Risk Characteristics and Underwriting Standards for Price Level Adjusted Mortgages Versus Other Mortgage Instruments

by J. Huston McCulloch

Using vector autoregression techniques, it is found that real incomes and house prices are more predictable than nominal incomes and house prices. It follows that price level adjusted mortgages, if properly underwritten, can be safer than either traditional fixed payment mortgages or graduated payment mortgages from the point of view of both the borrower and the lender, at the same time they have lower initial payments and provide greater credit. Adjustable rate mortgages are also investigated and found to be dominated by price level adjusted mortgages as well.

I. Introduction

Price level adjusted mortgages (PLAMs), in their simplest form, have payments that are constant in real terms. Their nominal payments increase in proportion to the price level rather than being constant as is the case with the traditional fixed payment mortgage (FPM).

Because the real value of payments on an FPM decline with inflation, it is necessary in an inflationary environment to increase the initial payments inordinately relative to income in order to maintain a given present value when the payments are discounted by any given real interest rate. This "tilt" problem of the FPM is an important source of

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Housing Finance Review 5, 65–97 (1986)

0276-4415/86/$03.50

the affordability crisis that crushed the housing construction industry in 1980–1982 and which is still depressing it, to a lesser extent, today.[1]

On the other hand, since the payments on a PLAM all retain their real purchasing power, the PLAM's initial payments can start off much lower. For example, during 1984, nominal interest rates on FPMs ran 13% and higher, while a 7% real rate would probably have made PLAMs attractive to both borrowers and investors.[2] At a 13% nominal rate, a 30-year FPM has monthly payments of $110.62 per $10,000 of loan value, while at a 7% real rate, the monthly payments on a 30-year PLAM would begin at only $66.53 per $10,000 of loan value, or almost 40% less. Since the PLAM dramatically eliminates the "affordability" problem, it has been hailed by proponents such as Milton Friedman (1980) as "how to save the housing industry."

The PLAM advocates base their case on the conviction that real incomes and real house values, if not completely certain, are at least far more predictable than their nominal counterparts, making PLAMs safer for borrowers, as well as exposing lenders to smaller default risks. Many base this belief on the assumption that real uncertainty and price level uncertainty are for all practical purposes uncorrelated with one another. Baesel and Biger (1980) show that if real income is uncorrelated with inflation, risk-averse borrowers will clearly prefer PLAMs to FPMs at equal expected real interest rates.

Resistance to PLAMs, on the other hand, derives largely from the belief that nominal quantities are more predictable than real quantities. If this were true, borrowers might prefer fixed nominal payments to fixed real payments, and the risk of default on PLAMs could exceed that on FPMs. These concerns are apparently one reason why Federally chartered Savings and Loan Associations have not taken advantage of the 1982 regulations allowing them to make PLAM loans. [See McCulloch, (1982b).]

An extreme case of this nominalist position is taken by HUD in the preamble to its proposed "Indexed Mortgage" (PLAM) regulations. The HUD observes that if the inflation of 1971–1983 were to continue for the next 30 years in repeated 12-year cycles, the nominal monthly payments on a 30-year level real payment PLAM "would increase more than sevenfold over the full term of the mortgage, and nearly double within the

[1] See Lessard and Modigliani (1975) and Cohn and Fischer (1975). Alm and Follain (1982) estimate that eliminating this tilt would increase housing demand by at least 25% under 5% inflation, and by considerably more at 10% inflation. See also Kearl (1979). At moderate inflation rates, the tax deductibility of interest payments does to some extent offset the tilt effect. Schwab (1982) attributes only a small welfare loss to the tilt problem. To some extent the poor performance of the housing industry during 1980–1982 was due to high real interest rates, but I believe the tilt was even more important.

[2] Today (January 1986), nominal FPM rates have fallen to under 11%, but then a real rate of 6 or even 5% may now be closer to the market clearing rate on PLAMs.

first 10 years." Furthermore, the nominal loan balance "at its highest level would nearly double the original loan amount (in the 22nd year)." The HUD concludes without further ado that "at this rate, the risk of mortgagor defaults would clearly exceed acceptable levels." (1983, 23,066) Such an inflation would, in HUD's view, apparently not be associated with any nominal income growth or nominal house appreciation worth mentioning.[3]

As it happens, if per capita personal income grew in similar repeated 12-year cycles based on the same period 1971–1983, nominal income would increase more than 17-fold over 30 years, so that a mere 7-fold increase in the payment would greatly *reduce* its burden. Similarly, new house prices would increase by more than 7-fold in 22 years, so that a mere doubling of the mortgage balance would provide no incentive to default. But such scenarios by themselves prove nothing; it may have just been a fluke that the 1971–1983 general inflation was accompanied by strong nominal income growth and house appreciation.

While most economists would probably subscribe to the assumption that real variables are more predictable, the nominalist view taken by HUD and others is not entirely implausible in terms of economic theory. Suppose first that inflation is entirely a matter of supply shocks that simultaneously drive prices in one direction and real incomes in the other. To the extent that the two cancel out, nominal income will be more predictable than real income. Or, from a monetarist point of view, suppose that income velocity is perfectly constant and that the Fed follows a constant money growth rule. Then the only fluctuations in the price level will be caused by equal and opposite fluctuations in real income, and nominal income will be perfectly constant. In either case, a more predictable nominal income is not unlikely to be associated with a more predictable derived nominal demand for housing.

The nominalist position is therefore not fundamentally unsound on the basis of economic theory. Which view is correct is basically an empirical matter. If the nominalist position is correct, it is *nominal* incomes and house prices that are virtually uncorrelated with the price level, while *real* incomes and house prices would be strongly *negatively* correlated with the price level. Such a negative correlation between real income and prices was actually found by Fama (1981) during 1953–1977. His evidence has led many economists to incline toward the nominalist argument.

In the present paper, we employ vector autoregression (VAR) techniques to investigate whether it is real or nominal incomes and house prices that are more predictable. This enables us to reach some conclu-

[3] At this writing, HUD appears reluctant to comply with the 1983 mandate of Congress to conduct a PLAM demonstration program by September 30, 1985.

sions about the risk characteristics of PLAMs versus FPMs and graduated payment mortgages (GPMs), and to evaluate the stringent underwriting standards that the author has proposed for PLAMs.

We investigate the behavior of income in Section II and turn to house prices in Section III. Section IV applies the findings of Sections II and III to GPMs. In Section V, we employ a similar VAR methodology to compare PLAMs to adjustable rate mortgages (ARMs). Section VI considers complications arising from individual risk characteristics, and Section VII concludes.

II. Real and Nominal Income

Let Y be the natural logarithm of nominal per capita personal income, P be log of the CPI, and $y \equiv Y - P$ be the log of nominal per capita personal income deflated by the CPI. We deliberately use the CPI rather than the personal income deflator, in spite of the defects of the pre1983 CPI,[4] since a predefined index such as the CPI is more practical, if not more accurate, for indexation purposes than one that is revised ex post. Any unforeseen flaws in such an index are therefore part of the uncertainty we must model. Personal income was used rather than disposable personal income, since mortgage payments are largely tax deductible in the United States.

A vector autoregression is a set of regressions in which a number of variables are each regressed on a constant plus the first n lagged values of each of these variables, including itself (Sims, 1980a). It provides a method of calculating simple, inertial forecasts of each variable that take account of the variable's own recent history and long-run dynamics, as well as the variable's interactions with the other variables being forecast, without commiting one to any controversial position about the structure of the economy. Packaged programs such as RATS [see Doan and Litterman (1983)] compute these forecasts automatically, along with measures of their uncertainty. Single equation methods such as the Box-Jenkins ARIMA procedures would not take into account any interactions that may exist between the variables, and would not guarantee that the identity $Y \equiv P + y$ would hold for the forecasts.

A third-order VAR with a constant term was fit to the first differences of these three series, using annual data from 1927 to 1984, and then each series (in level form) was forecast to 2014, 30 years being the longest term mortgage we consider.[5] Figure 1 shows the history of each

[4] See Dougherty and Van Order (1982), and Blinder (1980). Ironically, it was the absence of PLAMs that caused the CPI to overstate inflation greatly in 1978–1981.

[5] Following Nelson and Plosser (1982), first differencing is more reliable for questionably stationary series like these than fitting levels to an equation that incorporates a trend term.

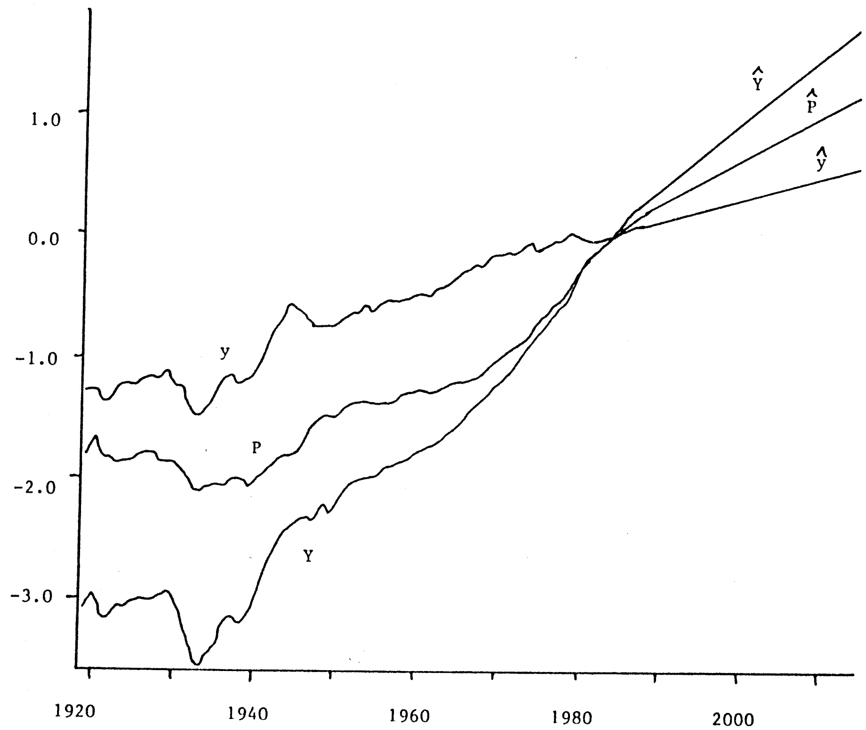

Figure 1. Log of nominal income (Y), CPI (P), and real income (y), 1919–1984, with projections to 2114 (1919–1923 not used in reported regressions).

series, along with the forecasts. Each series was normalized to 0 in 1984. The forecasts $\hat{y}$ and $\hat{Y}$ of y and Y are tabulated in the first two columns of Table 1.

The VAR forecasts have two sources of uncertainty: One, which we call the "impulse uncertainty," derives from the cumulative effect of future disturbances to the regressions. The standard deviation of this component is calculated automatically by RATS from the partial moving average representation of the process. The second, which we call the "coefficient uncertainty," derives from the imprecision of the coefficient estimates, and is potentially as important as the impulse uncertainty. The standard deviation of this uncertainty was estimated by constructing ten Monte Carlo simulations of the three series from 1927 to 1984, recalculating the VAR system and forecasts for each simulation, and

Because of the identity $Y \equiv P + y$, each series may be fit as a VAR on any two of the three, the third series being redundant. See Appendix for data sources and computational details.

Table 1. Forecasts and Risk Parameters of Real and Nominal Income (Based on 1927–1984 Experience)

Year	$\hat{y}$	$\hat{Y}$	σ_y	σ_Y	ρ_{yP}	ρ_{YP}	b_{YP}
0	0	0	0	0	—	—	—
1	.031	.089	.047	.061	.37	.70	1.66
2	.058	.170	.083	.124	.41	.79	1.52
3	.078	.230	.119	.185	.45	.82	1.54
4	.092	.282	.144	.232	.47	.84	1.54
5	.103	.334	.161	.269	.47	.85	1.50
6	.115	.389	.172	.301	.45	.86	1.43
7	.132	.445	.180	.330	.42	.87	1.36
8	.152	.502	.187	.358	.40	.88	1.32
9	.172	.558	.195	.385	.39	.88	1.29
10	.192	.615	.204	.413	.38	.89	1.27
11	.211	.671	.212	.440	.37	.89	1.25
12	.229	.725	.220	.467	.37	.90	1.24
15	.285	.887	.242	.540	.36	.91	1.21
20	.381	1.156	.275	.648	.34	.92	1.19
25	.476	1.423	.305	.745	.34	.92	1.18
30	.572	1.691	.333	.833	.33	.93	1.17

Note: y and Y are measured as the log of the change from year 0 (1984).

then computing the standard deviation of the simulated forecasts about the "true" forecast. The two sources of uncertainty were then combined under the justifiable assumption of independence. The results for y and Y are tabulated as σ_y and σ_Y, respectively, in the third and fourth columns of Table 1.

We see that at every forecasting horizon, real income is more predictable than nominal. The difference is not large in either absolute or relative terms in the first year, but σ_Y is twice as large as σ_y by year 10, and is more than 2.5 times σ_y by year 30.

Columns 5 and 6 of Table 1 show the correlation coefficients ρ_{yP} and ρ_{YP} of real and nominal income with prices. Far from being negative, ρ_{yP} is actually positive, which guarantees that σ_Y will be greater than σ_y. Y is strongly and positively correlated with P, particularly at long horizons.

The last column in Table 1 shows the projection coefficient of Y on P, defined as $b_{YP} = \rho_{YP}\,\sigma_Y/\sigma_P$. At every maturity this coefficient is greater than unity, which means that each 1% surprise in the price level actually implies a *greater* than 1% expected surprise in nominal income. The HUD's projections of rapid inflation without comparable nominal income growth, indeed without any nominal income growth at all, are thus entirely unfounded.

Before people came to believe they could count on inflation to erode the real value of conventional mortgage payments, lenders customarily imposed a ceiling of 20% on the initial ratio of the loan payment to the borrower's income (Starr, 1975, p. 24). As inflation appeared to become

Table 2. Confidence Regions for PLAM Current PTY (1927–1984 Experience)

Year	.95 Lower Bound	.50 Lower Bound	Point Estimate	.50 Upper Bound	.95 Upper Bound
0	20.0	20.0	20.0	20.0	20.0
1	17.7	18.8	19.4	20.0	21.2
2	16.0	17.8	18.9	20.0	22.2
3	14.7	17.1	18.5	20.0	23.4
4	13.8	16.5	18.2	20.1	24.2
5	13.2	16.2	18.0	20.1	24.7
6	12.7	15.9	17.8	20.0	25.0
7	12.3	15.5	17.5	19.8	24.9
8	11.9	15.1	17.2	19.5	24.8
9	11.5	14.8	16.8	19.2	24.7
10	11.1	14.4	16.5	18.9	24.6
11	10.7	14.0	16.2	18.7	24.6
12	10.3	13.7	15.9	18.4	24.5
15	9.3	12.8	15.0	17.7	24.2
20	8.0	11.4	13.7	16.5	23.4
25	6.8	10.1	12.4	15.3	22.6
30	5.9	9.0	11.3	14.1	21.7

Note: Table shows payments as a percentage of income and assumes 20% initial PTY.

more reliable, lenders increased this limit to 25%, then to 28%, and today sometimes even higher. Such a high ratio of payment to income (PTY) is not considered to be either safe for the lender or desirable for the borrower as a permanent state of affairs. It is tolerated by lenders and borrowers only under the assumption that nominal income growth will quickly bring it down to a safer and more affordable level.

Because inflation will not reduce the real payment on a PLAM, the traditional 20% underwriting standard would be more appropriate for PLAMs than the 28% commonly used for other instruments.[6] Even with this restriction, borrowers will still qualify for appreciably more credit with a PLAM than with an FPM. For example, at the 13% nominal interest rate mentioned above, a borrower with an annual income of $35,000 would only qualify for a $73,800 FPM under a 28% qualification rate with 30 years to pay. Even at an historically high 7% real rate, the same borrower would qualify for an $87,700 PLAM under a 20% qualification rate with 30 years to pay, or almost 19% more credit in spite of the much smaller initial payments.

Table 2 shows how the current PTY on a 30-year PLAM is likely to

[6] A 20% maximum initial PTY ratio for PLAMs was first proposed in McCulloch (1982a,b). Webb (1982) measures potential delinquency risk as the probability of an upward *change* in the PTY. Under this assumption the initial and subsequent absolute level of the PTY is completely immaterial. By his criterion, Webb finds PLAMs to be "riskier," but we take the position here that the *absolute* PTY is the more important consideration.

behave, based on the data of Table 1 and a 20% initial PTY. The middle column is the point estimate. The adjoining two columns show the lower and upper bounds of a 50% confidence interval, formed by subtracting and adding 0.675 SD to the point estimate of log PTY and exponentiating. The actual value should lie within this range with probability 0.50. The outer columns give the lower and upper bounds of a 0.95 confidence interval, formed by exponentiating log PTY plus and minus 1.960 SD. The true value would be very unlikely to lie outside this range (i.e., would do so only with probability 0.05).

The dark area in Figure 2 is the 0.50 range, while the lightly shaded area is the 0.95 range. We arbitrarily take 25% as the "distress" level of the PTY, below which the payment is manageable, though perhaps uncomfortable, and above which the PTY causes acute regret and begins to contribute substantially to the probability of default. This threshold is the horizontal line through Figure 2.

The 0.50 band for the PLAM PTY never rises above 20.1%, its upper limit in the 5th year, and thereafter declines monotonically to 14.1% or less in year 30. The 0.95 band does just graze the 25% "distress level" in year 6, but elsewhere lies entirely below it. To see how rare a PTY that rises from 20 to 25% or higher in year 6 would be, note that this would occur on average only once in every 40 successive nonoverlapping 6-year intervals, or once in every 240 years.

Table 3. Confidence Regions for FPM Current PTY (1927–1984 Experience)

Year	.95 Lower Bound	.50 Lower Bound	Point Estimate	.50 Upper Bound	.95 Upper Bound
0	28.0	28.0	28.0	28.0	28.0
1	22.7	24.6	25.6	26.7	28.9
2	18.5	21.7	23.6	25.7	30.1
3	15.5	19.6	22.2	25.2	32.0
4	13.4	18.0	21.1	24.7	33.3
5	11.8	16.7	20.0	24.0	34.0
6	10.5	15.5	19.0	23.2	34.2
7	9.4	14.4	17.9	22.4	34.2
8	8.4	13.3	17.0	21.6	34.2
9	7.5	12.4	16.0	20.8	34.0
10	6.7	11.5	15.1	20.0	34.0
11	6.0	10.6	14.3	19.3	33.9
12	5.4	9.9	13.6	18.6	33.8
15	4.0	8.0	11.5	16.6	33.2
20	2.5	5.7	8.8	13.7	31.4
25	1.6	4.1	6.7	11.2	29.0
30	1.0	2.9	5.2	9.1	26.4

Note: Table shows payment as a percentage of income and assumes 28% initial PTY.

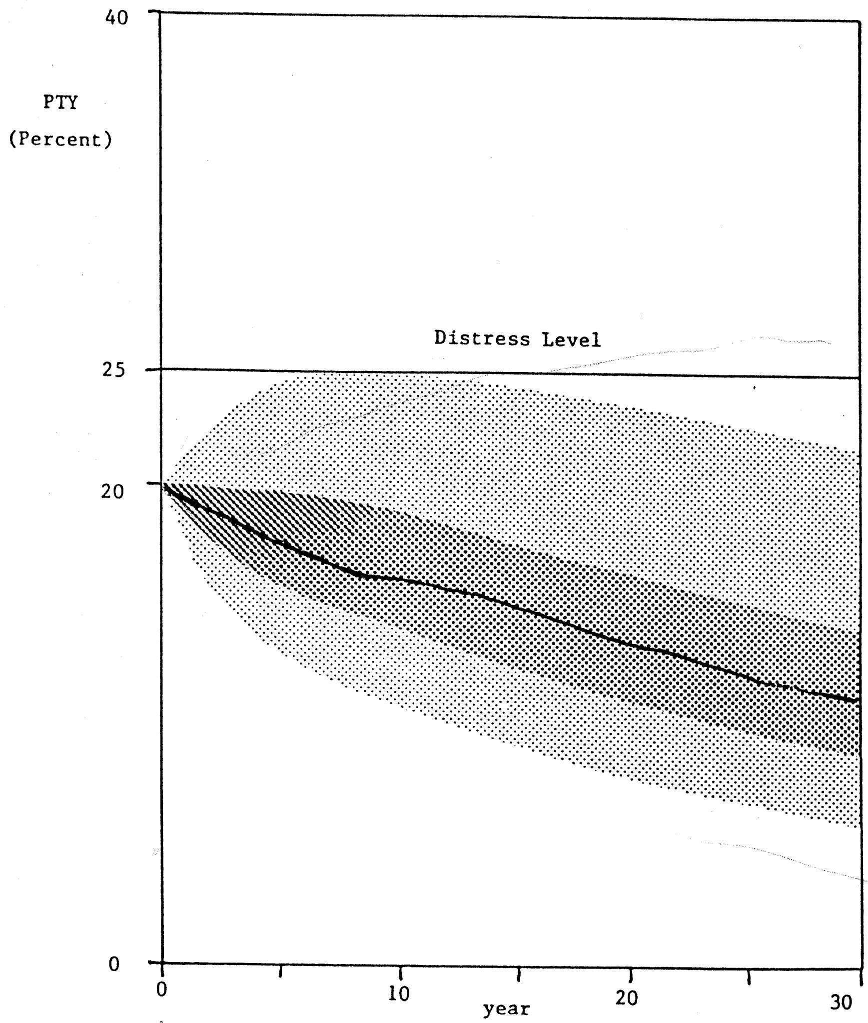

Figure 2. PLAM PTY (1927–1984 experience). Dark shaded area is 0.50 confidence region, light area is 0.95 confidence region. Assumes initial PTY of 20%.

In year 30 the 0.95 range extends from 5.9% up to 21.7%, so there is considerable real income uncertainty. However, HUD's implicit projection of a 7-fold decline in real income (which corresponds here to a PTY of 140%) is entirely out of the question.

Table 3 shows analogous values for a 30-year FPM, again based on the data of Table 1, but now with an initial PTY of 28%. The confidence regions are plotted in Figure 3.

Although the 0.50 band for the FPM's PTY ratio falls below the

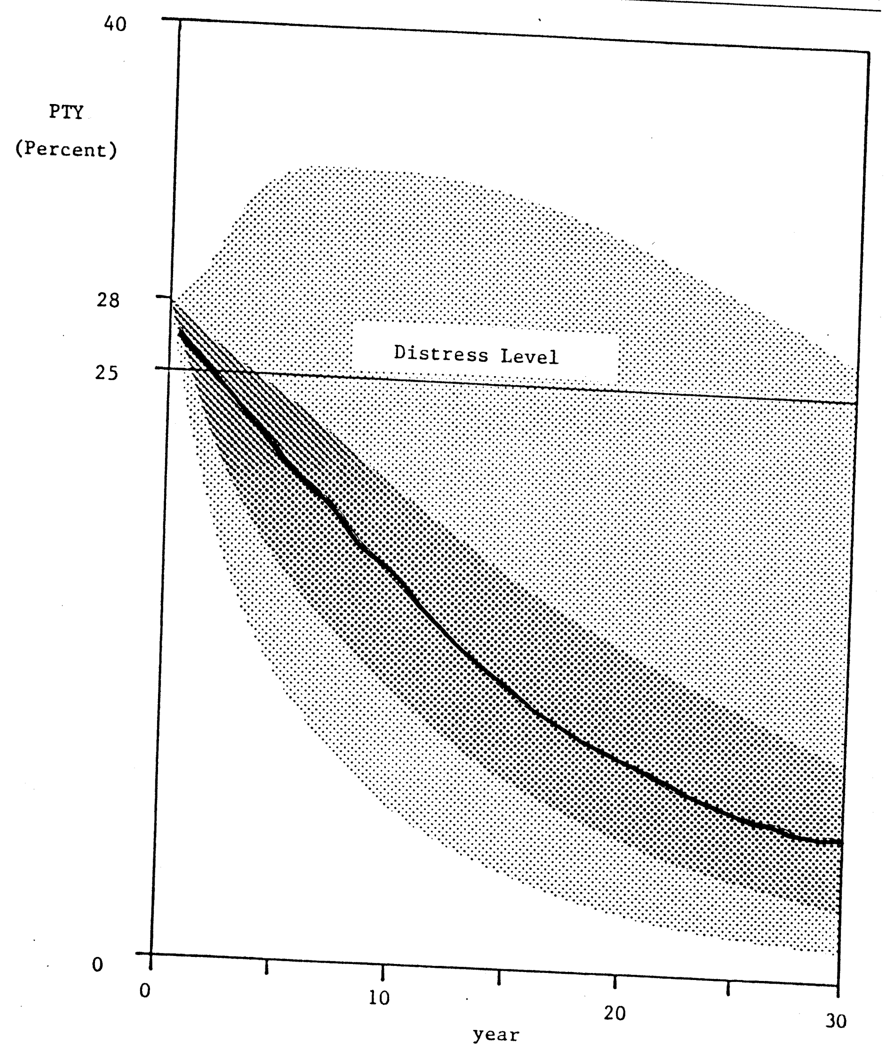

Figure 3. FPM PTY (1927–1984 experience). Dark shaded area is 0.50 confidence region, light shaded area is 0.95 confidence region. Assumes initial PTY of 28%.

distress level of 25% by year 4, there is no guarantee that it will *ever* fall below this level. The upper edge of the 0.95 range actually exceeds 30% during most of the life of the mortgage.[7] Even though the 0.50 band falls

[7] The low inflation scenarios associated with these high PTY ratios are likely to be associated with falling nominal interest rates and therefore with opportunities to refinance with lower payments, a factor that we make no attempt to model here. Note, however,

Table 4. Forecasts and Risk Parameters of Real and Nominal Income (1950–1984 Experience)

Year	$\hat{y}$	$\hat{Y}$	σ_y	σ_Y	ρ_{yP}	ρ_{YP}	b_{YP}
0	0	0	0	0	—	—	—
1	.016	.076	.020	.025	−.10	.60	.88
2	.027	.143	.030	.043	−.22	.73	.83
3	.043	.209	.035	.059	−.25	.81	.84
4	.062	.280	.038	.074	−.28	.87	.86
5	.079	.350	.041	.091	−.34	.91	.85
6	.096	.419	.045	.107	−.42	.92	.84
7	.113	.488	.050	.123	−.49	.94	.83
8	.131	.558	.054	.140	−.54	.94	.82
9	.148	.628	.059	.156	−.58	.95	.81
10	.165	.697	.064	.172	−.62	.96	.81
11	.182	.766	.069	.188	−.66	.96	.80
12	.199	.836	.074	.204	−.68	.96	.79
15	.250	1.044	.089	.249	−.75	.97	.78
20	.336	1.391	.114	.319	−.80	.98	.77
25	.422	1.738	.138	.383	−.84	.98	.77
30	.508	2.085	.159	.441	−.85	.98	.76

Note: y and Y are measured as the log of the change from year 0 (1984).

to 9% or less by the end of the loan, this FPM has very unfavorable risk characteristics as compared to the PLAM of Figure 2.

In large part the comparative safety of the PLAM is due to the fact that the initial PTY does not need to be as high to maintain a given, or even a higher, present value. If the PLAM PTY were allowed to start at 28% like the FPM, it would give the borrower almost twice as much credit under the assumptions of the illustration above. However, the PLAM's upper 0.95 bound would then look very much like that of the FPM, without the FPM's redeeming virtue of a steeply declining 0.50 region when the price level forecast is for inflation. The PLAM would then become the *riskier* instrument. Restoring something like the proposed 20% underwriting standard for the initial PTY on PLAMs is therefore very important. Once it is imposed, however, the PLAM becomes safer while still providing considerably more credit.

The above figures are based on 1927–1984 experience, using lagged data back to 1924. Table 4 duplicates Table 1, using 1950–1984 experience instead (with lagged data back to 1947). Figures 4 and 5 duplicate Figures 2 and 3, but based on this recent experience.

As with the longer experience, σ_Y is consistently much larger than

that the value of the prepayment option is much greater with an FPM than with a PLAM, which means that it adds more to the FPM's contractual rate, and therefore raises the FPM's payment more from the start.

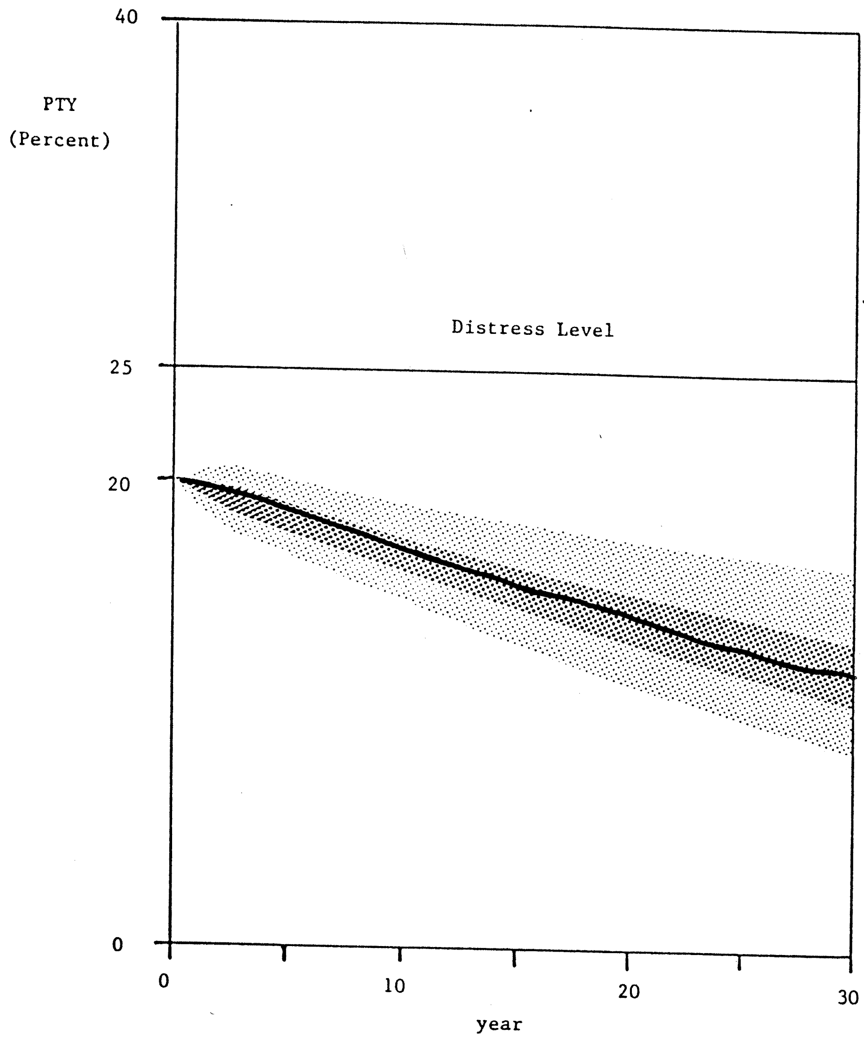

Figure 4. PLAM PTY (1950–1984 experience). Dark shaded area is 0.50 confidence region, light area is 0.95 confidence region. Assumes initial PTY of 20%.

σ_y. The main difference is that now both are much smaller so that inflation and real income growth now both appear to be more of a sure thing. The 0.95 region for the PLAM now stays entirely below 20.7%. That for the FPM declines monotonically from 28%, and falls below 25% by year 4. The FPM PTY is now very unlikely to lie above 8.3% in the last year. Except for the first couple of years of the FPM, neither poses any serious problem vis-à-vis the PTY ratio. [This much smaller postwar

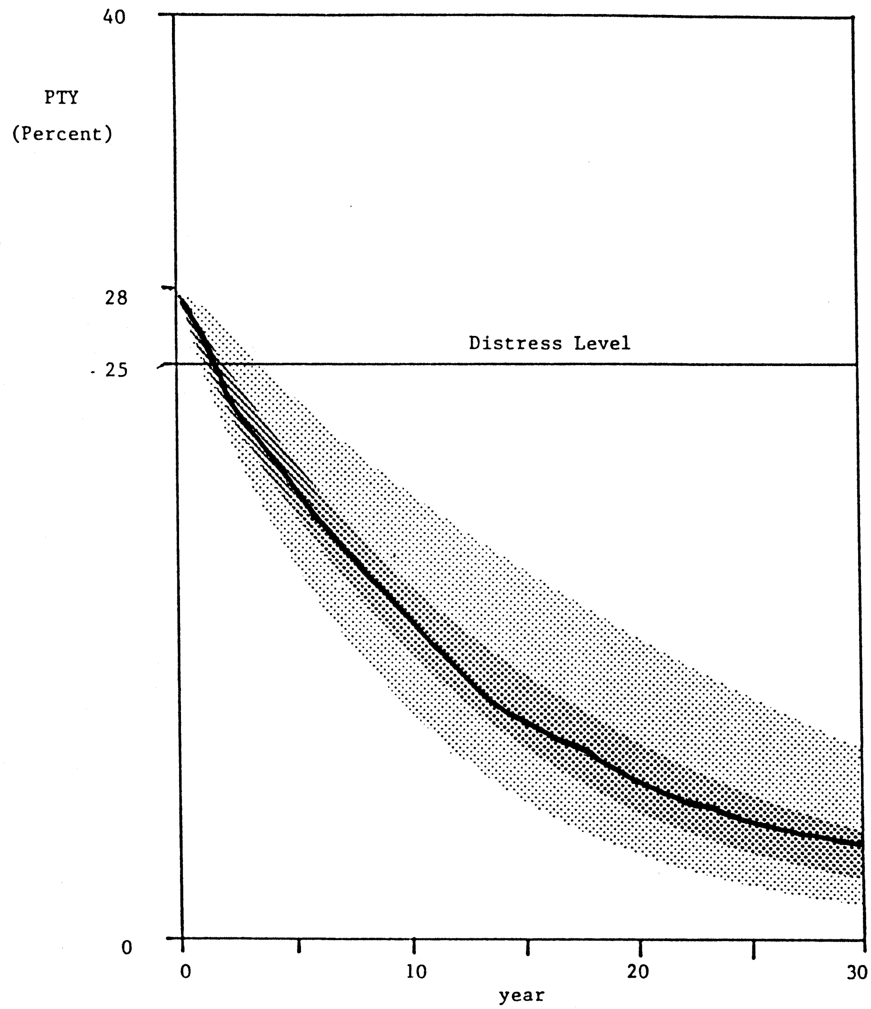

Figure 5. FPM PTY (1950–1984 experience). Dark shaded area is 0.50 confidence region, light shaded area is 0.95 confidence region. Assumes initial PTY of 28%.

uncertainty of income and prices has also been noted by Sims (1980b, p. 252).]

Note that whereas ρ_{yp} was positive for the 1927–1984 period, it is negative for the postwar period, as found by Fama (1981), and strongly so for the longer horizons. This means that there is some truth to the assumptions behind the nominalist position in the postwar period. Whether this was due to the supply shock story, the money growth rule story, or some other mechanism does not concern us here. In the longer period, the Depression and World War II experiences of deflation and inflation accompanied by a real contraction and expansion, respectively, dominate and make the correlation positive, so that Fama's finding of $\rho_{yP} < 0$ is specific to the postwar period.

However, even though Fama's finding that real income shocks and price shocks are negatively correlated in the postwar period is confirmed, this is only a necessary, and not a sufficient, condition for $\sigma_y > \sigma_Y$. As it happens, the variance of P is sufficiently large that this negative correlation is swamped and we still have $\sigma_Y > \sigma_y$. Note also that Y and P are still strongly positively correlated, and nearly perfectly so for longer maturities.

In Table 4, the projection coefficient b_{YP} is less than unity, so that a 1% surprise increase in prices predicts a less than 1% surprise in nominal income—in other words, some fall in real income. This means that the adverse cases in Figure 4 tend to be high inflation scenarios, as opposed to those in Figure 2, which tend to be associated with lower inflation than expected.

The unexpectedly increased burden of a PLAM caused by such a fall in real before tax income in the face of an inflationary surprise during the postwar period would to a great extent be offset by the fact that the real tax advantage of interest deductibility rises with inflation with a PLAM. This is because the inflation adjustment would be deductible as interest at the time it is actually paid. With moderate inflation the initial payments would therefore be 100% deductible, and this complete deductibility would last longer, the higher the realized inflation rate. If we base our projections on the postwar experience, therefore, the already smaller risk of the PLAM is thus even further reduced by tax considerations.

I personally believe the longer experience is more relevant if we are trying to make forecasts decades into the future. Since others may place greater weight on the more recent experience, however, we include it for comparison.

III. House Prices

A second important component of mortgage risk is the current loan-to-value (LTV) ratio. From the point of view of the highly leveraged borrower, fluctuations in this ratio can cause even larger proportionate fluctuations in home equity and net worth. And from the point of view of the lender, the LTV is an important component of default risk. Indeed, in an idealized world in which there were no relocation costs and no costs to an impaired credit rating, the LTV would be the *only* default consideration, and mortgage default could be modeled as the exercise of a put option.[8]

In the real world, relocation does entail costs of moving and of search for a new domicile, as well as emotional costs, that can be substantial. In many states the lender can sue on the note as well as the mortgage, and thereby attach assets other than the house by means of a deficiency judgment. Even if the lender has limited recourse, the loss of credit for future loans can be an important cost of default.[9]

We would, therefore, expect the current LTV to be an important, though imperfect, measure of default risk. If the LTV is less than unity by enough to cover the seller's brokerage costs, default will be negligible regardless of the current PTY ratio, since it is possible simply to sell the house and come out ahead. If the LTV is greater than unity, default will become a consideration, but by no means a certainty. Default probability will then be an interactive function of both LTV and PTY.[10]

In order to model the LTV ratio, we would ideally like an index of the change in value of existing houses, abstracting from improvements, but incorporating depreciation. Unfortunately, no such index exists, so we instead were forced to splice together a number of less than fully comparable series in order to go back to the 1920s.

From 1924 to 1934 we used an index of the estimated and/or market value of owner-occupied houses in 22 cities. From 1934 to 1947 we used the median asking price for existing houses in Washington, D.C. From 1947 to 1964 we used the average construction cost of private nonfarm homes, and from 1964 to 1984 the average sales price of kinds of houses sold in 1977.[11]

Let V be the log of this nominal average house price index, P be the log of the CPI as before, and $v \equiv V - P$ be the log of the average real house price. These three variables were fit with a first difference third-order VAR as above.

Figure 6 shows the history of each series, normalized to 0 in 1984, along with the forecasts of the levels to 2014. The forecasts and their risk parameters are tabulated in Table 5.

[8] Cunningham and Hendershott (1984) stress this pure option aspect.

[9] According to HUD sources, default on an FHA loan does not reduce one's eligibility for future FHA loans, at least as far as FHA goes. Nevertheless, lenders indicate they would be very reluctant to make an FHA loan to an individual with a default record, since they incur many administrative and opportunity costs on delinquent FHA loans, even though they are ultimately protected against loss of principal.

[10] Campbell and Dietrich (1983) maintain that both ratios are important. Foster and Van Order (1984), on the other hand, challenge the significance of the PTY ratio. There are problems with the measures both studies use for the current PTY ratio, so there is room for further research on this important issue. See also Footnote 6 above.

[11] See Appendix for sources and details.

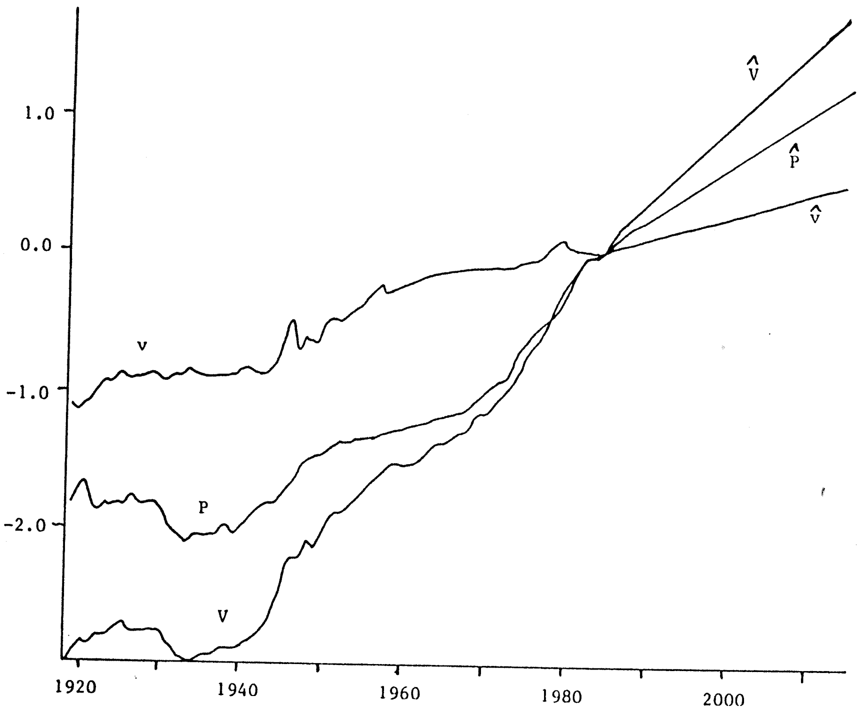

Figure 6. Log of nominal house value (V), CPI (P), and real house value (v), with projections to 2114 (1919–1923 not used in reported regressions).

Real house prices have a much smaller standard deviation than nominal house prices at most horizons. Real house prices are generally weakly to positively correlated with prices. Nominal house prices and the price level are almost perfectly correlated at long maturities. The projection coefficient $b_{VP} = \rho_{VP}\, \sigma_V/\sigma_P$ is near unity at all horizons. Real house prices are clearly much more predictable than nominal house prices by all measures. The HUD's projections of rapid inflation without any house appreciation are therefore totally at odds with experience.

The forecasts of v and V in Table 5 are for a house of constant age. Any given house collateralizing a mortgage can be expected to depreciate. In order to take this into account, we arbitrarily assume that the structure represents 80% of the initial value of the property, and depreciates geometrically at 2.5% per year, while the site, which constitutes the other 20% of the initial value of the property, does not depreciate at all. The resulting depreciation factor $D = 0.20 + 0.80\,(0.975)^T$ is shown in the last column of Table 5. The reader may easily substitute any alternative depreciation assumption below.

Table 6 shows the upper and lower bounds of 0.50 and 0.95 confi-

Table 5. Forecasts and Risk Parameters of Real and Nominal House Values (1927–1984 Experience)

Year	$\hat{v}$	$\hat{V}$	σ_v	σ_V	ρ_{vP}	ρ_{VP}	b_{VP}	D
0	0	0	0	0	—	—	—	1.000
1	.021	.071	.041	.047	−.06	.48	.90	.980
2	.028	.127	.055	.074	−.15	.68	.86	.961
3	.047	.189	.070	.105	−.15	.75	.89	.941
4	.066	.247	.077	.132	−.10	.82	.93	.923
5	.088	.309	.085	.163	.00	.85	1.00	.905
6	.105	.369	.093	.196	.08	.88	1.05	.887
7	.121	.428	.102	.229	.13	.90	1.07	.870
8	.138	.484	.109	.262	.16	.91	1.08	.853
9	.157	.542	.116	.294	.19	.92	1.09	.837
10	.175	.599	.123	.325	.23	.93	1.10	.821
11	.193	.656	.130	.357	.26	.94	1.11	.806
12	.209	.712	.137	.388	.29	.94	1.12	.790
15	.262	.878	.156	.478	.35	.95	1.14	.747
20	.347	1.151	.186	.615	.42	.96	1.15	.682
25	.432	1.422	.214	.739	.46	.97	1.16	.625
30	.516	1.691	.240	.851	.49	.97	1.17	.574

Note: $\hat{v}$ and $\hat{V}$ are measured as the log of the change from year 0 (1984). The depreciation factor D assumes that the structure is 80% of the initial house value, and depreciates by 2.5% of its remaining value annually, while the site does not depreciate.

dence regions for the future real value of a house relative to its current value, based on the data of Table 5, adjusted for the depreciation factor D explained above. The last three columns of Table 6 show the year-end real balance on various PLAMs under the assumption of a 7% real interest rate. The three columns correspond respectively to a 30-year PLAM with an initial LTV of 80% (i.e., 20% down payment), a 25-year PLAM with an initial LTV of 90% (10% down), and a 20-year PLAM with an initial LTV of 95% (5% down).

With 20% down, the 30-year maturity causes no problems for the PLAM. The loan balance stays at least 7 percentage points below the lower bound of the 0.95 region for the real house value. With a 5% down payment, however, a 30-year PLAM maturity could lead to a serious erosion of equity in the early years of the mortgage, as can be seen by multiplying the PLAM balance figures for 20% down by 95/80, and comparing to the 0.95 lower bound figures.

With this small a down payment, it would therefore be prudent to accelerate the PLAM's amortization rate somewhat. This is most easily done by shortening its maturity appropriately. The last column of Table 6 shows that with 5% down and a 20-year maturity, equity would almost surely remain positive, except possibly in years 1 through 3. Even then, it would be very unlikely to fall below −1.6%. The value of equity based on the point estimate of the house value grows steadily from 5%, and

Table 6. Confidence Regions for Real House Value (1927–1984 Experience) with Amortization Schedules for Various PLAMs

	Real House Value					Year-End Real PLAM Balance (7% Real Interest Rate)		
Year	.95 Lower Bound	.50 Lower Bound	Point Estimate	.50 Upper Bound	.95 Upper Bound	20% Down, 30 years	10% Down, 25 years	5% Down, 20 years
0	100.0	100.0	100.0	100.0	100.0	80.0	90.0	95.0
1	92.3	97.3	100.1	102.9	108.5	79.2	88.6	92.7
2	88.7	95.2	98.8	102.6	110.1	78.2	87.1	90.2
3	86.0	94.1	98.7	103.4	113.2	77.3	85.4	87.6
4	84.9	93.6	98.6	103.9	114.6	76.2	83.7	84.7
5	83.7	93.3	98.8	104.6	116.6	75.1	81.8	81.7
6	82.2	92.6	98.6	104.9	118.2	73.9	79.8	78.4
7	80.5	91.7	98.2	105.2	119.9	72.7	77.7	74.9
8	79.1	91.0	98.0	105.5	121.4	71.3	75.4	71.2
9	78.0	90.5	97.9	105.9	122.9	69.9	73.0	67.2
10	76.9	90.0	97.8	106.3	124.5	68.3	70.3	63.0
11	75.7	89.5	97.7	106.6	126.0	66.6	67.5	58.4
12	74.5	88.8	97.5	106.9	127.5	64.9	64.5	53.5
15	71.5	87.3	97.1	107.9	131.8	58.7	54.2	36.8
20	67.0	85.1	96.5	109.4	139.1	45.3	31.7	0
25	63.3	83.3	96.2	111.2	146.4	26.4	0	0
30	60.2	81.9	96.2	113.1	153.9	0	0	0

Note: Table shows percentages of initial real house value. Adjusted for depreciation schedule *D* from Table 5.

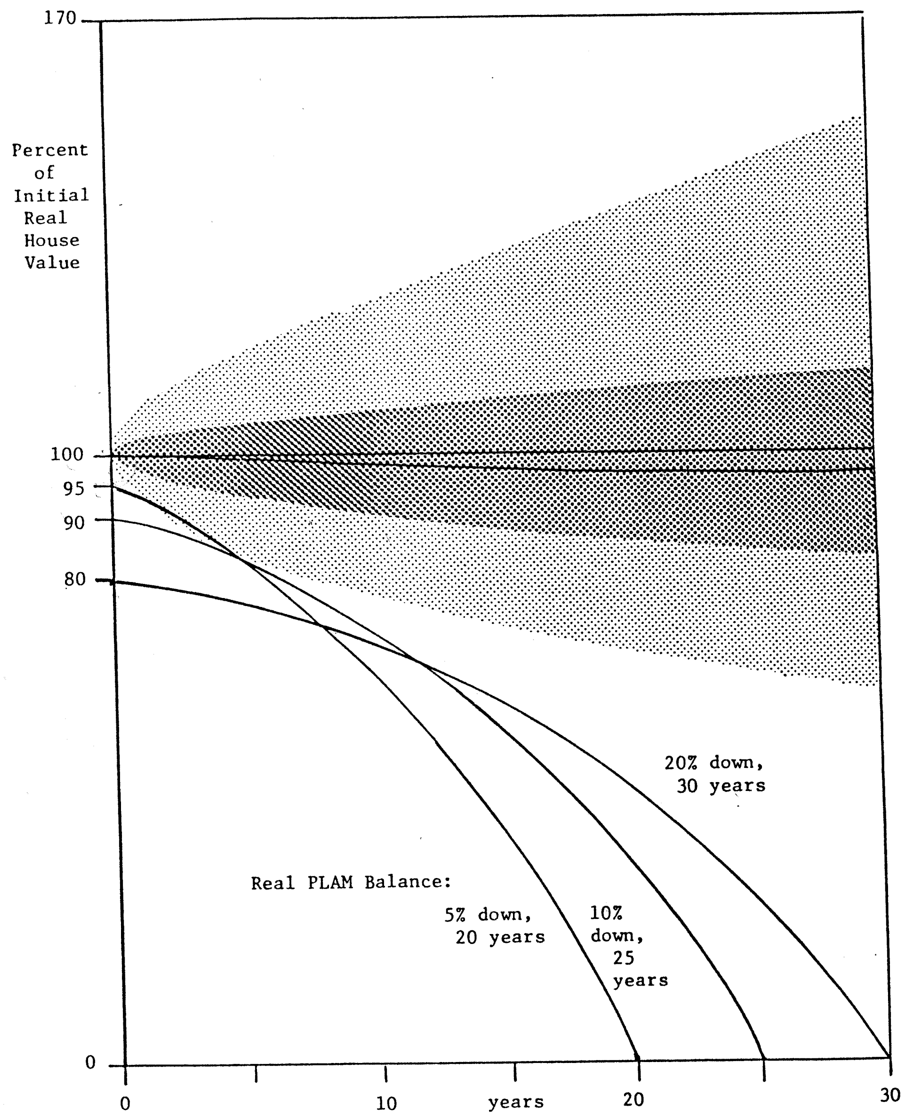

Figure 7. Real house value as a percentage of initial real house value. Dark shaded area is 0.50 confidence region, and light shaded area is 0.95 confidence region. Adjusted for depreciation schedule *D* in Table 5.

reaches 20% of the original house value by year 6, even allowing for depreciation.

The next to the last column of Table 6 shows that with a 10% down payment and 25 years to pay, equity would with very high probability

Table 7. Confidence Regions for Nominal House Value (1927–1984 Experience) with FPM Amortization Schedule

	Nominal House Value					
Year	.95 Lower Bound	.50 Lower Bound	Point Estimate	.50 Upper Bound	.95 Upper Bound	Year-End FPM Balance (13% Nominal Rate) 5% Down, 30 Years
0	100.0	100.0	100.0	100.0	100.0	95.0
1	96.0	101.9	105.2	108.6	115.3	94.7
2	94.4	103.8	109.1	114.7	126.1	94.3
3	92.5	105.9	113.7	122.1	139.8	93.9
4	91.2	108.1	118.1	129.2	153.0	93.4
5	89.6	110.5	123.3	137.6	169.7	92.9
6	87.5	112.5	128.3	146.5	188.3	92.3
7	85.1	114.3	133.4	155.8	209.2	91.6
8	82.9	116.1	138.5	165.3	231.4	90.9
9	80.9	118.0	143.9	175.4	255.8	90.0
10	79.0	120.0	149.4	186.1	282.7	89.0
11	77.1	122.0	155.2	197.5	312.5	87.9
12	75.2	123.9	161.0	209.3	344.7	86.7
15	70.5	130.2	179.8	248.2	458.5	81.9
20	64.6	142.5	215.8	326.8	720.2	68.8
25	60.9	157.3	259.0	426.4	1101.6	44.6
30	58.8	175.4	311.5	553.3	1651.0	0

Note: Table shows percentages of initial nominal house value. Adjusted for depreciation schedule *D* from Table 5.

always be positive. The point estimate of equity grows to 20% of the initial house value by year 7.

The 20–25–30-year maximum maturity underwriting standard that the author has proposed for PLAMs with initial LTVs of up to 95, 90, and 80% respectively, in conjunction with the proposed 20% maximum initial PTY ratio, would therefore keep mortgagor delinquencies well under control.[12]

Figure 7 graphically displays the data of Table 6. The darkly shaded region is the 0.50 confidence region for the real house value, and the lightly shaded area is the 0.95 confidence region. The horizontal line at 100 shows the initial real house value.

Table 7 gives confidence regions for *nominal* house prices using the depreciation schedule *D* from Table 5, along with the amortization schedule for a 30-year FPM with a 13% nominal interest rate and a 5% down payment. These values are illustrated in Figure 8.

Although the FPM has very slow initial amortization in nominal

[12] This standard was proposed by the author in 1982a,b in response to reservations expressed by Follain and Struyk (1977).

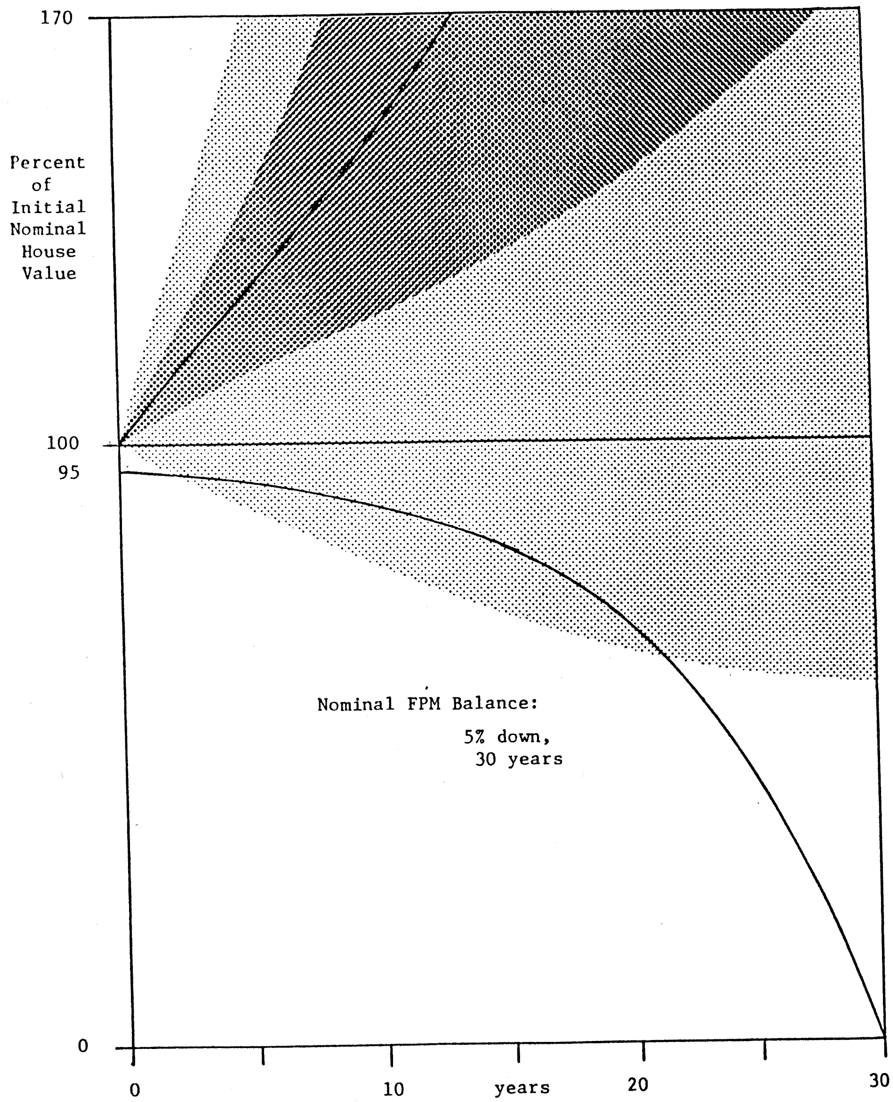

Figure 8. Nominal house value as a percentage of initial nominal house value. Dark shaded area is 0.50 confidence region, light shaded area is 0.95 confidence region. Adjusted for depreciation schedule D in Table 5.

terms, nominal equity builds up very rapidly, when the FPM balance is compared to the values within the 0.50 confidence region. But in comparison to the 0.95 confidence region, the equity buildup is not so certain. Negative equity cannot be ruled out in years 3 through 21, and may go as deep as −11.7% in year 13. It is not until year 26 that we can be quite confident of 20% equity with an FPM.

Tables 5–7 and Figures 6–8 are based on the period 1927–1984 (with three lags, back to 1924). Table 8 reproduces Table 5 for the period 1950–1984 (with three lags, back to 1947). This table is based entirely on the construction cost and new home price portion of our house price index. It therefore omits the collapse of nominal house prices during the Depression, as well as the boom in Washington, D.C. house values during the New Deal and World War II. Nevertheless, the results are surprisingly similar to the figures in Table 5.

The postwar period predicts a little less real growth and a little more nominal growth in house prices, but the differences are not large. The standard deviations are actually somewhat smaller than for the longer period, in contrast to what we found for income. Nominal house prices are clearly less predictable than real at all horizons, and σ_V becomes twice as large as σ_v by year 11. Although negative, ρ_{vP} is small in absolute value at all horizons. The projection coefficient b_{VP} is just under unity at all horizons.[13]

Because of their similarity to Tables 6 and 7 and Figures 7 and 8, analogous tables and figures for the postwar period are not shown here (though they could easily be constructed from Table 8). The only important difference is that substantial house deflation is now much less likely: The lower bound of the 0.95 confidence region for the nominal house price after adjustment for depreciation now just grazes the FPM amortization schedule and then rises back to its initial level, instead of cutting well below it as in Figure 8.

Although the postwar series is internally more consistent than the longer series, it is further removed from the sort of series we would ideally like than is the earlier portion of the series. We therefore regard the longer experience as more reliable for our purposes.

IV. Graduated Payment Mortgages

The FPM appears to be greatly overamortized when compared to the point estimate nominal house values in Figure 8. A mortgage with 5% down could have negative nominal amortization each year in excess of 5.5% of the initial loan balance each year and still never catch up with the point estimate of the future house price. Similarly, Figure 3 indicates that an upward tilt of 8% per year could be put into the nominal pay-

[13] Statman (1982) likewise finds a near-unitary coefficient in a regression of nominal house price changes on CPI inflation (less shelter), 1963–1981, which in his model implies a clear borrower preference for the PLAM. He does find some interesting regional variation, but this is insignificant. The VAR approach used here captures dynamic interactions not considered by Statman, and permits us to construct the projection coefficient at longer horizons.

Table 8. Forecasts and Risk Parameters of Real and Nominal House Values (1950–1984 Experience)

Year	$\hat{v}$	$\hat{V}$	σ_v	σ_V	ρ_{vP}	ρ_{VP}	b_{VP}
0	0	0	0	0	—	—	—
1	.004	.049	.024	.028	−.12	.54	.84
2	.016	.098	.044	.050	−.27	.54	.70
3	.035	.152	.061	.074	−.22	.60	.76
4	.054	.210	.072	.096	−.17	.67	.84
5	.070	.266	.081	.117	−.13	.73	.89
6	.085	.321	.090	.139	−.12	.77	.91
7	.101	.377	.097	.160	−.11	.80	.92
8	.117	.433	.104	.181	−.11	.82	.93
9	.132	.490	.110	.202	−.11	.84	.93
10	.148	.546	.116	.223	−.12	.86	.93
11	.163	.602	.122	.244	−.12	.87	.93
12	.179	.659	.128	.264	−.13	.88	.93
15	.225	.830	.143	.324	−.15	.90	.93
20	.302	1.116	.168	.418	−.19	.92	.92
25	.379	1.403	.191	.504	−.22	.93	.92
30	.455	1.692	.213	.583	−.24	.94	.91

Note: v and V are measured as the log of the change from year 0 (1984).

ment stream of the FPM without impairing the borrower's ability to pay, relative to the point estimate of future nominal income.

The graduated payment mortgage (GPM) introduces such an upward tilt into the nominal payment stream of a mortgage, allowing negative nominal amortization, in order to improve its initial affordability. If future inflation were known today with certainty, a GPM could be designed to be exactly equivalent to a PLAM.

Unfortunately for the GPM, future inflation is very unpredictable. A PLAM can safely permit rapidly increasing nominal payments and rampant negative nominal amortization, since, as we have shown above, real incomes and house values are much more predictable, particularly over periods of several years, than are nominal incomes and house values. But since a GPM requires a predetermined amount of nominal payment growth and negative amortization, whether or not inflation materializes, it can be much riskier. The only way a GPM can be safe is if it greatly underestimates future inflation, and then its initial affordability (and therefore its entire *raison d'être*) is greatly diminished.

Since nominal incomes and house prices are less predictable than real incomes and house prices, using either sample period, any mortgage whose payments are set in nominal terms (such as the FPM or GPM) must be either riskier, less affordable, smaller, or some combination of these, than a mortgage than can be designed with predetermined real payments. As it happens, the level real payments of the simple PLAM approximate the ideal tradeoff of PTY and LTV considerations.

The GPM is therefore completely dominated, both in terms of affordability and safety, by the PLAM.

V. Adjustable Rate Mortgages

We model an adjustable rate mortgage (ARM) as a 30-year loan whose nominal rate is set at 2.0 percentage points above a short-term interest rate index. In order to use a long experience extending back to the 1920s for comparison to the above PLAM and FPM projections, we take the 4- to 6-month commercial paper rate as our index.

Let A be the log of the annual payment that amortizes a given size loan over 30 years at this interest rate, Y be the log of nominal per capita personal income as above, and $R \equiv Y - A$ be the log of the ratio of income to this mortgage payment. A, Y and R were normalized to 0 in 1984. Their first differences were fit with a third-order VAR as above, and their levels projected to 2014. The forecasts of A and R and selected risk parameters are given in Table 9.[14]

Y is positively—though not very strongly—correlated with A at all horizons, and $b_{YA} = \rho_{YA}\, \sigma_Y/\sigma_A$, the conditional expectation of the surprise in Y given a one-unit surprise in A, is positive, though it falls short of unity.

The actual ARM PTY will not be proportional to $\exp(-R)$, since A and therefore R are based on the first year's payment on an ARM with a given value and 30 years to run, whereas an actual ARM will have a payment that recasts the slowly declining balance over the remaining life. Since the portion of this payment that corresponds to interest declines over the life of the loan, A will overstate the true change in the payment, and σ_A may overstate its volatility.

It is difficult to model this feature precisely, since the amount of depreciation that occurs will depend on the exact path of the ARM's interest rate. Nevertheless we can approximately adjust for it if in each forecasting horizon T we replace $\hat{A}$ by $\hat{A}^* = F \cdot \hat{A}$, where F is a factor that equals the portion of the T^{th} year payment on a 30-year mortgage that corresponds to interest, relative to the value of this portion during the first year. For this purpose the mortgage interest rate is taken as the simulated ARM rate for 1984 (10.16 + 2.00 = 12.16%). This procedure slightly understates the true mortgage payment in the adverse cases of high interest rates, since amortization will then be even slower than

[14] Because they are based on different information sets, the explicit forecast of Y in Table 1 is not exactly the same as the implicit forecast in Table 9, though it is similar. Likewise, the implicit forecast of P in Table 1 is not exactly the same as that in Table 5. This problem could in principle be eliminated by fitting Y, P, A, and V in a single VAR system. We chose not to do this, in order to conserve degrees of freedom.

Table 9. Forecasts and Selected Risk Parameters of ARM Income/Payment Ratio (1927–1984 Experience)

Year	$\hat{A}$	$\hat{R}$	σ_R	ρ_{YA}	b_{YA}	F	$\hat{R}^*$	σ_{R^*}
0	0	0	0	—	—	—	0	0
1	.162	−.087	.102	.32	.19	1.000	−.087	.102
2	.171	−.026	.169	.32	.25	.996	−.025	.169
3	.110	.094	.204	.37	.38	.991	.095	.203
4	.108	.144	.227	.44	.53	.986	.145	.226
5	.159	.137	.249	.49	.62	.981	.140	.248
6	.187	.154	.272	.50	.64	.974	.159	.271
7	.178	.212	.291	.51	.65	.967	.218	.288
8	.172	.268	.305	.53	.68	.959	.275	.302
9	.187	.304	.319	.53	.69	.950	.313	.316
10	.208	.334	.334	.54	.70	.940	.346	.330
11	.219	.375	.349	.54	.71	.929	.390	.344
12	.224	.421	.363	.54	.71	.916	.440	.357
15	.259	.538	.402	.55	.74	.868	.572	.394
20	.311	.740	.461	.56	.76	.741	.820	.451
25	.363	.940	.514	.57	.78	.514	1.117	.518
30	.416	1.141	.562	.58	.79	.112	1.510	.646

Note: A and R are measured as the log of the change from year 0 (1984).

otherwise. Likewise we replace σ_A with $\sigma_{A^*} = F \cdot \sigma_A$, $\hat{R}$ with $\hat{R}^* = \hat{Y} - \hat{A}^*$, and appropriately recompute

$$\sigma_{R^*} = \sqrt{\sigma_Y^2 + F^2\sigma_A^2 - 2F\rho_{YA}\sigma_Y\sigma_A}.$$

The values of F, $\hat{R}^*$, and σ_{R^*} are shown in Table 9. The adjustment makes $\hat{R}^*$ greater than $\hat{R}$, which will tend to reduce the projected PTY ratios. However, the adjustment does not actually make σ_{R^*} less than σ_R, since A is positively correlated with Y and we are now reducing the extent to which A and Y cancel out.

The adjusted ARM volatility σ_{R^*} is uniformly almost twice the PLAM volatility σ_y in Table 1. For years 1 through 4 it is even greater than the FPM volatility σ_Y in Table 1. The uncapped ARM clearly has a great potential for payment shock, which can result in great disutility to the borrower, and perhaps even default.

Table 10 gives confidence intervals for the ARM PTY ratio, based on an initial ratio of 28%. These are plotted in Figure 9. The 0.5 confidence band falls below the 25% "distress" level within 3 to 10 years. However, the 0.95 band takes 26 years (not tabulated) to fall completely below this level. In the first 15 years, the upper edge of the 0.95 band lies well above that of the FPM in Table 3 and Figure 3. The ARM therefore

Table 10. Confidence Regions for ARM Current PTY (1927–1984 Experience)

Year	.95 Lower Bound	.50 Lower Bound	Point Estimate	.50 Upper Bound	.95 Upper Bound
0	28.0	28.0	28.0	28.0	28.0
1	25.0	28.5	30.5	32.7	37.3
2	20.6	25.6	28.7	32.2	40.0
3	17.1	22.2	25.5	29.2	37.9
4	15.5	20.8	24.2	28.2	37.7
5	15.0	20.6	24.4	28.8	39.6
6	14.1	19.9	23.9	28.7	40.6
7	12.8	18.5	22.5	27.4	39.6
8	11.8	17.3	21.3	26.1	38.4
9	11.0	16.5	20.5	25.3	38.0
10	10.4	15.8	19.8	24.8	37.8
11	9.7	15.0	19.0	23.9	37.2
12	9.0	14.2	18.0	23.0	36.3
15	7.3	12.1	15.8	20.6	34.2
20	5.1	9.1	12.3	16.7	29.8
25	3.3	6.5	9.2	13.0	25.3
30	1.7	4.0	6.2	9.6	21.9

Note: Table shows payment as a percent of income. Assumes 28% initial PTY.

generates a much greater probability of distress than either the PLAM or the FPM.[15]

Many of the ARMs in the market today have interest rate and/or payment caps, which we have not attempted to model above. An interest rate cap will simply make the instrument behave like a cross between the uncapped ARM we have modeled and an FPM. Payment caps generally imply negative nominal amortization which, as we have shown in Table 7 and Figure 8, can be very risky, unless it is conditioned on realized inflation as with a PLAM.

It has been called to my attention that at least one lender in the Philadelphia area is offering an ARM with a payment cap tied to the CPI. If the nominal rate were determined ex post by inflation plus a contractual real rate that was used to set the initial payment, this would amount

[15] The ARM payment *A* is projected to rise some 16% in the first year (1985) as rates return to their "normal" levels of 1980–1982, before resuming a slow upward drift. Even if we discount this first year rise, and multiply each value in Table 10, after year 0, by 0.84, the ARM still appears very risky.

In McCulloch (1985a), we show that interest rate uncertainty exhibits substantial conditional heteroskedasticity, so that "noisy" periods like 1979–1982 are more likely to be followed by large surprises than are "quieter" periods. We make no attempt here to incorporate this. Its inclusion would substantially raise the already high uncertainty of the ARM PTY.

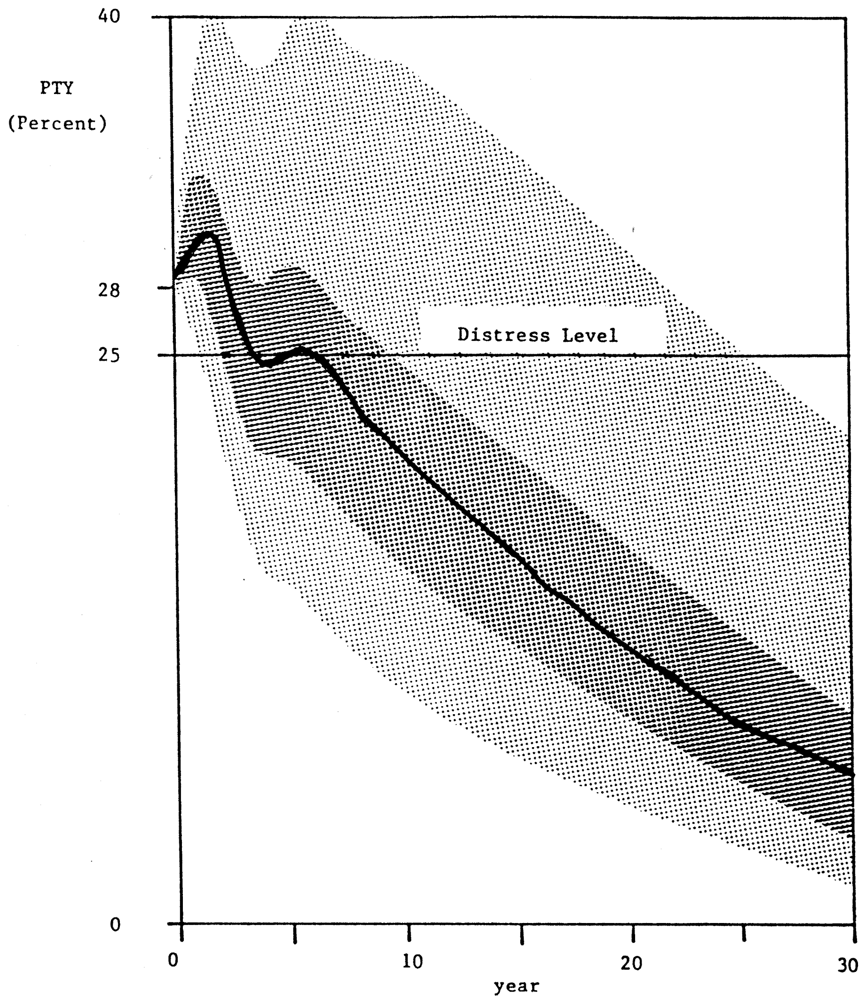

Figure 9. ARM PTY (1927–1984 experience). Dark shaded area is 0.50 confidence region, light area is 0.95 confidence region. Assumes initial PTY of 28%.

to a PLAM thinly disguised as an ARM. In fact, however, the nominal rate is based on an index of other nominal interest rates, which permits dangerous negative real amortization for two reasons: First, the nominal rate index contains an inflation premium that is only an imperfect *forecast* of inflation, not an ex post *hindcast*. And second, as Antoncic (1986) shows, the real rate built into short-term nominal rates can and has undergone swings in excess of 800 basis points in recent years.

The 1950–1984 experience (not tabulated here) tells a similar story about the ARM's potential for payment shock. The 0.95 band stays above 25% until year 17, and rises as high as 43.4% (in year 2).

VI. Individual Characteristics

The above projections are based on national average incomes and house prices. In addition to the economy-wide shocks to these variables, there will be borrower-specific shocks that affect the current PTY and LTV. Distress and/or default experience on all types mortgages may therefore exceed that which would be predicted on the basis of the above projections.

To the extent that borrower-specific income shocks occur, they will affect the borrower's real and nominal income equally, and the same is true for borrower-specific house-price shocks. Therefore, those shocks are not a particular problem of the PLAM or of any other mortgage. All types of mortgage should have some margin for such idiosyncrasies built into the projected PTY and LTV ratios. However since, as we have demonstrated, the average behavior of these ratios is far more predictable for the PLAM than for the other mortgage instruments, it is easier to build such a margin for error into the PLAM.[16]

It should be noted that since individual shocks by definition cancel out on average, they can be actuarially insured against. The aggregate shocks we have modeled above, on the other hand, would from time to time create a net drain on an insurer in excess of current premiums.[17]

Although individual shocks average to zero, they need not be entirely random, in that they may be correlated with observable borrower characteristics such as whether the borrower is a wage earner. Many individuals have expressed concern as to whether wage income, in particular, keeps up with inflation. In order to check this we reran the calculations of Table 1 and 4, using average weekly earnings in manufacturing in place of per capita personal income. The results were qualitatively very similar, particularly for the 1927–1984 period, where the standard deviations of log real and nominal wage earnings grew from 0.041 and 0.054, respectively, at year 1, to 0.281 and 0.648 at year 30. The projection coefficient of nominal wages on the CPI falls from 1.39 at year 1 to 0.90 at year 30.

For the 1950–1984 period, real wage uncertainty is actually slightly higher than nominal in year 1 (0.024 versus 0.022) though nominal un-

[16] Manchester (1985) investigates the behavior of median nominal and real income for several demographic and occupational groups. She finds that the PLAM would provide a relatively level ratio of payment to income for all groups.

[17] We make no attempt in the present paper to study the appropriateness of the Gaussian probability model that underlies our OLS VAR estimates and which serves as the basis for our confidence regions. Preliminary investigations indicate that y and Y may actually be stable Paretian with a characteristic exponent of 1.3 or less. In this case the precise value of insurance would be far greater than a Gaussian model like that of Cunningham and Hendershott (1984) would predict. See McCulloch (1985b). Nevertheless, the above figures still give a valid picture of whether the probability of an excessive PTY or LTV is "high" or "low".

certainty catches up by year 4. By year 30, real and nominal uncertainty are 0.265 and 0.395, respectively. Here the projection coefficients rise from 0.39 in year 1 to 0.61 in year 30. In the longer run, where uncertainty is more important, real wage income still is substantially more predictable than nominal.

Note that in all of our comparisons, there is much greater nominal predictability, comparatively speaking, at short horizons than at the longer ones. In the short run, real uncertainty may be close to or even slightly greater than nominal uncertainty, but the scale of the errors is such that neither is yet a serious problem. In the long run, the real shocks tend to cancel themselves out much more than do the nominal shocks, making real uncertainty less in the long run, where uncertainty is a much greater problem. A major advantage of our VAR approach is that it enables us to make this distinction in a systemmatic fashion.

One individual characteristic that is predictable but which we have not incorporated is the inexorable tendency of borrowers to move up 1 year in the age-earnings profile each year. Since this profile is upwardly sloped, particularly for younger individuals who are likely to be home buyers, the PLAM PTY is likely to have even more downward slope than is shown in Figure 2.

VII. Conclusions

Many individuals have expressed concern that price level adjusted mortgages would tend to generate excessive financial burdens and even defaults if nominal incomes and house prices fail to keep up with inflation. Indeed, HUD's official policy recommendations on FHA indexed mortgages are based on the presumption that incomes and house prices would not follow inflation at all.

We have shown that in fact nominal incomes and house prices do typically keep up with inflation, and that real incomes and house prices are more predictable than their nominal counterparts, particularly at longer forecasting horizons. A properly structured and underwritten PLAM can therefore be designed so as to have far less risk, at the same time it extends more credit, than nominal alternatives like the FPM and GPM. The "20–20" underwriting standards we have proposed elsewhere (20% maximum initial PTY, and at most 20 years to pay with 5% down payment) would give a level real payment PLAM a good balance of risk characteristics in terms of both the current payment-to-income ratio and the current loan-to-value ratio.[18] The ARM's payment-to-in-

[18] The payments on the "real dollar payback" (RDP) loan proposed by Arthur Sharplin (1981) include equal real amortization each period plus real interest on the linearly declining real balance. These mortgages have been used successfully alongside the regular PLAM in Brazil (see Anderson and Lessard, 1975). They amortize faster and thus look

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Technical Appendix

I. *Data Sources*

The price level is the CPI-U. Values for 1957–1984 are from *Economic Report of the President*, 1985 edition (hereafter *ERP*), Table B-54; 1919–1957 is from *Historical Statistics of the United States*, 1976 edition (hereafter *HSUS*), Series E113. The two series were linked at 1957.

Personal income 1947–1984 is from *ERP*, Table B-20. 1919–1947 is from *HSUS*, Series F-8. The two were linked at 1947.

Population is total U.S. population including Armed Forces Overseas. 1940–1984 from *ERP*, Table B-28; 1919 and 1930–1940 are from

HSUS, Series A-1 and Footnote 1. The two agree in 1940; 1920–1929 was inferred from *HSUS* Series A-2 (total population residing in the United States) and the assumption that Armed Forces Overseas was constant at the 1930 level during this period.

Nominal house prices, 1919–1934, is price index for one-family houses, owner-occupied houses, 22 cities, adjusted for depreciation, *HSUS*, Series N260. (A 1 3/8% annual adjustment for depreciation included in Series N260 is intended to remove the actual depreciation that enters Series N259. The adjusted series should be more comparable with the other house price series we use, which include no systematic depreciation.) The 1934–1947 is median asking price for existing houses, Washington, D.C., *HSUS*, Series N261, linked to above at 1934; 1947–1959 is average construction cost of private nonfarm houses, old series, from *Savings and Loan Fact Book*, linked to the above at 1947; 1947–1949 was taken from 1956 edition and 1950–1959 from 1970 edition; 1959–1964 is same index, new series from 1970 edition, and linked at 1959; 1964–1984 is price index of new one-family houses sold, including value of lot, based on kinds of houses sold in 1977, from *Construction Reports* (Census Bureau), C27-84-Q3. The 1984 value was based on average of second and third quarters, since fourth quarter was not yet in. This was linked at 1964.

The ARM rates 1957–1984 based on 6-month commercial paper rate, *ERP*, Table B-66; 1919–1957 is 4- to 6-month prime commercial paper, *HSUS*, Series X306. The two agree in 1957.

II. *Regressions*

All regressions were run with RATS version 4.11 [see Doan and Litterman (1983)] on OSU's IBM 3081.

Extensive specification tests with log income and price variables in levels form with deterministic trends gave greatly divergent forecasts with just minor changes in specification. First differences gave much more robust forecasts, as Nelson and Plosser (1982) would suggest.

With first differences of P, Y, and y, two lags whitened residuals with Q test, but third lag was significant in P equation. The fourth lags were all insignificant, but fifth lags were strong and significant in Y and P equations, and brought fourth lags back in significantly with value nearly equal to fifth lag but opposite sign. This behavior seemed to be spuriously overfitting 1930 and 1932, so three lags were used throughout.

In P, V, v, model, third lag was significant on P in V, P, and v equations, and three lags whitened residuals.

In A, Y, R model, three lags were still used though third lag was never significant; three lags whitened residuals.

In the P, Y, y model, alien lags were collectively insignificant in each equation, so that single equation methods could have been used in principle. However, these would not have given consistent forecasts of the three variables, so VAR was still used. Alien lags came in significant in at least some equations in the other models.

Forecasts were initialized with actual 1982–1984 history. Except for A and R, initialization values had little effect.

"Impulse uncertainty" was calculated with RATS procedure ERRORS. In order to get RATS to consider covariance of cross-equation errors, it is necessary to actually compute the covariance matrix, adjusting for degrees of freedom, and pass this to ERRORS.

"Coefficient uncertainty" could in principle be calculated by retrieving the system's coefficient vector and its covariance matrix, and then drawing random coefficient vectors with this matrix. The procedure in the text, which is equivalent in spirit, was easier to encode and so was used.

The impulse error at horizon T of the restored levels of a first differenced VAR with constant term is asymptotically proportional to $T^{1/2}$. The coefficient error, on the other hand, must behave like T, and so must dominate eventually, though it will tend to be dominated by the impulse error for small T. In this paper, the coefficient error makes hardly any contribution at all to the total error except at the very longest maturities. (In levels equations, the coefficient uncertainty is much more important, since the impulse error quickly approaches a constant value.)