INTEREST RATE VOLATILITY AND HOME MORTGAGE LOANS

Eric Hillebrand
Department of Economics
Louisiana State University
Baton Rouge, LA 70803-6306

Faik Koray*
Department of Economics
Louisiana State University
Baton Rouge, LA 70803-6306

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Abstract

The U.S. economy has experienced substantial fluctuations in real and nominal interest rates since the 1970s. This paper investigates empirically the relationship between home mortgage loans and volatility in mortgage rates for the period 1971:02 through 2003:03. Contrary to common wisdom, we find a positive relationship between mortgage rate volatility and home mortgage loans. Further investigation indicates that this is due to volatility in the bond market. In times of high interest volatility, households disinvest in government securities and invest in real assets, which yield a positive relationship between mortgage rate volatility and home mortgage loans.

JEL Classification: E44, C51, G1

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*Corresponding author is Koray; email is eokora@lsu.edu and fax is 225-578-3807. Email for Hillebrand is erhil@lsu.edu

1. Introduction

The U.S. economy has experienced substantial fluctuations in real and nominal interest rates since the 1970s. This has important implications for the economy. The common wisdom is that unanticipated variations in interest rates increase risk and this causes economic agents with risk-averse preferences to revise their plans and divert their resources to less risky alternatives. The effects of volatility of financial variables, such as exchange rates, interest rates, or stock prices, on economic activity have been studied extensively (Cushman 1983, Kenen and Rodrik 1986, Bacchetta and van Wincoop 2000, Edwards and Susmel 2001, Reinhart and Reinhart 2001). The relationship between home mortgage loans and interest rate volatility, however, has not received much attention. Wolswijk (2005) analyzes the fiscal aspects of mortgage debt in the EU and finds that housing prices, financial deregulation, and stock markets affect mortgage debt growth. Perli and Sack (2003) study the effects of mortgage hedging on interest rate volatility.

The purpose of this research is to investigate the influence of interest rate volatility on mortgage debt. We find a surprising result, which indicates that an increase in interest rate volatility increases home mortgage loans. This counterintuitive phenomenon can be explained by a substitution effect: An increase in mortgage rate volatility is the result of increasing uncertainty in the markets for fixed income assets such as government bonds. Therefore, in times of high interest rate volatility, households disinvest in fixed income assets, and invest in real assets such as houses. The outcome is a positive relationship between interest rate volatility and home mortgage loans.

The paper is organized as follows. Section 2 discusses the model specification. Section 3 describes the data employed in this paper. Section 4 presents the estimation results. Section 5 provides some concluding remarks.

2. Model Specification

The relationship between home mortgage loans and interest rate volatility can be modeled as follows:

$$HML_t = a_0 + a_1 Y_t + a_2 RR_t + a_3 V_{M,t} + e_{1,t} \, , \qquad (1)$$

where *HML* is the logarithm of real home mortgage loans (home mortgage loans in current dollars deflated by the consumer price index (CPI)), *Y* is the logarithm of real personal income (personal income in current dollars deflated by the CPI), *RR* is the *ex ante* real mortgage rate (calculated as the difference between the effective nominal interest rate on home mortgage loans closed and the expected inflation rate), V_M is a measure of volatility in mortgage rates, and *e* is a random disturbance term.

The demand for home mortgage loans is assumed to vary positively with real personal income and negatively with the *ex ante* real mortgage rate. We use real rather than nominal interest rates since the real cost of borrowing is reflected better by the real interest rate. The real interest rate is a crucial element in investment, saving, and consumption decisions and therefore, the demand for home mortgage loans can be specified as a function of the real mortgage rate.

The real interest rate, or more precisely, the *ex ante* real mortgage rate, is based on the Fisher equation

$$RR_t = R_{M,t} - E(\pi_t) \qquad (2)$$

where R_M is the effective nominal interest rate on home mortgage loans closed and $E(\pi_t)$ is the expected inflation rate.

Although the *ex post* real rate is observable, the *ex ante* rate is not. Therefore, in order to measure and make inferences about the *ex ante* real interest rate, some identifying assumptions are needed. Following Mishkin (1981) and Huizinga and Mishkin (1986), we can use the assumption that expectations of inflation are formed rationally and that the real interest rate can be reasonably approximated by linear projection onto an observable information set. The assumption of rational expectations implies that inflation forecast errors are not predictable given any information available at time *t.* Using Huizinga and Mishkin (1986) we can show that the real mortgage rate can be estimated as the fitted values from the OLS regression:

$$RR_t = R_{M,t} - E(\pi_t) = b_0 + b_1 R_{M,t} + b_2 \pi_{t-1} + b_3 \pi_{t-2} + e_{2,t}\,, \qquad (3)$$

where π_t is the log difference of the CPI, multiplied by 1200 to express the inflation rate on a.p.r. basis just like R_M.

Volatility in mortgage rates is related to volatility in the bond market

$$V_{M,t} = c_0 + c_1 V_{B,t} + e_{3,t}\,, \qquad (4)$$

where $V_{B,t}$ is a measure of volatility in the bond market. Since fluctuations in mortgage rates are by and large determined by fixed income markets and not by the housing market, we relate mortgage rate volatility to volatility in the long-term bond market yield.

Finally, we include a link between the long-term bond yield $R_{B,t}$ and volatility in the bond market.

$$R_{B,t} = d_0 + d_1 V_{B,t} + e_{4,t}\,. \qquad (5)$$

3. Data

The monthly data are obtained from the DRI database and the Board of Governors of the Federal Reserve System. For *HML*, we use conventional plus FHA and VA mortgage holdings (DRI series AMFVNS@FHLMC). For *Y*, we use personal income for the U.S. (DRI series YP), divided by the CPI (DRI series CPI@US); for R_M, we use the 30-year conventional mortgage rate (Board of Governors of the Federal Reserve System, series MORTG). For R_B, we use the long-term U.S. government bond yield (DRI series RMGBL@US). The inflation rate π is calculated as the log difference of the CPI, multiplied by 1200. For V_M, we use the squared difference of the 30-year mortgage rate; for V_B, we use the squared difference of the long-term U.S. government bond yield. The sample period is February 1971 through March 2003. The choice of the sample period is dictated by data availability. Even though most of the data are available until March 2006, the data on *HML* begin on February 1971 and end on March 2003.

4. Estimation

Cointegration

The main challenge model (1) through (5) poses to estimation is that many of the involved aggregates, like income, interest rates, and price indices, are non-stationary. Least-squares type estimators will be spurious unless the variables are cointegrated. For the case of cointegration, Hsiao (1997a, 1997b) has shown that 2SLS and 3SLS estimators remain consistent and that Wald coefficient tests still have the usual asymptotic chi-square distribution.

Table 1 shows the result of unit-root tests for the variables considered in (1) through (5). The time series that are tested as I(1) and considered for a cointegration test are *HML*, *Y*, R_M, and R_B. With regard to V_m and V_B, Table 1 reports only results for the squared difference in the mortgage rate since the conditional volatility process of a GARCH process is stationary by construction.

First, we run a series of unrestricted VAR(p) models to determine the lag length. We find p=3 as the smallest lag that whitens the residuals at all common significance levels. Using this lag structure, the Johansen (1988, 1990) test statistics (trace and largest eigenvalue) for cointegration indicate at all common significance levels that there is one cointegrating linear combination ε, given by the equation

$$\varepsilon_t = HML_t - 7.98Y_t - 1.77R_{M,t} + 2.18R_{B,t} + 63.63,$$

where the VAR(3) used in the test does not have a constant. That is, we do not allow for a linear trend. If we include a linear trend, there is no cointegrating relation. The applicability of Hsiao (1997a, 1997b) seems somewhat doubtful.

The sample from 1971 through 2003 contains different monetary policy regimes. Arthur Burns served as chairman of the Board of Governors of the Federal Reserve System between 1970 and 1979. During this period the world economy moved from a fixed exchange rate regime to a floating exchange rate regime, and faced two major oil price shocks. The policy procedures that were employed during this period underwent a drastic change in October 1979 after the appointment of Paul Volcker. Since the policy procedures, monetary policies, and their outcomes under Arthur Burns differ significantly from those under Paul Volcker and Alan Greenspan, we split the sample into the sub-periods 1971:02 through 1979:09 and 1979:10 through 2003:03.

Estimating the cointegrating relations on the sub-segments, we obtain two cointegrating relations

$$\varepsilon_{1,t} = HML_t - 3.45R_{M,t} + 4.34R_{B,t},$$

$$\varepsilon_{2,t} = Y_t - 0.24R_{M,t} - 0.34R_{B,t},$$

on the first sub-period. On the second sub-period, we find one cointegrating relation

$$\varepsilon_t = HML_t - 4.08Y_t - 1.12R_{M,t} + 1.63R_{B,t}.$$

The VAR(3) used in the test after splitting the sample does include a constant, and the cointegrating relationships are more robust to different specifications. Therefore, the applicability of Hsiao's (1997a, 1997b) results is clearly established for the specification using two sub-samples. Tables 2 and 3 report the adjustment coefficients from the corresponding Vector Error Correction Model. Note that even though the finding of cointegration is very robust, the reversion to equilibrium seems to be very slow as indicated by the small adjustment coefficients, at least in the second segment.

3SLS Specification and Estimation

We report the 3SLS estimation of the system of equations (1) through (5) and the corresponding Wald statistics for the sub-samples in Tables 4 and 5. The instruments used are all right-hand side variables: log income, mortgage rate, squared differences of mortgage rate, first and second lags of inflation, and squared differences of the long term yield. We refrain from reporting R-squared or t-statistics, since these are not reliable due to the unit root behavior of the time series.

The correlation between mortgage rate volatility as measured by the squares of changes in monthly mortgage rates and the volume of mortgage loans is somewhat weak during the first sample period, but it is highly significant during the second sample period. The estimated coefficient a_3, however, is positive for both periods, indicating that there is a positive correlation between mortgage rate volatility and home mortgage loans. Likewise, the correlation between the *ex ante* real mortgage rate and home mortgage loans is somewhat weak during the first sample period, but it is highly significant during the second sample period. The estimated coefficient a_2, however, is positive for both periods, indicating that there is a positive correlation between the *ex ante* real mortgage rate and home mortgage loans.

These results are surprising because we would expect the signs of both of these coefficients to be negative. Further analysis of the model, however, illustrates why we are getting positive signs for a_2 and a_3. The correlation between bond market volatility and mortgage rate volatility (equation (4)) is positive and significant for both sample periods. We also observe that the estimated coefficient c_1 increases from 0.19 to 0.49 from the first to the second sample period, which indicates that volatility in the bond market has become quantitatively more important for volatility in the mortgage market. This explains why volatility in the mortgage rate is more significant during the second sample period. Another important finding is the correlation between volatility in the bond market and the long term U.S. government bond yield (equation (5)). The estimated coefficient d_1 is positive for both sample periods, but it is highly significant only for the second sample period, indicating that an increase in bond market volatility is associated with a rise in the long term bond yield. We also estimated the system using conditional volatility series from GARCH(1,1) models (estimated on the entire sample and on the two sub-samples) for the mortgage rate and for the long-term yield instead of squared differences. The results were very similar.

We interpret the findings above as follows. Volatility in the bond market increases the risk of holding bonds, which decreases the demand for holding government bonds. This leads to a decrease in bond prices and hence to an increase in government bond yields. Reallocation of wealth by individual investors to diversify risk leads to an increase in demand for real assets, which increases the demand for home mortgage loans.

Competition for home mortgage loans increases the nominal home mortgage rate and hence the *ex ante* real mortgage rate. Therefore, due to re-allocation of risk, the volume of home mortgage loans increases despite the increase in mortgage rate volatility and the *ex ante* real mortgage rate.

4. Conclusion

We investigated the empirical relationship between home mortgage loans and volatility in mortgage rates for the period from 1971:02 through 2003:03 by breaking the sample period into two sub-periods. Our findings indicate that contrary to common wisdom, home mortgage loans increase despite an increase in mortgage rate volatility and an increase in the *ex ante* real mortgage rate. We explain this by showing the correlation between volatility in the bond market and volatility in the mortgage market. An increase in volatility in the bond market increases the risk of holding bonds. Therefore, reallocation of wealth by individual investors to diversify risk leads to an increase in demand for real assets, which increases the demand for home mortgage loans as well as the mortgage rate.

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Table 1: Unit root tests*.

Prob.	*HML*	*Y*	R_M	R_B	V_M	V_B	π
Dickey-Fuller	0.80 (0.00)	0.73 (0.00)	0.75 (0.00)	0.65 (0.00)	0.00	0.00	0.00
Phillips-Perron	0.80 (0.00)	0.74 (0.00)	0.66 (0.00)	0.61 (0.00)	0.00	0.00	0.00
KPSS	<0.01 (>0.10)	<0.01 (>0.10)	<0.01 (>0.10)	<0.05 (>0.10)	0.24	0.39	<0.01 (>0.10)

*The columns state the probability to reject the null of a unit root in the case of the Augmented Dickey-Fuller and the Phillips-Perron test and the null of trend stationarity in the case of KPSS. The numbers in parenthesis are the probabilities of rejection of the null for the first difference of the series.

Table 2. Adjustment coefficients from error correction model for *HML*, *Y*, R_M, and R_T in the sub-period 1971:02 through 1979:09, two cointegrating relations

left-hand side variable	HML_t	Y_t	$R_{M,t}$	$R_{B,t}$
adjustment coeff (standard error)	-0.04 (0.01)	-0.002 (0.001)	0.03 (0.02)	0.05 (0.03)
adjustment coeff (standard error)	-0.63 (0.16)	-0.04 (0.02)	-0.31 (0.24)	1.10 (0.44)

Table 3. Adjustment coefficients from error correction model for HML, Y, R_M, and R_T in the sub-period 1979:10 through 2003:03, one cointegrating relation

left-hand side variable	HML_t	Y_t	$R_{M,t}$	$R_{B,t}$
adjustment coeff (standard error)	0.01 (0.004)	0.001 (5.7e-4)	-0.004 (0.03)	-0.12 (0.03)

Table 4. Estimated coefficients from the 3SLS estimation of equations (1) and (5), sub-period 1971:02 through 1979:09.

Dependent Variable	Coefficient	Explanation	Estimated Value	Wald Statistic	Probability
Home mortgage loans	a_0	constant	-6.38	0.30	0.583
	a_1	log income	0.78	0.23	0.629
	a_2	real interest rate	0.30	2.88	0.090
	a_3	squared changes in mortgage rates	1.98	2.77	0.096
Real mortgage rate	b_0	constant	0.96	8.44	0.004
	b_1	mortgage rate	0.63	209	0.000
	b_2	inflation, lag 1	-0.17	1.91	0.167
	b_3	inflation, lag 2	-0.33	7.44	0.006
Mortgage rate volatility	c_0	constant	0.01	12.64	0.000
	c_1	squared changes in long-term yield	0.19	4.44	0.035
Long-term bond yield	d_0	constant	6.83	4760	0.000
	d_1	squared changes in long-term yield	1.38	0.40	0.527

Table 5. Estimated coefficients from the 3SLS estimation of equations (1) and (5), sub-period 1979:10 through 2003:03.

Dependent Variable	Coefficient	Explanation	Estimated Value	Wald Statistic	Probability
Home mortgage loans	a_0	constant	-63.9	846	0.000
	a_1	log income	8.08	1056	0.000
	a_2	real interest rate	0.09	19	0.000
	a_3	squared changes in mortgage rates	0.19	21	0.000
Real mortgage rate	b_0	constant	1.20	130	0.000
	b_1	mortgage rate	0.69	3595	0.000
	b_2	inflation, lag 1	-0.38	7.86	0.005
	b_3	inflation, lag 2	-0.13	0.92	0.338
Mortgage rate volatility	c_0	constant	0.08	7.79	0.005
	c_1	squared changes in long term yield	0.49	23	0.000
Long-term bond yield	d_0	constant	7.90	3197	0.000
	d_1	squared changes in long term yield	3.69	50	0.000