HOUSING DEMAND, REAL MORTGAGE RATES AND THE TILT PROBLEM

Changes in real mortgage rates as well as changes in the tilt factor can influence housing demand.

by Michael T. Bond

The interest rate on a home mortgage is an important determinant of the demand for housing. Periods of high interest rates on housing loans have been accompanied by dramatic slowdowns in the sale of both new and existing houses in the United States. Drops in the cost of housing money generally have been associated with a marked increase in home sales. This article develops a theoretical framework to explain why the housing industry suffers when mortgage rates rise in nominal terms but not in real terms (i.e., when adjusted for inflation). This phenomenon, referred to in the literature as the tilt problem,[1] has been addressed as a determinant of housing demand over time.

The Tilt Problem

The following problem illustrates the use of a conventional fixed-rate mortgage during a period of inflation. Assume there is a five-year mortgage on an initial balance of $50,000 with annual payments. Also assume that the buyer of the home has a dollar income at time period zero of $30,000. If the rate of interest on the mortgage is 6 percent, the annual payment of principal and interest is $11,869.82. If there is no inflation over the life of the contract and the homeowner's income remains the same in real terms, the homeowner will have a ratio of debt service to income of 39.57 percent in each of the years the mortgage is outstanding, as shown in Table 1.

Now assume that 10 percent inflation has been anticipated and built into the mortgage agreement. The inclusion of an inflation factor necessitates a nominal yield on the mortgage of 16.6 percent (the original 6 percent plus the expected inflation of 10 percent and a cross-product term). Thus, a mortgage rate of 16.6 percent is needed to keep the real cost of the mortgage at 6 percent, as suggested by Fisher.[2]

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The tilt problem now becomes obvious (see Table 2). With a built-in inflation factor, the amortized amount for the five-year, fixed-rate mortgage becomes $15,484.74. If the homeowner's income remains the same in real terms, the ratio of debt service to income in the first year is 46.92 percent. Thus, even though the real cost of the mortgage is the same (6 percent), it is more difficult up front to afford the home in question. Of course, if income remains the same in real terms and inflation is actually 10 percent, the servicing ratio over time will become easier to handle. Note the ratio of debt service to income declines to 32.05 percent in the last year of the mortgage.

Probably the best method for dealing with the tilt burden is a price level-adjusted mortgage (PLAM). Table 3 presents the data for the above mortgage when the real interest rate of 6 percent is used in a PLAM. In this example, when a nominal yield of 6 percent is set in the contract and the mortgage payment is indexed to the rate of inflation over time, the debt service to nominal income ratio does not change. In each time period the ratio of debt service to nominal income remains 39.57 percent. This phenomenon also occurs with a fixed-rate mortgage

TABLE 1

Debt Service Ratio On A Conventional, Five-Year, Six Percent, Fixed-Rate Mortgage for $50,000

Year	Annual Payment on Principal and Interest	Amount Paid for Interest	Amount Paid on Principal	Unpaid Balance	Homeowner's Income	Debt Service Ratio
1	$11,869.82	$3,000.00	$ 8,869.82	$41,130.18	$30,000	39.57%
2	11,869.82	2,467.81	9,402.01	31,728.17	30,000	39.57
3	11,869.82	1,903.69	9,966.13	21,762.04	30,000	39.57
4	11,869.82	1,305.72	10,564.10	11,197.94	30,000	39.57
5	11,869.82	671.88	11,197.94	0.00	30,000	39.57

TABLE 2

Effect On Inflation On A Conventional, Fixed-Rate Mortgage For $50,000 And The Tilt Problem

Year	Annual Payment on Principal and Interest	Amount Paid for Interest	Amount Paid on Principal	Unpaid Balance	Homeowner's Income	Debt Service Ratio
1	$15,484.74	$8,300.00	$ 7,184.74	$42,815.26	$33,000.00	46.92%
2	15,484.74	7,107.33	8,377.41	34,437.85	36,300.00	42.66
3	15,484.74	5,716.68	9,768.06	24,669.78	39,930.00	38.78
4	15,484.74	4,095.18	11,389.56	13,280.23	43,923.00	35.25
5	15,484.74	2,204.52	13,280.23	0.00	48,315.30	32.05

TABLE 3

Effect Of PLAM On The Tilt Problem

Year	Annual Payment on Principal and Interest	Amount Paid for Interest	Amount Paid on Principal	Unpaid Balance	Homeowner's Income	Debt Service Ratio
1	$13,056.80	$3,300.00	$ 9,756.80	$49,767.52	$33,000.00	39.57%
2	14,362.48	2,986.05	11,376.43	42,230.20	36,300.00	39.57
3	15,798.73	2,533.81	13,264.92	31,861.80	39,930.00	39.57
4	17,378.60	1,911.71	15,466.90	18,034.40	43,923.00	39.57
5	19,116.46	1,082.06	18,034.40	0.00	48,315.30	39.57

TABLE 4

Effect Of PLAM On A Five-Year, Eight Percent Mortgage for $50,000

Year	Annual Payment on Principal and Interest	Amount Paid for Interest	Amount Paid on Principal	Unpaid Balance	Homeowners Income	Debt Service Ratio
1	$12,522.82	$4,000.00	$ 8,522.82	$41,477.18	$30,000	41.74%
2	12,522.82	3,318.17	9,204.65	32,272.53	30,000	41.74
3	12,522.82	2,581.80	9,941.02	22,331.51	30,000	41.74
4	12,522.82	1,786.52	10,736.30	11,595.21	30,000	41.74
5	12,522.82	927.62	11,595.21	-0.00	30.000	41.74

when there has been no anticipated or actual inflation over the life of the contract.

While this tilt effect has been noted and discussed in the literature, there is another effect, which I will call the real effect, that also influences the affordability of a mortgage. Assume that the $50,000 mortgage is set up as a PLAM, the homeowner's income remains at $30,000 in real terms and there is 10 percent inflation. What if the real mortgage rate is 8 percent? The results are shown in Table 4. Note that in each of the five years the ratio of debt service to nominal income is 41.74 percent. Thus, even though the PLAM has eliminated the tilt problem, it has not eliminated the negative influence of the higher mortgage rates.

The Tilt Problem's Effect On Housing Demand

There is a substantial body of literature on housing demand and mortgage rates. The tilt problem has been recognized in the literature and has been shown to have a negative influence on the demand for housing. The influence on housing from changes in real mortgage rates also has been examined. For example, Cohn and Lessard suggested that the conventional fixed-rate mortgage was a central determinant of the dramatic decline in the United States housing market in the 1974-1975 period.[3] Among their recommendations for diluting the impact of high-cost, fixed-rate mortgages on housing demand was a PLAM that would maintain over time a constant rate of real interest on a mortgage by relating the payments on the loan to an appropriate price index. Hyer and Kearl also suggested that a PLAM would have the potential of ameliorating the difficulties encountered with fixed-rate mortgages in an inflationary environment.[4] Vandell, using simulation analysis, demonstrated that PLAMs were far less likely to discourage home ownership during periods of high inflation than were both fixed-rate mortgages and variable rate mortgages.[5] Alm and Follain estimated that the use of PLAMs would allow the average homebuyer to purchase a house valued at 30 percent more than the homebuyer could afford under a standard fixed-rate mortgage.[6]

However, Vandell also suggested that PLAMs would be unpopular with many lenders because the real incomes of certain groups of borrowers might not keep up with increases in the monthly mortgage payment over time.[7] Cassidy pointed out that because of the lower initial cash flow from a PLAM, lenders would resist this type of mortgage, and a similar type of instrument would have to be developed for savers.[8]

Batten and Hein pointed out that, adjusted for ex-post inflation, real mortgage rates were relatively stable through the 1967-1982 period in the United States. They attributed the variation in housing activity in the country to the fixed-payment feature of fixed-rate mortgages, although they did not attempt to quantify this phenomenon or name it.[9] Harris defined the increase in the ratio of mortgage cost to homeowner income when fixed-rate mortgage costs rose as the tilt problem but did not attempt to use it as a variable in explaining housing demand.[10]

Both Kearl[11] and Schwab[12] attempted to measure the effect of changes in real mortgage rates. Kearls' study involved only the 1966-1973 time period, while Schwabs' work was a simulation analysis that focused primarily on the microfoundations of housing demand.

This article represents an additional contribution to the literature because it estimates the effect of changes in real mortgage rates and the tilt burden through 1986. The paper constructs theoretical measures of the tilt problem and the real problem using survey-based measures of expected inflation, and it tests these measures as determinants of housing demand in the United States.

Measurements Of Tilt And Real Burdens

The tilt burden may be defined roughly as the increase in the ratio of debt service to nominal income when a mortgage rate rises in nominal terms but remains constant in real terms. This definition obviously ignores the fact that, over the life of a fixed-rate mortgage, the debt service burden will decline because of increases in nominal incomes. However, it does capture the upfront lockout problem that faces many homebuyers.

In order to measure for empirical examination, the upfront tilting of real mortgage payments on a fixed-rate mortgage when there is expected inflation, an index has been constructed in Equations 1 through 3 below using the following variables: the current after-tax nominal mortgage rate, the expected inflation rate over the life of the mortgage, the amount being financed and the income of a prospective homeowner.

$$1 \qquad \frac{\left[\dfrac{L}{1 - \left[\dfrac{1}{(1 + mr/12)^n}\right]}\right]}{HI}$$

Equation 1 represents the present value of a stream of payments for a fixed-rate mortgage. It divides the loan amount L by an annuity factor for n years with a mortgage rate equal to the real rate r and the expected inflation rate i. The quotient from this equation produces the monthly mortgage payment, which is then divided by the homeowner's initial income HI.

$$2 \qquad \frac{\left[\dfrac{L}{1 - \left[\dfrac{1}{(1 + rm/12)^n}\right]}\right]}{HI}$$

Equation 2 expresses algebraically the real value of the payments on a PLAM. The loan amount L is divided by an annuity factor using the real after-tax rate of interest to generate the base payments on the mortgage. The real rate on the mortgage is equal to the observed nominal rate minus the expected rate of inflation over the contract. (These payments would rise over time at the rate of inflation of 1 percent to keep the mortgage payment constant in real terms.) The initial payment is then divided by household income HI to give a debt service ratio on the PLAM.

Equation 3 is the result of dividing Equation 1 by Equation 2 and produces the tilt index:

$$3 \qquad \frac{\left[1 - \left[\frac{1}{(1 + rm/12)^n}\right]\right]}{\left[1 - \left[\frac{1}{(1 + mr/12)^n}\right]\right]}$$

By dividing Equation 2 into Equation 1, both the loan amount L and the household income amount HI are eliminated. The numerator of the tilt index is equal to the annuity factor that uses the after-tax nominal mortgage rate. The denominator is equal to the annuity factor that uses the real after-tax mortgage rate as the per period interest rate. It is obvious that if the anticipated rate of inflation is zero percent, the nominal and real mortgage rates will be equal and the tilt burden will be 1.

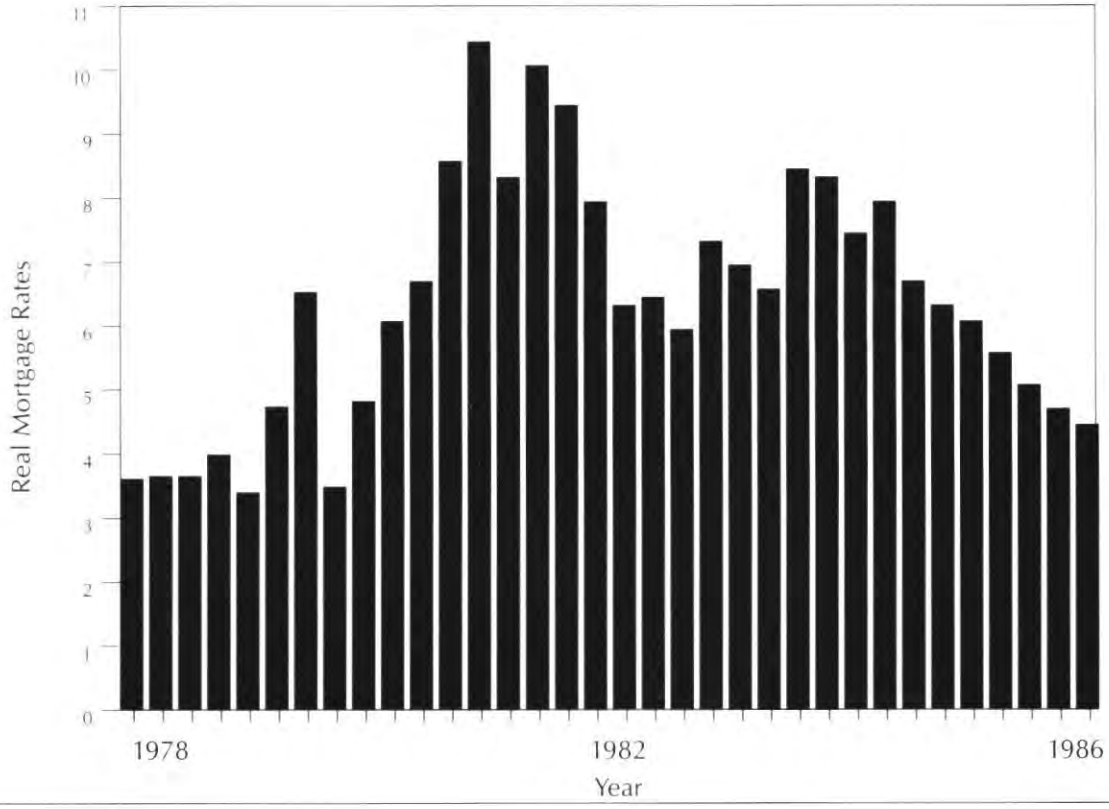
Empirical Evidence

From the previous discussion, it would appear that changes in the tilt burden as well as changes in the level of real mortgage rates should influence the affordability of and, hence, the demand for housing. In this section, the demand for housing is related statistically to measures of the real mortgage rate and the level of the tilt burden. Since increases in either the real mortgage rate or the tilt burden increase the ratio of debt service on a mortgage to income, both of these variables should be related in a negative manner to the demand for housing.

Three dependent variables have been used in the study as measures of the demand for housing: the number of new housing starts, the index of new starts authorized by local building permits and the number of sales of existing single family homes. The measure of real mortgage rates involves subtracting an expected inflation variable from an observed mortgage rate in each time period. The yields on secondary Federal Housing Administration (FHA)

FIGURE 1

Expected Real Mortgage Rates



mortgages have been used as proxies for nominal mortgage rates, and a long-term expected inflation series, which is compiled through quarterly surveys by Drexel-Burnham-Lambert,[13] has been used as a measure of anticipated inflation. The difference between the FHA mortgages and the inflation series has produced the expected real mortgage rates as shown in Figure 1. This variable has been converted to an after-tax figure using an average marginal tax rate series constructed by Joe Peek from *Statistics of Income Data*.[14] This adjustment is desirable because of the tax deductibility of interest on home mortgages and the positive impact that deductibility has on housing demand.

The tilt index is derived from Equation 3 using the measures of nominal and real after-tax mortgage rates indicated above, and the tilt burden TB is calculated for a 15-year mortgage TB15 and a 30-year mortgage TB30. The time period under study includes quarterly observations from the third quarter of 1978 (the first observation in the Drexel Series) to the fourth quarter of 1986 (the latest observation in the Drexel Series). Thus, there are 34 observations in the analysis. A larger sample is desirable, but the limited observations of the Drexel Series (which apparently is the only survey-based, long-term expected inflation series available) make a large sample impossible to obtain.

In order to test for the separate effects of changes in the real mortgage rate and changes in the tilt burden on the demand for housing, the parameters of Equation 4 have been estimated:

$$4 \quad HD = a_0 + a_1 rm + a_2 TB + e$$

where: HD = demand for housing
rm = real mortgage rates (after taxes)
TB = tilt burden
e = error term

The hypothesis is that changes in both real mortgage rates as well as changes in the tilt factor would influence housing demand if both a_1 and a_2 were found to be negative. In addition, since there would be a positive demand for housing even if real mortgage rates were zero percent and if there were no tilt burden, a positive intercept a_0 has been anticipated.

The results of least square regression using the Cochrane-Orcutt method[15] for autocorrelation correction are presented in Table 5. For all three dependent variables (new housing starts, new housing permits and existing home sales), the explanatory variables (real mortgage rates and the 30- and 15- year tilt burdens) are negatively related to housing demand. The explanatory power of the regressions is good, ranging from an r^2 correlation coefficient of .8213 in regression 1 to a coefficient of .8951 in regression 5, and all six regressions have a positive and statistically significant intercept. The real mortgage rate variable in all the regressions is statistically significant at the five percent level of confidence.

The only disturbing aspect of the results is the statistical insignificance of the tilt burden measures, particularly in regressions 5 and 6. The tilt burden's statistical insignificance may be explained partially by the small size of the

TABLE 5

Regression Of Real Mortgage Rates And Tilt Burden On Quarterly Housing Demand
(From Third Quarter 1978 To Fourth Quarter 1986)

Regression Number	Dependent Variable	Constant	Real* Mortgage Rates	Tilt Burden (15-year Mortgage)	Tilt Burden (30-year Mortgage)	Correlation Coefficient (r^2)	S.E.E.
1	New Housing Starts	4330.04 (3.44) †	-101.46 (2.35)	-1689.28 (2.19)	—	.8213	148.08
2	New Housing Starts	3394.72 (4.10)	-146.22 (2.52)	—	-746.44 (2.21)	.8234	147.20
3	New Housing Permits	307.53 (2.98)	-8.77 (2.67)	-112.36 (1.77)	—	.8436	10.99
4	New Housing Permits	240.29 (3.54)	-11.49 (2.53)	—	-47.47 (1.72)	.8443	10.96
5	Existing Home Sales	6.538 (2.97)	-.2024 (3.03)	-1.973 (1.46)	—	.8951	.2199
6	Existing Home Sales	5.218 (3.67)	-.2409 (2.61)	—	-.7726 (1.35)	.8942	.2208

*Real Mortgage Rates = yields on secondary FHA mortgages after taxes (Department of Housing and Urban Development, Federal Housing Administration) minus long-term anticipated inflation series (Drexel-Burnham-Lambert, Inc.)

† t statistics are presented in parentheses

Sources:

New private housing starts (Department of Commerce, Business Conditions)

Index of new private housing units authorized by local building permits (Department of Labor, Bureau of Labor Statistics)

Existing single family home sales (National Association of Realtors, Economics and Research Division)

sample under investigation. Collinearity may explain the insignificance of the 30-year tilt burden variable which has a correlation coefficient with the real mortgage rate of .6. Overall, however, it appears that the model supports the assertion that the demand for housing is a function of both the real costs of borrowing and the tilt burden.

Effect Of PLAM On Housing Demand

As was demonstrated earlier, the tilting effect on housing demand probably could be eliminated by replacing the standard fixed-rate mortgage with a PLAM. How would a PLAM effect the demand for housing? Earlier work by Kearl indicated that the total U.S. housing stock would have been 10 to 12 billion higher during the 1966-1973 time period if PLAMs had been available.

One way to examine the effect of PLAMs during the time period of this study is to take the parameters from one of the previous regressions and calculate the predicted values for housing demand using the actual real mortgage rate in each period and a tilt burden equal to 1 (which is the result when a PLAM is used). This calculation has been done for regression 2 (which uses new housing starts as the dependent variable and a 30-year tilt burden). The mean, standard deviation and coefficient of variation for the predicted values have been calculated and compared to the mean, standard deviation and coefficient of variation for the actual housing starts:

	Mean	Standard Deviation	Coefficient of Variation
New Housing Starts (Actual)	1552.48	332.05	.2138
New Housing Starts (Predicted)	2358.99	195.52	.0828

The contrast is striking. The predicted mean for new housing starts is nearly 50 percent higher than the actual mean during the period. In addition, the overall variability of the housing cycle in relative terms is much lower. These figures indicate that the housing industry would be a stronger, more stable economic concern if standard, fixed-rate mortgages were replaced with PLAMs.

The benefit of using PLAMs would not be limited to the apparent positive effect on housing demand. If the lender eliminated inflation risk by linking mortgage payments to price levels, there should be little reason for the housing finance industry to oppose assumable mortgages. Mortgages that are assumed would have significantly higher payments if inflation increased since the granting of the mortgage. In contrast, fixed-rate mortgages would have lower payments on the loan because the payments were not adjusted for inflation.

In addition, holders of mortgages in secondary markets, Government National Mortgage Association (GNMA), etc., would have significantly less prepayment risk because periods of falling inflation would reduce only the growth of dollar payments on PLAMs and not the actual contract rate on the mortgage. Since PLAM borrowers already have a relatively low contract rate, they would have significantly less incentive to incur point charges and closing costs on refinancing. However, fixed-rate borrowers would observe a fall in the contract rate on new mortgages with a decline in inflation, giving many an economic incentive to pay off older, higher rate loans.

The above benefits from PLAMs reduces the risk of supplying funds to the mortgage markets. This, in turn, increases the willingness of lenders to loan in this market and tends to reduce the real cost of obtaining a mortgage. Thus, a switch to PLAMs by the housing finance industry would not just eliminate the tilt burden. It also would lower the real cost of home mortgages, which would further stimulate the demand for housing.

Summary And Conclusions

Periods of relatively high nominal mortgage rates in the United States have been accompanied by declines in housing demand and vice versa. This article addresses why housing activity is affected when the real cost of home mortgages remains the same. Numerical examples and a review of the literature reveal that a tilt burden occurs when nominal mortgage rates rise and real mortgage rates remain the same. While this effect has been examined both theoretically and empirically in the literature (and has been found to affect housing demand negatively), previous study of changes in real mortgage rates and their influence on housing demand has not focused on the housing market in the inflationary period of the late 1970s and 1980s.

This article separately considers the influence of changes in real mortgage rates and changes in the tilt burden on the demand for housing using a survey-based measure of inflation. The empirical results of the study, in general, support the proposition that *both* of these influences are important in determining housing demand. Finally, it demonstrates that a movement to PLAMs would, through elimination of the tilt burden, significantly increase the level of housing demand in the United States and decrease its variability over time. By reducing the risk to mortgage lenders, PLAMs should reduce the real cost of housing mortgages as additional funds flow into these markets.

NOTES

1. See, for example, Alm, J. and Follain, J. "Alternative Mortgage Instruments, the Tilt Problem, and Consumer Welfare," *Journal of Financial and Quantitative Analysis* (March 1984): 113-126.
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6. See Alm and Follain, above.
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13. Obtained via personal communication.
14. Obtained via personal communication.
15. Cochrane, D. and Orcutt, G., "Application of Least Squares Regression to Relationships Containing Autocorrelated Error Terms," *Journal of the American Statistical Association*, 44 (1949): 32-61.