves unable to prepay, since the value of their property has fallen below the mortgage balance.

Those who manage portfolios of mortgages already have learned to hedge, to the extent that prepayments are determined only by interest rate movements, both the interest rate risk and the prepayment risk in the long-term interest rate futures and options markets. In fact, the very first interest rate futures market (established in 1975), the GNMA (Government National Mortgage Association) bond futures market, was a market was for prepayment risk as well as interest rate risk. A GNMA bond is a pool of mortgages that is guaranteed against default by the full faith and credit of the U.S. government, so that there is no default risk.[1] But the bearer of the bond does bear all of the prepayment risk. The GNMA futures market was very active, until problems in its delivery procedure caused this market to be supplanted by the Treasury bond futures market.[2]

The disappearance of the GNMA futures market in no way indicates the disappearance of demand to hedge the prepayment risk. The hedging can be done on other existing markets, since prepayment is determined fairly well by levels of interest rates, given other information about the mortgage pool. That holders of mortgage-backed securities are in

---

[1]Default risk does exist in these bonds only in the sense that when default occurs the mortgage is prepaid by GNMA; it thus translates into some prepayment risk.

[2]The GNMA futures market lost out eventually to the treasury bond futures market apparently because the delivery option in the GNMA contract made the futures price a poor hedge against the risk of prepayment for the representative mortgage based security; see Johnston and McConnell (1989).

effect writers of options on interest rates is well known in the industry, and theories of hedging mortgage-backed securities rely on the theory of such options.[3]

If there were a futures market in real estate prices, this hedging behavior could be refined to take account of the effects of real estate price movements on prepayment. This would be a sort of fine tuning of the hedging of mortgage risk, and is not our primary concern here. We turn to a discussion of hedging the effects of default on mortgage investments.

Theory of Defaults and Hedging

Strong evidence, discussed below, shows that the best single predictor of default is the current loan-to-market value ratio of each property. This suggests that as prices fall, the probability of defaults will rise. Unfortunately, the cost to lenders of default also rises as prices fall. While default probabilities and default losses rise with falling prices, default losses will rise non-linearly and faster than the decline in house prices. Such a dynamic means that the mortgage holder would ideally want a non-linear, or dynamic, hedge. In this section we derive a nonlinear model that indicates how dynamic hedging should proceed.

Let us first agree on some notation; we will follow the notation of Case and Shiller (1987). Household i buys a house at time t_i, the (log) price of the house at time t is P_{it}. We suppose that the (log) house price is the sum of three components:

$$P_{it} = C_t + H_{it} + N_{it} \tag{1}$$

where C_t is the log of the citywide level of housing prices at time t, H_{it} is a Gaussian random walk (where ΔH_{it} has zero mean and variance σ_H^2 that is uncorrelated with C_t), and N_{it} is a time-of-sale house-specific random error (which has zero mean and variance σ_N^2 for all i and is serially uncorrelated and uncorrelated with C_t and N_{it} at all leads and lags), due to unpredictable noise in the sales process. This model imposes a beta of one with respect to the city-wide house price level for all houses, an assumption that could be relaxed.

Suppose that the house is financed with a fixed-rate mortgage. The (log) mortgage balance is M_{it}. M_{it} as a function of time t is determined by a schedule specified at time t_i that depends on the mortgage rate and the length of the mortgage.

The risk of default is related to the (log) loan-to-value ratio $L_{it} = M_{it} - P_{it}$, and is related as well to a vector X_{it} of other economic conditions that affect default, such as

[3]For example, Toevs (1985) defines a concept of "option-adjusted duration" to allow hedging of prepayment risk in interest rate markets.

unemployment rates. Note that there is a hazard of default even if L_{it} is negative; though as it becomes large and negative the hazard tails off towards zero.

Our model says that the probability p_{it} of defaulting at time t for house i is a nonlinear function:

$$p_{it} = f(L_{it}, X_{it}). \tag{2}$$

It is important that we represent the function as nonlinear, since with very low values of L_{it} there will be virtually no defaults. A hypothetical example of such a function is plotted in Figure 1 for a given value of X_{it}. Note that for very negative values of the log loan to value ratio the function approaches zero; virtually no one would want to default in these circumstances. As the loan-to-value ratio grows, the probability of default becomes higher and higher. The probability that a house is in foreclosure never reaches 1.00, since the foreclosure process does not happen immediately, and because the foreclosure is ended after some time. Because the function is nonlinear, the cross-sectional variance of house prices matters for aggregate portfolio behavior, as we shall see.

We seek now to describe the relationship between the change in value of a portfolio of mortgages on houses and the price level C_t for the city in which the house is situated. For this portfolio, we have a list of the dates of mortgage origination for each property, and hence a specification of the function M_{it} for each property. The probability that property i will go into foreclosure over the relevant time period is:

$$p_{it} = f(M_{it} - (C_t - C_{t_i} + H_{it} - H_{it_i}) - P_{it_i}, X_{it}). \tag{3}$$

Note that value of the time-of-sale error N_{it} does not affect the default decision, since we have assumed that it is not known to the homeowner until the house is actually sold. Now, the example shown in Figure 1 was drawn for a given specific value of the vector X_{it}; we hypothesize that varying elements of X_{it} will shift the curve shown in Figure 1 to the left or right, without affecting its basic shape. An owner of a mortgage portfolio with information about the selling prices, mortgage terms of the underlying properties, and the values of X_{it} still does not know the relation of p_{it} to the city price C_t because the house-specific noise component $H_{it} - H_{it_i}$ is not known. Fortunately, our Gaussian model of the variance of changes in H allows us to calculate the functional relationship between average losses due to foreclosure F and the city-wide price level C_t. Suppose, for a simple example, that all houses in a portfolio were purchased by the mortgagors on the same date t_i at the same log price P_{it_i}, have identical schedules M_{it}, and identical vectors X_{it} of economic conditions affecting default, and that the properties are otherwise randomly selected. Then the expected fraction F of properties in foreclosure at time t is:

$$F = \int_{-\infty}^{+\infty} f(M_{it} - (C_t - C_{t_i} + \sqrt{t - t_i}\, s) - P_{it_i},\ X_{it})\, n_H(s) ds. \tag{4}$$

where $n_H(s)$ is the normal density function with mean zero and variance σ_H^2. Moreover, assuming that the expected loss to the mortgagee given that the property defaults (taking account of the distribution of the time-of-sale noise term N_{it}) is given by the function $V(M_{it} - P_{it}, X_{it})$, the expected average loss in the portfolios due to foreclosure is:

$$\begin{aligned} E = \int_{-\infty}^{+\infty} & V(M_{it} - (C_t - C_{t_i} + \sqrt{t - t_i}\, s) - P_{it_i},\ X_{it}) \\ & \times f(M_{it} - (C_t - C_{t_i} + \sqrt{t - t_i}\, s) - P_{it_i},\ X_{it})\, n_H(s) ds. \end{aligned} \tag{5}$$

The above equation can then be used to define the positions in futures or options markets to hedge the risk of losses due to mortgage default. In practice, of course, where portfolios are not so uniform, one would have to expand the analysis to take account of the joint distribution of purchase dates, purchase prices, and economic conditions.

The same analysis as represented by equation (4) can allow us to compute the empirical relationship between foreclosures in a geographical area, such as a state, and the variables that determine overall foreclosures. However, we face serious complications of the analysis due to the many vintages of mortgages, issued at times when price levels and interest rates were different. Moreover, many of these mortgages are paid off or defaulted and disappear in response to changing economic conditions, allowing for such things as echo effects of past interest rate or price changes. Moreover, we do not have data on all the vintages for a geographical region such as a state.

It is beyond the scope of this paper to derive analytically the relation between average foreclosures for a state and the city-wide price level C_t. However, some general principles will emerge from the analysis here. First of all, we note that foreclosures will tend to be determined by a sort of distributed lag on past price changes. The length of the distributed lag depends on the vintages of mortgages whose mortgage balances have not been reduced by amortization to the point that they are so far below prices that the put is in the near-zero portion of the function f. Presumably, the distributed lag dies faster the higher the rate of price increase. There do not need to be aggregate price declines for there to be foreclosures; a period of five years or so of flat prices will tend to cause a burst of foreclosures, since mortgage balances are not reduced much by amortization in the first five years, and five years is enough time for a good number of houses to see their value drift downwards randomly due to the H_{it} term, such things as changing neighborhood characteristics. The effect of other variables X_{it} such as the unemployment rate interacts with the effects of the distributed lag of price changes: if prices have been rising smartly then there will be less of an effect of other variables on foreclosures.

Each of the inputs to the strategy noted above: the loan-to-value ratios of the portfolio, the metropolitan area price to neighborhood price betas and the default discounts can change through time. Therefore an ideal hedging strategy would require the mortgage holder to update its hedging analysis on a regular basis.

Mortgages and Home Prices: Methods of Dealing with Price Risk

Because of the non-linear relationship between actual losses (deficiencies) and house prices, even regionally diversified mortgage portfolios are exposed to potentially catastrophic risk from sharp regional price drops (this point will be discussed further below). Given the experiences of Texas, New England and Alaska and the recent worries over California, the increasing rush to shed risk is not surprising. First, there is increasing pressure for broader and deeper private mortgage insurance. Agencies are offering reduced "guarantor fees" in exchange for deep pool coverage when acquiring pools.

One way of dealing with mortgage risk is securitization, but securitization simply transfers the risks directly to mortgage-backed securities holders. Non-agency investor worries, particularly about California, have led to demands for mortgage-backed securities credit enhancement via a "super-senior" structure. Classes of mortgage-backed securities are set aside to bear any default losses ahead of more senior protected paper.

All of these complex methods of passing on default risk could be avoided if a hedging vehicle were available.

Empirical Literature on Default Risk

There is no shortage of evidence on the importance of home prices and equity on the default decision. Quercia and Stegman (1992) present a review of 29 empirical studies done over a thirty year period. They conclude:

> Consistently, home equity, or the related measure of loan to value ratio, has been found to influence the default decision. There is a consensus in most recent default studies that the correct measure of a borrower's net equity is the contemporaneous market value of property less the contemporaneous market value of the loan, a

> measure that also incorporates borrower expectations.[4]

Kau, Keenan and Kim (1991) reach the same conclusion:

> There exists a significant literature examining causes of default. In conformity with this paper's approach, considerable empirical evidence exists showing that it is the house versus the mortgage value, rather than such personal characteristics as the homeowners liquidity position, that explains default.[5]

Even more recently, in a study using a discrete proportional hazard model, micro level mortgage data from Freddie Mac and WRS (weighted repeat sales) price indexes, Quigley, Van Order and Deng (1993) state:

> The results show that the probability of negative equity ratio is the main time varying covariate influencing mortgage holders' default decision.[6]

The history of the mortgage industry provides dramatic evidence that default risk is related in a non-linear way to housing prices. Losses from default depend not only on the incidence of defaults, but on the severity of deficiencies after collateral liquidation. Unfortunately, there are virtually no data on aggregate claims over time which are available on a non-proprietary basis. But this is an area where history is well known. The catastrophic losses in recent years have been in Texas and other parts of the Southwest, in Alaska, and in New England. In all three cases, housing prices dropped sharply. While the number of defaults increased, actual *losses* soared. In other areas of the country, default rates rise and fall with economic conditions, but actual deficiencies are kept to reasonable levels by collateral values when real estate prices haven't fallen.

This is a very important point in terms of the need for a hedging vehicle. If default risk were randomly distributed across the country, a regionally diversified portfolio would be sufficient to control the risks of default losses. But experience has shown that even regionally diversified portfolios can suffer catastrophic losses when large regions of the country suffer significant price declines.

---

[4]Quercia and Stegman (1992), p. 357.

[5]Kau, Keenan and Kim (1991), p. 8. The authors cite Jackson and Kaserman (1980), Foster and Van Order (1984), Waller (1988), and Cunningham and Capone (1990).

[6]Quigley, Van Order and Deng, 1993.

House Prices and Default Risk: Additional Evidence

Recent years have seen dramatic swings in house prices. Nowhere have they been more dramatic than in Massachusetts and in California. Figures 2 and 3 show the pattern of single family home price movements in the Boston CMSA and in Los Angeles County.[7] Between 1982 and 1988, home prices in Boston rose 177 percent. Following a gentle peak that lasted two full years, prices dropped sharply in 1990, bottoming in January of 1992 down 18%. Prices have since been on a gradual uptrend in Boston, an uptrend that has wiped out most of the loss since the peak.

Similarly, housing prices in Los Angeles County boomed from 1986 to 1989 rising 92%. Following a much sharper peak than in Massachusetts, prices began falling in 1990 and fell 26% by January 1994, followed by an apparent leveling off of the price decline starting with early 1994. It is of course impossible to tell whether the appearance of firmer prices since the beginning of 1994 is just a temporary interruption of the decline.

In Massachusetts, we calculated repeat sales price indexes for 64 separate geographical areas made up of individual zip codes or zip code clusters. For each of the 64 areas, the increase in price from 1982 (2nd quarter) to the peak was calculated as was the decline since the peak (through June 1993). Nearly all jurisdictions peaked during the 2nd half of 1988 or the first half of 1989. Summary statistics for the 64 jurisdictions are given in Table 1.

The important point to be made here is that the variation in declines across areas is larger than the variation in increases across the same areas. We have argued above that during periods of price decline, losses are likely to increase in a non-linear way since both the number of claims and severity increase when prices drop. Further, recall that in Figure 1 we argued that the likelihood of default increases in a non-linear fashion as the log loan to value ratio rises. This implies that if the cross-area variance of the log price change increases when prices drop, this would push clusters of properties into the category of severely depressed, sharply increasing default probability and severity of deficiency.

This is exactly what happened in Massachusetts. Thirteen of the 64 areas experienced declines of more than 20% since peak, virtually wiping out all equity for first time buyers between 1987 and 1989. The worst three areas (Lowell -56%, Brockton –44% and Chelsea/Revere –38%) are all large, severely impacted industrial areas with high rates of unemployment. In these three areas more than half of all recorded sales are foreclosure sales.

[7]The indexes plotted in Figures 2 and 3 are repeat sales indexes following the method discussed in Case and Shiller (1987, 1989) estimated from data on over 1.5 million sale pairs in Los Angeles and over 85,000 sale pairs from the five eastern counties in Massachusetts.

At the same time, 4 zip code clusters that include 13 towns show declines of 7% or less during the same period.

Figure 4 illustrates the effect of home price movements on default rates during the boom/bust cycle in Massachusetts. Default rates are "total default inventory" obtained from the Mortgage Bankers Association (MBA) *National Delinquency Survey* (quarterly). From 1982 through 1988, housing prices rose sharply, and default rates were pushed nearly to zero as loan to value ratios increased. As soon as prices flattened and ultimately dropped, total foreclosures rose sharply. Finally, as prices bottomed and stabilized, total foreclosures also stabilized.

The data for California, presented in Figure 5, show a similar pattern but over a longer time period. Sharp price increases during the first California boom from 1975 through 1980 pushed foreclosure rates down steadily to nearly 0.1%. The dislocation of the 1981/82 recession combined with stable prices in the early 1980's increased foreclosures to nearly 1%. The second California boom from 1986 through 1989 again decreased loan to value ratios and foreclosure rates fell sharply. When prices turned around and began falling in 1990, foreclosure rates shot up and are still climbing.

Note that the plots in Figures 4 and 5 show total foreclosure inventory as a fraction of total loan portfolios. A more accurate picture would be obtained by looking at foreclosure rates by vintage year. The highest foreclosure rates are for mortgages written in California in 1989 and 1990, while in Massachusetts the highest rates are for mortgages written in 1988 and 1989.

Regression Results

While the ideal data for studies of default incidence is micro data on individual seasoned mortgages from which hazard models might be estimated, we decided to look at default and foreclosure data from the MBA since 1975.

Three sets of regressions have been run. Table 2 presents the results when the log of the MBA total foreclosure rate for the state is regressed on a distributed lag of the log difference of the repeat sales indexes presented above. Since there is likely to be an autocorrelated residual, the regressions are run using the Cochrane–Orcutt procedure to estimate the residual autocorrelation coefficient rho.

In both Los Angeles and Massachusetts, the set of lagged price changes explains a substantial portion of the overall variation in foreclosure. In the Massachusetts equation the adjusted R^2 is .87 while in the Los Angeles equation it is .94.

While extraordinary default risk is created when substantial periods of boom are followed by a sharp downturn as was the case in California and in New England, what portion of the variation in default and foreclosure nationally can be explained by collateral depreciation?

To estimate the role of home prices on foreclosure rates across all states we have assembled a data base containing a number of state level economic variables quarterly since 1975 as well as default and foreclosure data from the MBA. Table 3 presents the results of a simple model of foreclosure rates, a time series-cross section regression where each observation of the dependent variable is a state in a given quarter. We use 2,603 observations of these state-quarter foreclosure rates; note that start dates for various series differ across states. The ordinary least squares regression includes a simple dummy variable for quarters when available data suggest significant declines home prices. Such declines have occurred in 10 states in four areas: the Southeast during the mid-1980s, the Northeast and California during the early 1990s, and Alaska during the late 1980s.

The most significant variables are per capita net migration for the state lagged one year and the "bust" dummy. Both have the anticipated signs. The average unemployment rate over the last 8 quarters is highly significant with the expected sign. The level of per capita income has the wrong sign, but the change in per capita income has the expected sign.

Finally, we have incorporated the distributed lags that were found to be so predictive in Table 2 for Massachusetts and Los Angeles into the time-series cross-section analysis for the 50 states. Doing this enables us to make use of data on all fifty states, to see whether distributed lags are really predictive of foreclosures in a wide variety of settings. Table 4 presents the results of the time-series cross-section model estimated with the same data base, this time using the Hildreth–Lu method to control for autocorrelation within individual states and fixed effects to control for differences across states. The log of the total foreclosure rate is regressed on distributed lags on changes in the National Association of Realtors' median home prices for the state and on the ratio of real per capita personal income in the state the quarter to its level four quarters earlier. The constant term and the coefficients of the state dummies are not shown in the table. Because of the sixteen-quarter distributed lag on changes in per capita personal income and the twelve-quarter distributed lag on house price changes (as well as the problem that start dates for some series are later for some states), the number of observations is reduced to 914. Even though the distributed lag coefficients were unconstrained (no polynomial or other functional relationship having been imposed) all of the price coefficients are negative, as we would expect; they are almost always significant at conventional levels, and the model explains 86 percent of the variation in foreclosures over the period. The peak effect of price changes on foreclosure occurs at a lag of about two years.

Conclusion and Further Research

The purpose of this paper was to add information relevant to the argument presented in Case, Shiller and Weiss (1993) calling for establishment of index-based futures and options markets in real estate for a variety of cities. The largest single group that would benefit from the ability to hedge in such markets is homeowners, who are generally underdiversified and highly leveraged. Unfortunately, homeowners are not well informed about the use of derivatives to reduce risk; thus, use of such markets would be likely to evolve over a long period of time as insurance and financial service companies develop consumer products to take advantage of the new markets.

The real issue is, what other groups stand to gain from the establishment of real estate futures and options markets that would have the requisite knowledge to use appropriate hedging to reduce risk? One obvious example is the group of mortgage holders or those who currently "own" the default risk associated with mortgages (i.e. private mortgage insurers or mortgage-backed securities holders).

Mortgage holders face risks from interest rate increases, prepayments and from default and foreclosure. Interest rate risk and prepayment risk can be hedged easily in interest rate futures and options markets, but foreclosure risk is uncorrelated with any existing hedging vehicle.

The empirical part of the paper presented evidence that home prices do indeed predict foreclosure, and that a set of derivative products based on regional price movements would provide an appropriate vehicle for hedging default risk.

Table 1

Price Increases and Decreases: 64 Areas in Massachusetts

	1982–Peak	Peak–1993
Minimum	136%	–2%
Maximum	235%	–56%
Mean	170%	–17%
Standard Deviation	21%	8%
Coefficient of Variation	0.12	0.50
1st Quartile	156%	–13%
3rd Quartile	182%	–19%

Table 2

Distributed Lag Regressions: Massachusetts and Los Angeles

Massachusetts: 1985:3–1991:4 Quarterly
Dependent Variable: LFT_t (Log of total MBA foreclosure rate for Massachusetts)
Independent variables: DP_t = Log $Price_t$ – Log $Price_{t-1}$
Price = Case Shiller Home Price Index for Massachusetts
Method: Cochrane–Orcutt; $N = 26$

Variable	Coefficient	t-Statistic
Constant	–.205	–0.948
DP_{t-1}	0.732	0.153
DP_{t-2}	–3.605	–0.758
DP_{t-3}	–3.362	–0.486
DP_{t-4}	–0.977	–0.133
DP_{t-5}	–11.065	–1.352
DP_{t-6}	7.891	–0.994
DP_{t-7}	2.263	–0.283
DP_{t-8}	–9.016	–1.134
DP_{t-9}	–2.121	–0.310
DP_{t-10}	–7.863	–1.117
DP_{t-11}	–7.594	–1.218
DP_{t-12}	2.876	0.497
RHO	0.425	1.531
$\bar{R}^2$ = .870		

Los Angeles: 1978:3–1991:4 Quarterly
Dependent Variable: LFT_t (Log of total MBA foreclosure rate for California)
Independent variables: DP_t = Log $Price_t$ – Log $Price_{t-1}$
Price = Case Shiller Home Price Index for Los Angeles County
Method: Cochrane–Orcutt; $N = 54$

Variable	Coefficient	*t*-Statistic
Constant	–0.042	–0.197
DP_{t-1}	0.005	0.005
DP_{t-2}	0.248	0.228
DP_{t-3}	–0.568	–0.503
DP_{t-4}	–2.506	–2.204
DP_{t-5}	–2.580	–2.311
DP_{t-6}	–1.674	–1.506
DP_{t-7}	–1.714	–1.538
DP_{t-8}	–1.683	–1.427
DP_{t-9}	–2.821	–2.392
DP_{t-10}	–3.456	–2.881
DP_{t-11}	–2.064	–1.771
DP_{t-12}	–1.330	–1.300
RHO	0.886	13.184
$\bar{R}^2$ = .943		

Table 3

Time-Series Cross-Section Regressions

Fifty States, quarterly data, 1975:1–1993:1. Start dates for series differ across states.

Dependent Variable: FT_t (total MBA foreclosure rate in state)

Independent Variables:

- Unemp — Average unemployment rate in state over the last 8 quarters
- PCY_{t-4} — Per capita personal income in the state lagged 4 quarters
- ChPCY — Change in log per capita personal income in the state over the last 4 quarters
- $PCNM_{t-4}$ — Per capita net migration for the state lagged 4 quarters
- $Natfor_t$ — National foreclosure rate
- $BUST_t$ — Dummy variable for quarters in which nominal home prices fell significantly in AK,
  CT, MA, NH, NY, NJ, CAL, TX, OK, RI

Method: Ordinary Least Squares

N = 2,603

Variable	Coefficient	*t*-Statistic
Constant	2.725	5.589
Unemp	0.048	6.545
PCY_{t-4}	0.027	4.131
ChPCY	–1.582	–3.437
$PCNM_{t-4}$	–24.421	–18.417
Natfort	1.141	7.780
BUST	1.277	17.283
$\bar{R}^2$ = .297		

Table 4

Time-Series Cross-Section Distributed Lag Regressions

Fifty States, quarterly data, 1975:1–1993:1. Start dates for series differ across states.

Dependent Variable: LFT_t (log total MBA foreclosure rate in state)

Independent Variables:

Unemp Average unemployment rate in state over the last 8 quarters

DPY_t PCY_t/PCY_{t-4}, Ratio in state of real per capita personal income to real per capita personal income 4 quarters ago

DP_t $Price_t – Price_{t–1}$

Price NAR Median Price of Existing Single Family Homes

Method: Hildreth–Lu with fixed effects for states.

N = 914

Variable	Coefficient	*t*-Statistic
Unemp	0.266	3.297
$DPY_{t–1}$	–4.515	–3.073
$DPY_{t–2}$	–1.376	–0.965
$DPY_{t–3}$	0.298	0.213
$DPY_{t–4}$	0.658	-.460
$DPY_{t–5}$	–0.193	–0.117
$DPY_{t–6}$	1.051	0.631
$DPY_{t–7}$	3.747	2.211
$DPY_{t–8}$	3.640	2.147
$DPY_{t–9}$	–1.092	–0.683
$DPY_{t–10}$	0.752	0.477
$DPY_{t–11}$	3.018	1.885
$DPY_{t–12}$	1.386	0.882
$DPY_{t–13}$	1.908	1.381
$DPY_{t–14}$	0.683	0.507
$DPY_{t–15}$	0.445	0.314
$DPY_{t–16}$	2.940	2.031
$DP_{t–1}$	–0.017	–3.253
$DP_{t–2}$	–0.023	–2.496
$DP_{t–3}$	–0.030	–2.550
$DP_{t–4}$	–0.037	–2.747
$DP_{t–5}$	–0.040	–2.833
$DP_{t–6}$	–0.045	–3.230
$DP_{t–7}$	–0.049	–3.728
$DP_{t–8}$	–0.049	–4.125
$DP_{t–9}$	–0.043	–4.121
$DP_{t–10}$	–0.032	–3.761
$DP_{t–11}$	–0.018	–2.938
$DP_{t–12}$	–0.005	–1.535
$\bar{R}^2$ =.857		

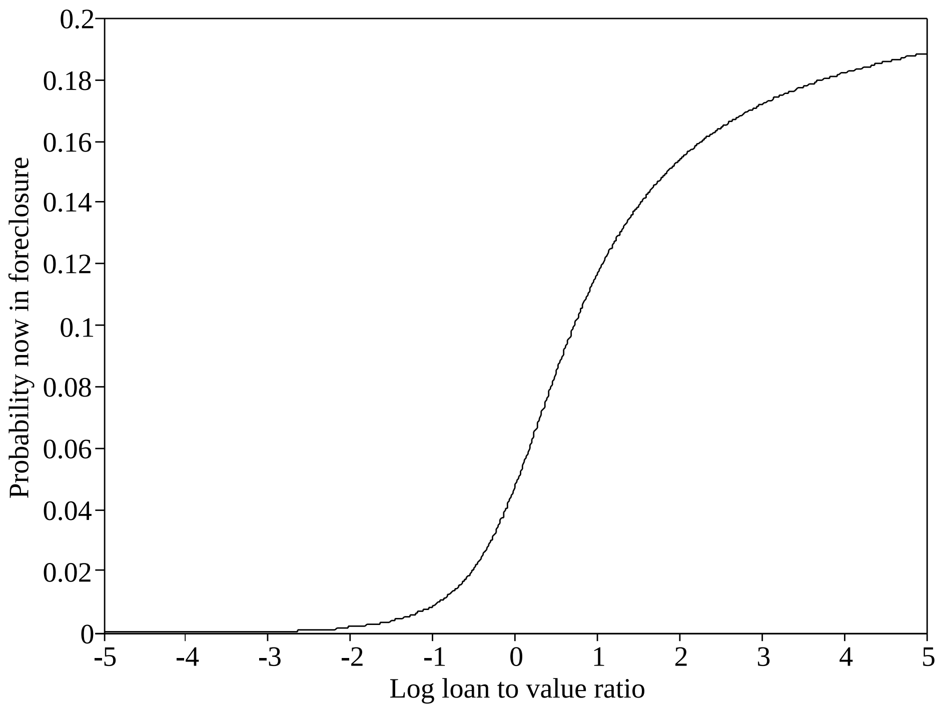

Figure 1. Hypothetical example of the function f relating probability of foreclosure to natural log of loan-to-value ratio.

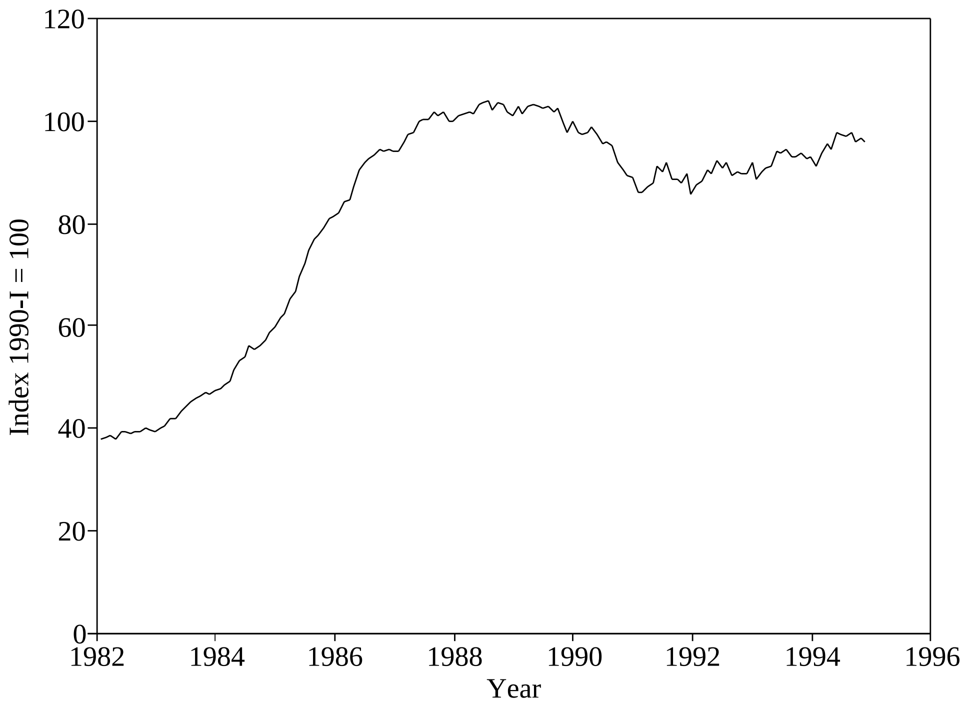

Figure 2. Case Shiller Monthly Home Price Index, 1982-1 to 1994-12, 1990-1 = 100, Greater Boston.

Source: Case Shiller Weiss, Inc.

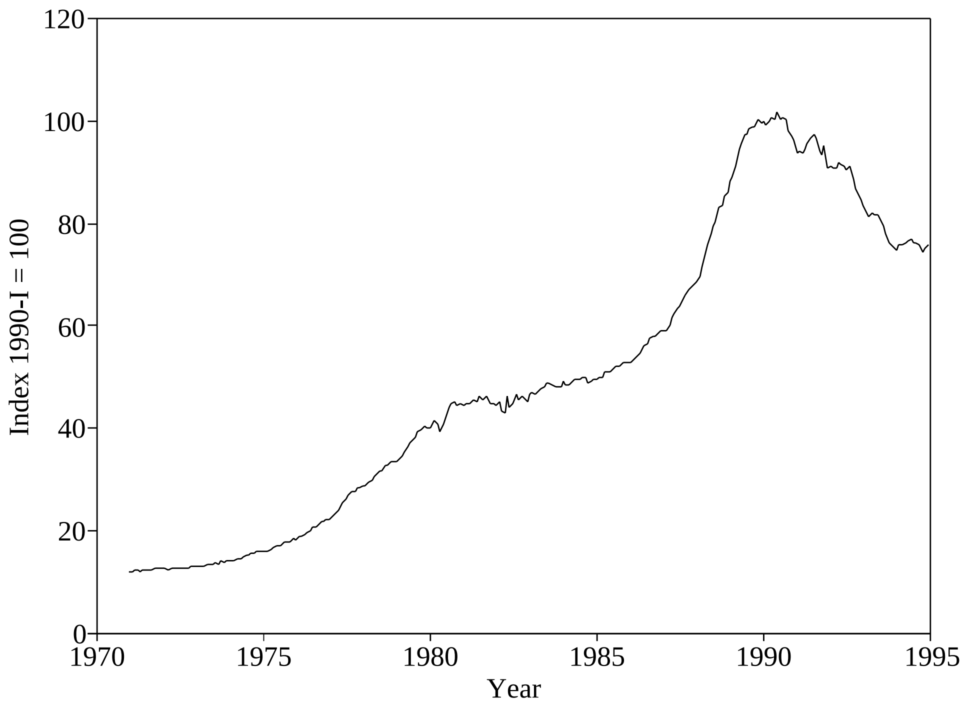

Figure 3. Case Shiller Monthly Home Price Index, 1971-1 to 1994-12, 1990-1 = 100, Los Angeles County.

Source: Case Shiller Weiss, Inc.

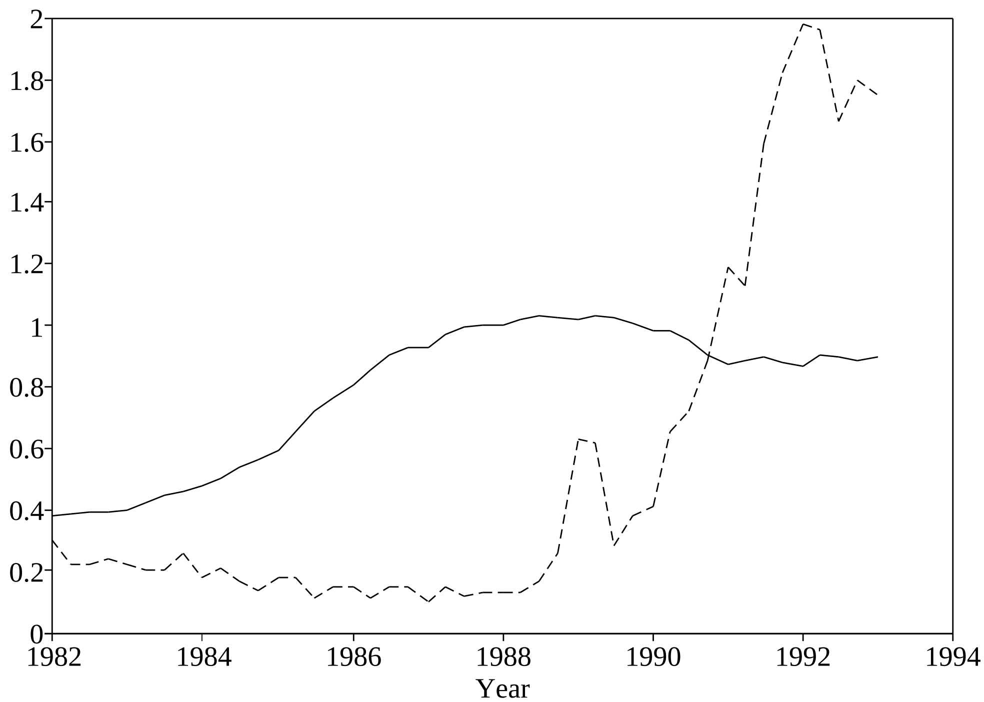

Figure 4. Total foreclosures Massachusetts in percent, dashed line, and Case Shiller Massachusetts Home Price Index, as fraction of base value, solid line, quarterly, 1982-1 to 1993-1.

Source: Mortgage Bankers Association and Case Shiller Weiss, Inc.

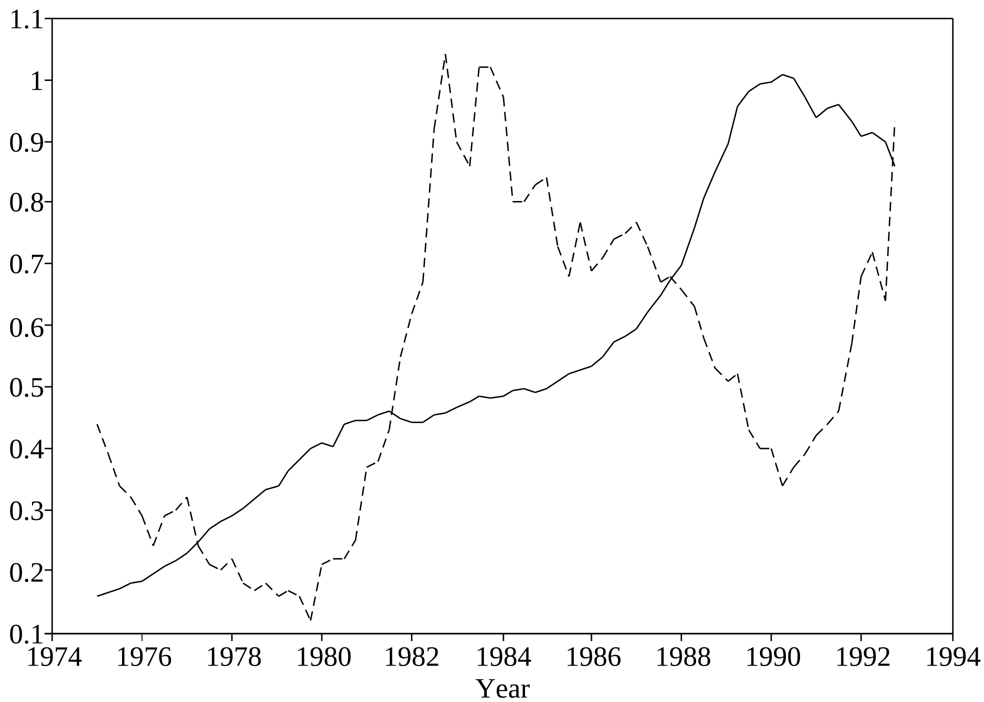

Figure 5. Total foreclosures California in percent, dashed line, and Case Shiller Los Angeles Home Price Index as fraction of base value, solid line, quarterly, 1982-1 to 1992-4.

Source: Mortgage Bankers Association and Case Shiller Weiss, Inc.

References

Case, Karl E. and Robert J. Shiller (1987). "Prices of Single Family Homes Since 1970: New Indexes for Four Cities," *New England Economic Review*, September/October, pp. 45–56.

Case, Karl E. and Robert J. Shiller (1989). "The Efficiency of the Market for Single Family Homes," *American Economic Review*, 79(1), pp. 125–137.

Case, Karl E., Robert J. Shiller and Allan N. Weiss (1993). "Index-based Futures and Options Markets in Real Estate," *Journal of Portfolio Management*.

Chinloy, Peter. "The Option Structure of a Mortgage Contract," *Journal of Housing Research*, 2, 21–38.

Cunningham, D, and C. Capone (1990). "The Relative Termination Experience of Adjustable to Fixed Rate Mortgages," *Journal of Finance*, 45(5): 1687–1703.

Fabozzi, Frank J. and Franco Modigliani (1992). *Mortgage and Mortgage-Backed Securities Markets*, Harvard Business School Press, Boston.

Foster, C. and R. Van Order (1984). "An Option Based Model of Mortgage Default," *Housing Finance Review* 3(4): 351–372.

Herzog, J.P. and J.S. Earley. (1970). *Home Mortgage Delinquency and Foreclosure*. New York, National Bureau of Economic Research.

Jackson, J. and D. Kasserman. (1980). "Default Risk on Home Mortgage Loans: A Test of Competing Hypotheses," *Journal of Risk and Insurance*, 3: 678–690.

Johnston, Elizabeth Tashjian and John J. McConnell (1989). "Requiem for a Market: an Analysis of the Rise and Fall of a Financial Futures Contract," *Review of Financial Studies*, 2, 1–23.

Kau, J., D. Keenan and T. Kim, (1991). *Default Probabilities for Mortgages*, Department of Insurance, Legal Studies and Real Estate, The University of Georgia. Mimeo.

Mortgage Bankers Association of America. *National Delinquency Survey*. Quarterly, 1975–1993.

Quigley, John M., Robert Van Order and Yongheng Deng (1993). "The Competing Risks for Mortgage Termination by Default and Prepayment in the Residential Housing Market," paper presented at the NBER Summer Institute, Mimeo.

Shiller, Robert J. and Allan N. Weiss (1994). "Home Equity Insurance." National Bureau of Economic Research Working Paper, National Bureau of Economic Research, Cambridge MA. (Forthcoming, *Journal of Real Estate Finance and Economics*.)

Stevens, N.A. (1976). "A Mortgage Futures Market: Its Development, Uses, Benefits and Costs," *Review of the Federal Reserve Bank of St. Louis*.

Toevs, Alden L. (1985). "Hedging the Interest Rate Risk of Fixed Rate Mortgages with Prepayment Rights," in Frank Fabozzi (ed.), *The Handbook of Mortgage-Backed Securities*, Probus, Chicago.

Waller, N. (1988). "Residential Mortgage Default: A Clarifying Analysis," *Housing Finance Review*, 7:321–333.