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Pricing Interest-Rate Risk for Mortgage REITs

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***Abstract*. Using tax-qualified mortgage REITs over three periods (1976–79, 1980–82, and 1983–90), this paper investigates the pricing of interest-rate risk for mortgage REITs at equilibrium. A system of nonlinear equations is estimated to determine the monthly interest-rate risk premium over each of the three time intervals. There is evidence to support the hypothesis that interest-rate risk is not diversifiable and hence commands a risk premium.**

Introduction

A REIT does not pay corporate taxes if it meets four separate tests on a yearly basis. These tests concern organizational structure, sources of income, nature of assets, and distribution of income. For example, a tax-qualified REIT has to distribute at least 95% of its net income to its shareholders in the form of dividends. Because of this pass-through feature, REITs generally have high dividend yields. Existing research indicates that other high-dividend-yield stocks, such as utilities, are sensitive to interest-rate changes (e.g., Bower, Bower and Logue, 1984; Sweeney and Warga, 1986). Consequently, REITs should possess a high degree of sensitivity to interest-rate fluctuations (e.g., Mengden, 1988).

Chen and Tzang (1988) addressed the issue of whether REITs were sensitive to changes in short-term and long-term interest rates for the period 1973–1985. REITs were found to be interest-rate sensitive and the magnitude of interest-rate sensitivity was found to be larger for mortgage REITs. In addition, Liang, McIntosh and Webb found that mortgage REIT returns were sensitive to long-term interest rates from 1973 to 1990, whereas equity REITs were not sensitive to the same interest-rate index. Moreover, hybrid REITs were less interest-rate sensitive than mortgage REITs during the same period. Apparently, REIT security returns are influenced by interest-rate changes and mortgage REITs display the most interest-rate sensitivity. However, the issue of whether interest-rate risk for REITs is diversifiable has not been specifically addressed thus far. Therefore, this study tests the null hypothesis that the interest-rate risk for mortgage REITs is systematic and hence commands a risk premium at equilibrium. Equity REITs and hybrid REITs are excluded from this study because they are less sensitive to unanticipated interest-rate changes than mortgage REITs.

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Methodology and Data

The methodology employed here is similar to Sweeney and Warga's (1986). They addressed the issue of whether utility companies are required to pay an ex ante premium to investors for bearing the risk of interest-rate changes. A two-factor model using the market and changes in the yield on long-term government bonds was employed. Their study showed that the sensitivity to changes in interest rates for utility company common stocks was priced.

If *n*-asset returns, R_{it}, have generating relationships:

$$R_{it}=E_i+\beta_{i1}\delta_{1t}+\beta_{i2}\delta_{2t}+e_{it}\ (i=1,\ n)\ , \tag{1}$$

where the two factors, δ_1 and δ_2, and the error term, e_i, have zero mean, and E_i is the expected return on asset *i*. Ross (1976) showed that if no arbitrage profits can be made, then (1) implies that

$$E_i=\alpha_0+\beta_{i1}\alpha_1+\beta_{i2}\alpha_2\ , \tag{2}$$

where α_0, α_1, and α_2 are constants. E_i linearly depends upon the *betas* and α_1 and α_2 can be viewed as risk premia for the two factors, respectively.

It is assumed that the first factor is related to the market and the second factor is related to interest-rate changes such that:

$$\delta_{1t}=R_{Mt}-E(R_M)\ , \tag{3}$$

$$\delta_{2t}=\Delta I_t-E(\Delta I)\ , \tag{4}$$

where R_{Mt} is the market return and ΔI_t is an unexpected interest-rate change index. $E(\ )$ is the expectation notation. The market risk premium, α_1, is,

$$\alpha_1=E(R_M)-\alpha_0\ . \tag{5}$$

The expected value on unexpected interest-rate changes should be zero:

$$E(\Delta I)=0\ . \tag{6}$$

Using equations (2), (3), (4), (5) and (6) to rearrange equation (1), the result is:

$$R_{it}=\alpha_0-\alpha_0\beta_{i1}+\alpha_2\beta_{i2}+\beta_{i1}R_{Mt}+\beta_{i2}\Delta I_t+e_{it}\ (i=1,\ .\ .\ .,\ n)\ . \tag{7}$$

There will be *n* nonlinear equations for *n* mortgage REITs. A nonlinear system estimation approach can be used to estimate α_0 and α_2 (assuming they are the same for all mortgage REITs) over various time periods using monthly returns of mortgage REITs, monthly market returns, and monthly unexpected changes in interest rates. α_2 can be interpreted as the monthly interest-rate risk premium. The significance and the magnitude of α_2 are of paramount concern in this study. If α_2 is significant, then the interest-rate risk for mortgage REITs is not diversifiable. If α_2 is statistically zero, the interest-rate risk is diversifiable.

The algorithm employed in this study is the Model Procedure in SAS version 6.06.[1] Equation (7) is estimated over the following time periods: 1976–1979, 1980–1982 and 1983–1990. The three periods are chosen for the following two reasons. First, according to Liang, McIntosh and Webb, the two-index regression relationship for mortgage REITs was not stable over the period of 1973–1990. Several distinct return-generating regimes existed over that period. Second, several significant fundamental economic events occurred during the 1970s and 1980s. The 1976 tax reform act, which significantly affected the operating environment for real estate investment, is the reason for selecting 1976 as the first year in our study. The Federal Reserve monetary regime change in October 1979 and the end of regulatory turmoil in 1982 are the major underlying factors for separating the period into the three non-overlapping intervals specified previously.[2]

A list of tax-qualified REIT's and their type (equity, hybrid, or mortgage) for each year from 1976 to 1990 was supplied by the National Association of Real Estate Investment Trusts. Because a REIT's status (qualified or non-qualified, equity, hybrid or mortgage) may change each year, only fourteen, eleven and ten mortgage REITs are chosen for the subperiods of 1976–79, 1980–82 and 1983–90, respectively.

The change in yields of long-term U.S. government bonds (taken from Citibase) is employed as a long-term interest-rate index (ΔI). In addition, the change in yields on three-month Treasury bills (from Citibase) is used as a short-term interest-rate index and the change in yields on intermediate-term bonds is used as an intermediate interest-rate index. The intermediate-term bonds have maturities close to five years and the bond yields are from the *Stocks, Bonds, Bills, and Inflation* (Ibbotson Associates, 1992). The monthly returns for the REITs are from the CRSP tapes. The market return index is the CRSP equally weighted monthly return index, including dividends.

Results

The following regression is estimated for the three subperiods:

$$R_{pt}=b_0+b_1R_{Mt}+b_2\Delta I_t+e_t \ , \tag{8}$$

where R_p is the monthly return on the equally weighted portfolios. ΔI is the interest-rate index, which is one of the following: changes in Treasury bill yields (short), changes in intermediate-term bond yields (intermediate), or changes in long-term bond yields (long). The results are shown in Exhibit 1. The expected sign for b_2 is negative because increases in unexpected interest rates tend to lower the performance of REITs. All the market *betas* (b_1) are significant. All but two interest-rate *betas* for mortgage REIT portfolios are significant at the 5% level. As expected, the interest-rate sensitivity of mortgage REITs is not stable over time.

The estimates of α_0 and α_2 and the associated t-values are reported in Exhibit 2 for all subperiods. The expected sign of α_2 is negative because b_2 has a negative expected sign. The estimated values of α_2 are negative as expected, but only three estimates are significant at the 10% level. The expected sign for α_0 is positive, but only one of the estimates of α_0 is significant at the 10% level. Nonconvergence of the algorithm occurs for the 1983–90 time period when ΔI is changes in intermediate-term bond yields.

Exhibit 1
Monthly Portfolio Regression Results for Mortgage REIT Portfolios
$R_{pt}=b_0+b_1R_{Mt}+b_2\Delta I_t+e_{it}$

Time Period	ΔI	b_1	b_2	$t(b_1)$	$t(b_2)$	R^2
1976–79	Short	.6337*	−5.1494*	6.36	−2.91	.6421
	Intermediate	.6621*	−5.7419*	6.20	−1.97	.6074
	Long	.6961*	−4.5188	6.44	−1.30	.5899
1980–82	Short	.7028*	−1.1186*	6.70	−3.12	.7133
	Intermediate	.7468*	−1.4733*	6.81	−2.18	.6753
	Long	.6839*	−3.4134*	6.76	−3.66	.7358
1983–90	Short	.5749*	−1.7057	7.25	−1.28	.3637
	Intermediate	.5546*	−1.6633*	7.04	−2.03	.3749
	Long	.5258*	−2.3867*	6.62	−2.41	.3905

Notes: R_p is the monthly return on the equally weighted portfolios. ΔI is the corresponding interest-rate changes.

*significant at the 5% level

Exhibit 2
Parameter Estimates of α_0 and α_2 from Mortgage REITs
$R_{it}=\alpha_0-\alpha_0\beta_{i1}+\alpha_2\beta_{i2}+\beta_{i1}R_{Mt}+\beta_{i2}\Delta I_t+e_{it}$

Time Period	ΔI	α_0	α_2
1976–79	Short	.3082	−.2011**
		(.39)	(−2.46)
	Intermediate	.3301	−.1004
		(.41)	(−1.05)
	Long	.2600	−.0847
		(.29)	(−2.12)**
1980–82	Short	.0368	−.1384
		(.03)	(−.41)
	Intermediate	.0754	−.1465
		(.06)	(−1.09)
	Long	.1007	−.1334
		(.08)	(−1.130)
1983–90	Short	.3315*	−.5178*
		(1.75)	(−1.79)
	Intermediate	nc	nc
	Long	.2885	−.1977
		(.81)	(−.87)

Notes: nc denotes nonconvergence. *t*-statistics are in parentheses. Estimates of α_0 and α_2 have been multiplied by 10^2.

*significant at the 10% level
**significant at the 5% level

The two factors, market return and interest-rate changes, are correlated. Exhibit 3 presents the regression results for the following two equations:

$$R_{Mt}=\gamma_0+\gamma_1\Delta I_t+e_{Mt}\text{ , and} \tag{9}$$

$$\Delta I_t=\delta_0+\delta_1 R_{Mt}+e_{It}\text{ ,} \tag{10}$$

where e_{Mt} and e_{It} denote the regression residuals from equations (9) and (10), respectively. The estimates of γ_1 and δ_1 are significant most of the time, which indicates that R_{Mt} and the ΔI_t's are correlated. The point estimates of γ_1 and δ_1 are negative, except for the period 1983-90 when ΔI is changes in short-term interest rates.

Exhibit 4 presents the regression results on the orthogonalized versions of regression models (11) and (12).

$$R_{pt}=c_0+c_1 e_{Mt}+c_2\Delta I_t+e_{it}\text{ ,} \tag{11}$$

$$R_{pt}=d_0+d_1 R_{Mt}+d_2 e_{It}+e_{it}\text{ .} \tag{12}$$

e_{it} is orthogonal to R_{Mt} and e_{Mt} is orthogonal to ΔI_t, since the OLS residual is always orthogonal to its dependent variable. The estimates and t-values of c_1 and d_2 are the same as the corresponding coefficients reported in Exhibit 1. The estimates and t-values of c_2 and d_1 are larger than their counterparts (b_2 and b_1) reported in Exhibit 1 because the market returns tend to be negatively correlated with the interest-rate index.

If the true return-generating process is either equation (11) or equation (12), α_2 can be estimated using the orthogonalized versions of models (13) and (14).[3]

$$R_{it}=\alpha_0-\alpha_0\beta_{i1}+\alpha_2\beta_{i2}+\beta_{i1}e_{Mt}+\beta_{i2}\Delta I_{It}+e_{it}\text{ ,} \tag{13}$$

$$R_{it}=\alpha_0-\alpha_0\beta_{i1}+\alpha_2\beta_{i2}+\beta_{i1}R_{Mt}+\beta_{i2}e_{It}+e_{it}\text{ .} \tag{14}$$

Exhibit 3
Parameter Estimates of γ_1 and δ_1
$R_{Mt}=\gamma_0-\gamma_1\Delta I_t+e_{Mt}$ and $\Delta I_t=\delta_0+\delta_1 R_{Mt}+e_{It}$

Time Period	ΔI	γ_1	δ_1	t-Statistics	R^2
1976–79	Short	−7.78*	−.0247*	−3.31	.1924
	Intermediate	−5.65*	−.0189*	−2.35	.1070
	Long	−14.92*	−.0144*	−3.54	.2142
1980–82	Short	−1.29*	−.1107*	−2.38	.1429
	Intermediate	−2.06*	−.0542*	−2.07	.1117
	Long	−3.56*	−.0418*	−2.44	.1490
1983–90	Short	1.09	.0038	.63	.0042
	Intermediate	−1.10	−.0082	−.93	.0090
	Long	−4.12*	−.0154*	−2.53	.0635

Notes: t-statistics are the same for both γ_1 and δ_1. R^2's are the same for both regression equations.
*significant at the 5% level

Exhibit 4
Monthly Mortgage REIT Portfolio Regression Results for
$$R_{pt}=c_0+c_1e_{Mt}+c_2\Delta I_t+e_{it}$$
and
$$R_{pt}=d_0+d_1R_{Mt}+d_2e_{It}+e_{it}$$

Time Period	ΔI	d_1	c_2
1976–79	Short	.7609*	−10.0826*
		(8.50)	(−6.35)
	Intermediate	.7609*	−14.5206*
		(7.88)	(−5.58)
	Long	.7609*	−14.9053*
		(7.94)	(−4.82)
1980–82	Short	.8266*	−2.0259*
		(8.51)	(−6.11)
	Intermediate	.8266*	−3.0136*
		(7.99)	(−4.72)
	Long	.8206*	−5.8495*
		(8.86)	(−6.80)
1983–90	Short	.5684*	−1.0803
		(7.18)	(−.81)
	Intermediate	.5684*	−2.2726*
		(7.24)	(−2.59)
	Long	.5684*	−3.8424*
		(7.33)	(−3.98)

Notes: *t*-statistics are in parentheses. R_p is the monthly return on the equally weighted portfolios. ΔI is the corresponding interest-rate changes. c_1 and d_2 have the same values as the corresponding coefficients reported in Exhibit 1.
*significant at the 5% level

The estimation results are presented in Exhibit 5. When the market return index is orthogonalized against the interest-rate index, the estimates of α_2 are significant at the 10% level for all periods and interest-rate indices (short-term, intermediate-term and long-term) except for one nonconvergence case. When ΔI is orthogonalized against R_M, only one estimate of α_2 over the period of 1983–90 is significant at the 10% level.

The annual implied interest-rate risk premia are presented in Exhibit 6. The risk premia are calculated using the estimated interest-rate *betas* in Exhibit 1 and the estimated α_2 in Exhibit 2 ($12*\alpha_2*\beta_2$). The annual risk premia range from 1.86% to 12.43%.

The results in Exhibit 1 indicate that the performance of mortgage REITs is influenced by market returns and interest-rate changes. Exhibit 3 tells us that market returns are correlated with interest-rate changes. Therefore, interest-rate changes influence REIT returns through two channels: the direct channel being the interest-rate change index itself and the indirect channel being the market return index. Thus, there are three ways of estimating interest-rate risk premium for mortgage REITs. One way is to ignore the correlation between the two indices. As indicated in Exhibit 2, the estimated interest-rate risk premiums are insignificant in most cases. The second way is

Exhibit 5
Estimates of α_2 for Orthogonalized Versions of Models for Mortgage REITs

$$R_{it}=\alpha_0-\alpha_0\beta_{i1}+\alpha_2\beta_{i2}+\beta_{i1}e_{Mt}+\beta_{i2}\Delta I_t+e_{it}$$

and

$$R_{it}=\alpha_0-\alpha_0\beta_{i1}+\alpha_2\beta_{i2}+\beta_{i1}R_{Mt}+\beta_{i2}e_{It}+e_{it}$$

		Orthogonalization Model	
Time Period	ΔI	$R_{Mt}=\gamma_0+\gamma_0\Delta I_t+e_{Mt}$	$\Delta I_t=\delta_0+\delta_1 R_{Mt}+e_{It}$
1976–79	Short	−.3592**	.0040
		(−6.50)	(.06)
	Intermediate	−.2107**	.0120
		(−4.91)	(·14)
	Long	−.1846**	−.0081
		(−6.32)	(−.21)
1980–82	Short	−.8028**	−.0322
		(−3.48)	(−.13)
	Intermediate	−.4143**	−.0234
		(−4.32)	(−.25)
	Long	−.3246**	−.0199
		(−4.44)	(−.28)
1983–90	Short	−.3330**	−.5489*
		(−1.99)	(−1.85)
	Intermediate	nc	nc
	Long	−.2591*	−.1815
		(−1.84)	(−.88)

Notes: nc denotes nonconvergence. *t*-statistics are in parentheses. Estimates of α_2 have been multiplied by 10^2.
*significant at the 10% level
**significant at the 5% level

Exhibit 6
Implied Annual Interest-Rate Risk Premia for Mortgage REITs

Time Period	ΔI	Risk Premium
1976–79	Short	12.43%
	Intermediate	6.92
	Long	4.59
1980–82	Short	1.86
	Intermediate	2.59
	Long	5.46
1983–90	Short	10.64
	Intermediate	n/a
	Long	5.66

to orthogonalize the market return index against the interest-rate index, which in essence allocates imbedded interest-rate sensitivity of the market return index to the second index. The estimated interest-rate risk premiums can be interpreted as the total interest-rate risk premiums and are statistically significant, as shown in Exhibit 5. The third way is to orthogonalize the interest-rate index against the market return index first. Then the estimated interest-rate risk premiums are "residual" interest-rate premiums, and are insignificant in general, as indicated in Exhibit 5. From the above analysis, two conclusions can be drawn. First, mortgage REITs are interest-rate-sensitive securities. Second, the total interest-rate- sensitivity of mortgage REITs is priced and commands a risk premium at equilibrium.

This study also sheds light on the issue of using a single-index model or a two-index model in evaluating the performance of REITs. For instance, McIntosh, Liang and Tompkins (1991) employed the single-index model to detect whether there was a small-firm effect within the REIT industry. Titman and Warga (1986) analyzed the risk-adjusted performance of a sample of REITs using both single-index and two-index models. Recently, Chan, Hendershott and Sanders (1990) found that three factors, unexpected inflation, changes in risk, and the term structure of interest rates, in addition to the percentage change in the discount on closed-end stock funds, consistently drive equity REIT returns. The results in Exhibit 2 weakly suggest that using a two-index model would be more appropriate.

Summary and Conclusions

Mortgage REITs are interest-rate sensitive because of the nature of their asset portfolios. Consistent with previous findings, this study concludes that the interest-rate sensitivity for mortgage REITs has changed over time. In addition, three distinct subperiods (1976–1979, 1980–1982 and 1983–1990) were selected to test the null hypothesis that the interest-rate risk for mortgage REITs is not priced at equilibrium. Using tax-qualified mortgage REITs that are listed on the NYSE, ASE and NASDAQ over the subperiods, a system of nonlinear equations was estimated for each subperiod. Changes in Treasury bill yields, changes in intermediate-term bond yields, and changes in long-term bond yields were used as the interest-rate index. There were significant as well as insignificant estimates of α_2, the monthly interest-rate risk premium per unit of interest-rate *beta*, over different periods and with different interest-rate indices. Since equity market returns and interest rates were correlated, the orthogonalized versions of the models were also estimated. When market return was orthogonalized against interest-rate indices, all the estimates of α_2 were significant. When the interest-rate indices were orthogonalized against market returns, only one estimate of α_2 was significant.

Several conclusions can be drawn from these results. First, a large part of market risk for mortgage REITs is derived from interest-rate uncertainties. Second, interest-rate risk as a whole is priced at equilibrium. Third, there is weak evidence to indicate that the additional interest-rate risk that is not captured by the equity market is also priced at equilibrium. Furthermore, the results of this study suggest that using the two-index model, instead of the single-index model, to evaluate the performance of mortgage REITs would seem to be more appropriate.

Notes

[1]The Model Procedure is generic and hence some programming is required.
[2]Stationarity of the return-generating process is important to estimate the interest-rate premium. However, considerations have to be given to *beta* stationarity as well as the number of mortgage REITs and the number of monthly observations over a subperiod.
[3]Giliberto (1985) showed that if equation (8) is the true return-generating process for a security, then the orthogonalization of ΔI against R_M will produce a biased estimate for b_1, but will not affect the estimate of b_2, and vice versa.

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