

*Real Interest Rates, Expected Inflation, and Real Estate Returns:
A Comparison of the U.S. and Canada*

by

Kuntara Pukthuanthong-Le and Richard Roll

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Abstract

In the United States, but not in Canada, nominal interest on residential housing mortgages is a deductible expense for the personal income tax. This suggests that changes in nominal interest rates could conceivably have differing impacts on real estate values in the two countries. The inflation component of nominal interest should have a negative impact on Canadian real estate, but its effect should be strictly less negative in the US and could even be positive. Using real estate investment trusts along with expected inflation imputed from inflation-indexed bonds in both countries, we find empirical support for a material and significant difference. In Canada, increases in nominal interest rates driven by inflation have a negative impact. The US impact is minimal and ambiguous in sign.

Authors' Coordinates		
	Pukthuanthong-Le	Roll
Address	Department of Finance San Diego State University San Diego, CA 92182	UCLA Anderson 110 Westwood Plaza Los Angeles, CA 90095
Voice	(619) 594-5690	(310) 825-6118
E-Mail	kpukthua@mail.sdsu.edu	rroll@Anderson.ucla.edu

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In the United States, but not in Canada, nominal interest on residential housing mortgages is a deductible expense for the personal income tax. This suggests that changes in nominal interest rates could conceivably have differing impacts on real estate values in the two countries. The inflation component of nominal interest should have a negative impact on Canadian real estate, but its effect should be strictly less negative in the US and could even be positive. Using real estate investment trusts along with expected inflation imputed from inflation-indexed bonds in both countries, we find empirical support for a material and significant difference. In Canada, increases in nominal interest rates driven by inflation have a negative impact. The US impact is minimal and ambiguous in sign.

Belief in a negative relation between mortgage rates and real estate values is virtually ubiquitous among journalists, homeowners, and real estate brokers.¹ It appears to be based on compelling logic: an increase in mortgage rates implies a higher monthly payment for new borrowers, who should thereafter be less able to afford a home. Allegedly, higher mortgage rates imply lower housing demand and reduced house prices. But beneath this alluring argument are several elements of *ceteris paribus* including (1) labor income is given and fixed for the prospective homeowners, (2) housing prices are unaffected, and (3) the tax burden is unchanged.

Previous empirical support for the above belief has not been overwhelming. For example, Poterba (1984) finds that higher inflation in the 1970s accompanied an increase in real house prices during a period of high nominal interest rates. Moreover, housing is widely believed and generally found to be a good hedge against actual inflation, (Gyurko and Linneman [1998], Huang and Hudson-Wilson [2007]).

Inflation has direct effects, not necessarily positive, on the real value of housing. Inflation induces nominal capital gains, which are not real gains but are nonetheless taxed (at capital gains rates in the U.S.) when houses are sold. This suggests that inflation might reduce the turnover rate of housing as owners postpone gains realizations. Nominal gains in house prices also trigger reassessments for property taxes, which then increase, but only in nominal terms; hence the impact on real values might be only of second order importance and could even be negative if property taxes are sluggish in their response to inflation. Neither of these influences is sufficient to explain the strong positive association found by Poterba and others between housing prices and inflation.

¹ Examples abound. For instance, *USA Today* published an article entitled “Buyers get squeezed out of housing market” on June 14, 2007, which said *inter alia*, “...over the long term, higher [mortgage] rates are likely to depress home sales and prices...” Experts agree. Former Fed chairman Greenspan, in an interview on September 21, 2007 stated, “...low interest rates in the past 15 years were to blame for the house price bubble...” (Reuters.)

Piazzesi and Schneider [2007] also point to the puzzling lack of empirical support for a monotonically negative connection between mortgage rates and house prices. They respond with a model that delivers a housing boom when interest rates are either abnormally low or high! This requires two types of investors, some with significant inflation “illusion” who confuse nominal and real interest rates and others, more rational, who understand the difference between real and nominal interest rates. The model explains why house prices were high in the 1970s, when mortgage rates were high, and also why they were high in the early 2000s, when mortgage rates were low.

In the United States, there is another influence that could attenuate or neutralize the negative impact of mortgage rates on housing prices, even without resorting to irrationality; below an upper constraint that is not binding for most borrowers, mortgage interest is fully deductible in the calculation of ordinary income taxes. Indeed, for many Americans who itemize, mortgage interest is the single largest deduction on their income tax returns.²

To see why mortgage interest deductibility could reduce or even reverse the supposed negative association between interest rates and real estate values, recall that a nominal interest rate consists of at least two parts, a real rate of interest plus the anticipated rate of inflation.³ Clearly, if an increase in mortgage interest rates is caused by a corresponding and equal increase in real interest rates, the impact on value is unambiguous; as with any other asset, real housing values should decline.

But if an increase in nominal rates is caused mainly or entirely by an increase in expected inflation, the ensuing real value effect is less obvious. The inflation component of nominal interest compensates the lender for erosion in the purchasing power of the principal. When inflation is high, the real value of the mortgage loan principal declines steadily over time. Consequently, nominal mortgage interest deductibility in a high

² In aggregate, mortgage interest deductions amount to the third largest decrement in Federal Treasury income revenues, after corporate pension fund and health contributions; (Geier [2006].) See also <http://www.irs.gov/taxstats/indtaxstats/article/0,,id=133414,00.html>

³ This is the well-known Fisher relation, named after Irving Fisher [1930]. Nominal rates might also contain embedded risk premia, but abstracting from them is convenient for the present discussion.

inflation environment implies that the borrower can essentially deduct a large portion of the real value of the original principal over time, which is much more than the real interest deduction.

As a simple numerical illustration, consider a typical thirty-year fixed-rate level pay mortgage with an original face amount of \$100,000. Also assume a real interest rate of 2% and two different inflation scenarios, 3% and 10%. For ease of illustration, these rates are in percent per annum, continuously compounded, and are then converted into monthly mortgage discount rates. At the end of the first year, the real value of the outstanding principal on the mortgage in the low (high) inflation environment would be \$95,615 (\$90,160). At a 45% marginal tax rate, roughly the marginal rate for high income earners in high tax states such as California and New York, the net gain in the real value of the housing loan, (the gain from the reduction in the real value of the principal less the after-tax interest payments), would be \$1,647 (\$3,218.) The homeowner/borrower would have gained almost twice as much in real terms in the higher inflation environment.⁴ If conditions remain unchanged, this differential benefit of inflation tax deductibility continues for a number of years.⁵

At lower marginal tax rates, the inflation benefit is less pronounced; indeed, at a marginal tax rate of about 22% for this example, there is no net difference; at still lower tax rates, the effect is reversed, thus favoring the lower inflation environment. The explanation is that the nominal interest rate contains both real and inflation components, but the reduction in the real value of the outstanding principal is determined only by the latter. The principal balance's real gain exceeds the nominal after-tax interest payments only at a sufficiently high marginal tax rate.

⁴ Even this difference is slightly understated because it does not take into account the lower real value of mortgage interest payments later in the year, which are reduced more in the high inflation environment.

⁵ After about nine years in the illustration of the text, the benefit would disappear if the homeowner persists with the original mortgage, because the real value of the remaining principal balance would have declined much further under high inflation. However, refinancing and borrowing more would restore much of the benefit. Borrowing more should be feasible because the original mortgage's remaining outstanding balance should represent a very low loan/value ratio (under high inflation) since the nominal house value should have increased (with inflation.)

It seems possible, then, that there could be a non-linear association of nominal interest rates and housing prices consistent with the theory of Piazzesi and Schneider, but for an entirely different (and rational) reason. If periods of low nominal interest rates are sometimes also periods of low real interest rates, housing prices should boom. If periods of high nominal interest rates are associated with higher inflation and improved tax benefits from homeownership, housing prices should also boom, particularly if real interest rates are low. To sort this out empirically, good measures of real rates and inflation would be extremely useful. This paper imputes real interest rates and expected inflation rates from indexed and nominal bonds and then assesses their separate effects on housing values.

Before proceeding with further details, we should mention two other considerations that could conceivably mitigate the homeowner tax benefit induced by higher inflation.

First, as inflation increases, taxable lenders will demand more than proportionately higher nominal interest rates to defray their increased effective taxes. Since nominal interest income is taxed at ordinary rates, lenders can remain whole in real terms only if nominal rates are high enough to offset the inflation tax. If effective tax rates were the same for mortgage lenders and borrowers, it seems possible that higher inflation would have no net beneficial impact on real housing values. True, mortgage interest would still be tax deductible for the borrower, but the equilibrium nominal rate would be so much higher than at lower inflation that the overall effect would be neutral.

These supply and demand effects of mortgage lenders and borrowers would be difficult to disentangle if we were limited to a single country and a given tax regime, but here we intend to exploit major tax differences between Canada and the United States. Canada does not allow mortgage interest to be deducted from ordinary income tax for residential homeowners.

Canadian lenders, like U.S. lenders, owe taxes on nominal interest income, so the two countries are symmetric from the perspective of the suppliers of loans. But the borrower

asymmetry suggests that, whatever the impact of inflation on mortgage rates, the impact of inflation on housing values will be algebraically less (more negative) in Canada than in the U.S. If lenders have lower tax rates on average than borrowers (perhaps because lenders are dominated by tax-exempt financial institutions such as pension funds), inflation could even have a positive impact on U.S. housing while it should be unambiguously negative in Canada.

The second consideration involves capital gains taxes. As mentioned earlier, the nominal gain on the house itself will be taxed at the capital gains rate when it is eventually sold. This clearly reduces the incentive to purchase a house just when the tax shelter represented by mortgage rates is high (in the U.S.) But any Canada/U.S. difference in capital gains treatment seems likely to be less important than the mortgage deductibility treatment, merely because capital gains tax rates are relatively low in both countries,⁶ can be postponed almost indefinitely by real estate exchanges, or can be evaded in bequests.

A Theoretical Perspective

To clarify the various forces that impinge on the connection between inflation and real estate values, it is convenient to formulate a simple theoretical structure. To render the analysis more tractable, we make the simplifying assumption that effective tax rates of mortgage lenders and borrowers can be captured by single values, say τ_B for borrowers and τ_L for lenders.⁷

In addition, let y denote the prevailing mortgage yield⁸ and let I^e denote the anticipated rate of inflation. Then the after-tax expected real yield for mortgage lenders is given by

$$\rho = \frac{1 + y(1 - \tau_L)}{1 + I^e} - 1. \quad (1)$$

⁶ Currently, capital gains in Canada are taxed at half the ordinary rate while the highest long-term capital gains tax rate (Federal only) is 15% in the U.S. and there is a \$500,000 one-time tax exclusion for homeowners.

⁷ Of course, in reality, there is a plethora of effective tax rates among both lenders and borrowers, from which we abstract for illustrative purposes.

⁸ Again, for simplicity of illustration, this is a single number.

If the supply of mortgage capital is perfectly elastic, then any change in expected inflation will result in no change whatsoever in the after-tax expected real yield. This implies that the pre-tax nominal mortgage yield, y , must respond quite a bit to changes in expected inflation so as to offset the implicit inflation tax on nominal interest. In this case, we can easily calculate the response of mortgage yields to inflation by taking the total derivative of (1) and setting $\hat{\rho}=0$. After some manipulation, this provides the following expression for the response in nominal yields to expected inflation:

$$\frac{\hat{\partial}y}{\hat{\partial}I^e} = \frac{1 + y(1 - \tau_L)}{(1 + I^e)(1 - \tau_L)} = \frac{1 + \rho}{1 - \tau_L}. \quad (2)$$

Since $0 \leq \tau < 1$ and presumably $\rho > 0$, $\hat{\partial}y/\hat{\partial}I^e > 1$; i.e., there is more than a 1:1 response of mortgage yields to expected inflation (because of the tax treatment of nominal interest.) Indeed, the response could be substantially larger than 1:1 if tax rates are high. For example, if mortgage lenders are fully taxable in such high tax states as New York and California, where marginal tax rates are about 45%, even if real yields are close to zero, one might have $\hat{\partial}y/\hat{\partial}I^e \approx 1.8$; an increase in expected inflation of one percentage point could drive mortgage yields up by 180 basis points. In the higher-taxed Canadian provinces such as Québec and British Columbia, the tax rates are slightly lower but are still around 40%.

There are several reasons to think, however, that the impact of inflation on mortgage yields will not be so high. First and foremost, many sources of capital such as pension funds are not taxed at all and other sources such as foreigners can avoid paying. Even fully taxed lenders have lower marginal rates if their incomes are not in the highest bracket or they live in low-taxed states or provinces. Comparison of tax-exempt municipal bonds and Treasuries generally show effective tax rates below 20%, though this comparison is complicated because municipal bonds have credit risk. Treasury inflation-protected bonds (TIPs) can also be used to impute effective tax rates because the inflation tax on their yields is lower than for nominal bonds. Roll [2004, table 8] estimates tax rates between 10% and 18% using TIPs with the longest sample records.

However, an inelastic supply of mortgage capital would tend to exacerbate the impact of inflation on nominal mortgage yields. Higher inflation-induced taxes on mortgage lenders might very well reduce the total supply of funds, particularly from lenders subject to higher tax rates. The resulting market equilibrium could feature a higher after-tax expected real yield. Again taking the total derivative of (1) and simplifying terms (but this time not assuming that ρ is unchanged), we obtain

$$\frac{\partial y}{\partial I^e} = \frac{1 + \rho}{1 - \tau_L} (1 + \eta_\rho), \quad (3)$$

where the elasticity, η_ρ , gives the response of after-tax expected real yields to inflation,

$$\eta_\rho = \frac{\partial \rho / (1 + \rho)}{\partial I^e / (1 + I^e)}. \quad (4)$$

If this elasticity is positive, which seems plausible, the nominal yield response in (3) is strictly greater than the response in (2). However, when supply is not perfectly elastic, the overall impact of inflation on real mortgage after-tax yields, as measured by η_ρ , also depends on the demand for mortgage borrowing. Nominal yields must go up with inflation, but the resulting demand response by borrowers should be different in Canada and the U.S. because U.S. borrowers can deduct most mortgage interest.

When expected inflation changes, government tax collections from interest income will change per period by $\tau_L[\partial(yQ)/\partial I^e]$, where Q is the outstanding quantity of mortgage debt. Expanding this derivative and simplifying, the per period change in government tax revenues from interest income will be

$$\frac{\partial(\text{Taxes})}{\partial I^e} = \tau_L Q \frac{\partial y}{\partial I^e} (1 - \eta_Q) = \tau_L Q \frac{1 + \rho}{1 - \tau_L} (1 + \eta_\rho)(1 - \eta_Q), \quad (5)$$

where η_Q is the elasticity of demand for mortgage borrowing with respect to nominal mortgage yields,

$$\eta_Q = -\frac{\partial Q / Q}{\partial y / y}. \quad (6)$$

If demand elasticity is sufficiently high ($\eta_Q > 1$), the housing stock responds so much that tax collections actually move in direction opposite to expected inflation. However, this is hardly conceivable in the short run because the stock of housing is relatively fixed, so it

seems likely that $\eta_Q < 1$ and hence $\partial(\text{Taxes})/\partial I^e > 0$. Moreover, mortgage interest tax deductibility must certainly decrease the elasticity of demand in (6), so $\eta_{Q,\text{Canada}} > \eta_{Q,\text{USA}}$, which implies via (5) that higher inflation should bring a larger increase in tax revenues from interest income in the U.S. than in Canada.

But increased taxes paid by lenders in the U.S. would be offset by decreased taxes paid by borrowers. The decrease in tax revenues from borrowers is simply $\tau_B[\partial(yQ)/\partial I^e]$, so it has exactly the same form as (5) but with τ_B replacing the first τ_L . Hence, for the U.S., the net change in tax collections from mortgage lending and borrowing following a change in expected inflation is

$$\frac{\partial(\text{NetUSTaxes})}{\partial I^e} = (\tau_L - \tau_B)Q \frac{1+\rho}{1-\tau_L} (1+\eta_\rho)(1-\eta_Q). \quad (7)$$

While more inflation should unambiguously increase Canadian government tax revenue in accordance with (5), (for $\eta_Q < 1$), the effect in the U.S. clearly depends on whether lenders are taxed more heavily than borrowers (as shown in 7.) If borrowers are more heavily taxed, government revenues could conceivably fall with higher inflation even with inelastic demand.

In the short run, which we take to mean something on the order of a few years, higher or lower net taxes from mortgage lending and borrowing should be capitalized into real estate values. For example, if an increase in mortgage yields leads to lower net tax collections in the U.S., values of existing single-family houses should rise and carry along the values of other real estate substitutes. Eventually, higher house values should elicit a response in supply but again depending on elasticity, this time the elasticity of housing construction, the tax impact on values might dissipate at least partially over time. Demand is typically believed to be more elastic in the long run, which also serves to ultimately mitigate or reverse shorter run tax effects.

Empirical Procedures and Data

To study the differential impact of mortgage rates on house prices in Canada and the United States, the ideal set of data would consist of (1) residential real estate prices in the two countries, (2) real interest rates and embedded expected inflation rates in mortgage yields, and (3) control variables unrelated to interest rate components. Alas, as with virtually every empirical study, the ideal data are not available. There are no high frequency reliable price series for residential real estate (futures markets for residential real estate are in their infancy in the U.S. and do not exist elsewhere) and all mortgage yields are nominal (in Canada and the U.S.)

But there are some sensible empirical proxies. For real rates and inflation, the proxies should actually be pretty good because inflation-indexed bonds have existed in both countries for at least the past decade. Since inflation-indexed bonds (TIPs) are linked to broad consumer price indexes, their yields are real.⁹ Consequently, with enough points along the maturity spectrum for both TIPs and nominal bonds, it is possible to derive frequent observations of the term structures of both real interest rates and expected inflation rates.

We adopt the procedures in Roll [2004] for this purpose. Specifically, when at least four bonds are available, which is always the case for nominal bonds, a term structure is estimated using a three-factor model based on Litterman and Scheinkman [1991]. This delivers estimates of the level, slope, and curvature of both the nominal and the real term structures.

To implement this approach, the term structure's shape is estimated on each observation date by a non-linear regression of yield (either real or nominal) against functions of duration;

$$Y_{j,t} = \text{Level}_t + \text{Slope}_t X_{L,j} + \text{Curvature}_t X_{Q,j}, \quad (8)$$

⁹ To be more precise, TIPs yields are “real” with respect to official government price index changes, which may be more sticky and less volatile than true inflation; Cf. Chowdhry, Roll, and Xia [2005].

where $Y_{j,t}$ is the (real or nominal) yield for the j^{th} bond on date t , $X_{L,j,t}=a_t+b_tD_{j,t}$ and $X_{Q,j,t} = -(3X_{L,j,t}^2 - 1)/2$ are, respectively, linear and quadratic Legendre transformations of $D_{j,t}$, the estimated duration on day t of bond j .¹⁰ The Legendre transformations are employed because they are approximately orthogonal over the range -1 to $+1$.¹¹ The transformation coefficients a_t and b_t are $b_t=2/[\max(D_t)-\min(D_t)]$ and $a_t=1-b_t\max(D_t)$, which assures that the transformed durations span the required range. The estimated regression coefficients, Level_t , Slope_t , and Curvature_t , jointly depict the general shape of the term structure on date t .

The differences between the nominal and real estimates of interest rate level, slope, and curvature provide corresponding estimates for the term structure of expected inflation. Changes in the estimated levels of both the real term structure and the expected inflation term structure become our two featured variables for explaining real REIT returns. During early sample months in both countries, four TIPs bonds were not always available, so a simple average of yields is used instead. We have verified that virtually the same results obtain when simple averages of (real rates and expected inflation) are used throughout.

The derived series of real interest rates and expected inflation rates differ, of course, from what might have been obtained from mortgages because the latter are complicated by embedded default and prepayment options. Consequently, there is an inevitable measurement error in the levels of our derived real rates and expected inflation. These errors, though, to the extent that they do not vary dramatically over short periods, might not represent a severe problem because we use changes in rates rather than levels in the empirical work below. Theoretically, changes in rates are the correct construct to explain real estate returns.

¹⁰ For constant maturity nominal Treasury yields, the duration was estimated by assuming that the yield was valid for a bond selling at par.

¹¹ They are exactly orthogonal if continuous from -1 to 1 . Curvature is positive if the term structure is concave downward.

To proxy for residential real estate returns, we employ observed market returns on real estate investment trusts (REITs) in both the U.S. and Canada. At first, one might think it is more problematic to use REITs as a residential property proxy than to use TIPs and nominal Treasury bond rates as mortgage yield proxies. Our defense is simply that all types of real estate are close substitutes, so any change in the value of one type of real estate should be well correlated with changes in values of other types. Most REITs do not invest in single-family houses, but rather in apartments, offices, shopping centers, etc.; hence, any empirical power within our approach admittedly depends on strong return correlations across property types. Again, the approach is conservative because weak correlations between single-family house prices and REIT prices would make it less likely to uncover significant patterns.

There is, moreover, another advantage of using REITs; they are marked to market continually because they trade actively. This is definitely not true of residential real estate since repeated sales of the identical property are rare and assessed valuations are notoriously sticky. The poor quality of residential real estate price series has long been a matter of concern for researchers; (see, *inter alia*, Ross and Zisler [1991].) Indeed, it seems conceivable that REIT prices could more closely track the true but unobservable values of residential real estate than any other currently available indicia.¹²

Table 1 gives pertinent information about REITs, TIPs, and Nominal Bond data. The sample size varies by asset type. New TIPs were issued throughout the sample period and one U.S. TIP matured. The 30-year nominal bond was not issued for part of the sample period in the U.S. Not every REIT was listed over the entire maximum sample period, so estimates for each REIT were calculated separately using the available number of months for that security.¹³ The first control variable is a broad market index, for which we employed the Toronto Stock Exchange 300 index in Canada and the S&P 500 index

¹² When futures contracts on residential properties become more actively traded, perhaps this problem will be alleviated.

¹³ The maximum sample covered May 1998 through November 2006 inclusive.

in the U.S. The broadest available consumer price indexes¹⁴ in both countries are used to convert nominal REIT returns and nominal market index returns into real returns.¹⁵ Subsequently, we expand the specification to include the Fama/French [1992, 1993] and Carhart [1997] factors as additional regressors.

Basic Empirical Results

For each REIT j , the following time series regression was fit for all available months t :

$$R_{j,t} = \alpha_j + \beta_r(r_t - r_{t-1}) + \beta_I(I_t^e - I_{t-1}^e) + \beta_M R_{M,t} + \varepsilon_{j,t}, \quad (9)$$

where $R_{j,t}$ is the observed real (i.e., CPI adjusted) excess return¹⁶ on REIT j in month t , r_t is the estimated real rate of interest at the end of month t , I_t^e is the estimated expected inflation rate at the end of month t , $R_{M,t}$ is the real excess return on a broad market index in month t , and $\varepsilon_{j,t}$ is the unexplained (residual) return. Estimated coefficients are denoted by the greeks.

Various possible econometric problems were investigated to ascertain the reliability of ordinary least squares, OLS. Possible autocorrelation was considered by using Newey/West [1987] estimated standard errors, without disclosing any material differences. This is not surprising because the dependent variable is a return, which is usually not very autocorrelated.

Table 2 reports cross-sectional averages from (9) along with tests of statistical significance (T-statistics) based on the assumption that the estimation errors are cross-sectionally unrelated. The table also gives other pertinent cross-sectional information.

¹⁴ For Canada, we use the “Canada Consumer Price Index” from the Dominion Bureau of Statistics. For the U.S., we use the Bureau of Labor Statistics all items consumer price index. These are the same indexes used for linkage by inflation-indexed bonds of the two countries.

¹⁵ Consumer price indexes are very sluggish compared to REIT market returns, so it turns out to make little difference whether nominal or real REIT returns are employed as the dependent variable. Only the regression intercept changes materially.

¹⁶ Real excess returns are computed as $[1 + \text{nominal return} - (1 - \text{month T-Bill rate})] / (1 + \text{Inflation rate}) - 1$.

Many of the results are similar across the two countries. The explanatory power is relatively low, which is typical for REIT return market models, but it is still significant on average.¹⁷ The coefficients of response to changes in real interest rates and to market equity returns are, respectively, significantly negative and positive in both countries, as one would have expected. For real interest rate changes, 94% of the coefficients are negative in Canada and 81% are negative in the U.S.; for market equity, the percentages of positive coefficients are 94% and 89%, respectively

But the slope coefficient for the change in expected inflation is strikingly different in Canada and the U.S. It is negative and about $-.056$ on average in Canada with a t-statistic of 3.9 while it is positive, $.02$, in the U.S. with a t-statistic of 4.8. In Canada, about 74% of the coefficients are negative while about 71% in the U.S. are positive. This coefficient is the only thing that seems to differ much across the two countries, which makes the difference stand out all the more starkly and seems to suggest a genuine underlying cause. The pattern is entirely consistent with mortgage deductibility of interest in the U.S. and a lack thereof in Canada.

To further elucidate the empirical results, Figure 1 presents non-parametric density estimates fit to the cross-sectional distributions of the T-Statistics for the interest rate-related variables, real interest rate on the right and expected inflation rate changes on the left. For real interest rate changes, aside from variations attributable to sampling error, the distributions appear to be very similar in the two countries. They extend over roughly the same range and both have negative modes. In contrast, the expected inflation change coefficient distributions appear to be translated apart from each other, the U.S. distribution lying well to the right of the Canadian one; although there is some overlap, the Canadian distribution has a negative mode and a longer left tail while the U.S. distribution is the opposite.

¹⁷ In all cases, the cross-sectional t-statistics are larger for the U.S. than for Canada, but this is quite understandable given the relatively sample sizes, 197 and 31 respectively.

Taking Account of Cross-Equation Dependence

Since most of the individual REIT return regressions were conducted with data from the same time period, it seems conceivable that estimation errors in the coefficients are correlated across equations. The most likely reason is that omitted factors, such as industry factors, are present in the regression disturbances. To the extent that cross-equation correlation is present, the significance levels previously reported are overstated. To deal with this simultaneous equations problem, the most familiar and probably simplest method is Seemingly Unrelated Regressions (SUR) of Zellner [1962].

When the explanatory variables are the same in all equations, the SUR coefficient estimates are exactly the same as the OLS estimate; see Green [2000, pp. 616-617.] However, the standard errors of the coefficients are different when there is cross-equation dependence.

Using boldface characters to indicate matrices, let $\boldsymbol{\beta}$ denote the $K \times M$ matrix of the coefficients in a system of M equations, each equation conforming to (9) with the same K explanatory variables, \mathbf{X} , ($T \times K$), where T is the number of time series observations. When T is the same in all equations, the asymptotic covariance matrix of the estimates of $\boldsymbol{\beta}$ is given by

$$\text{Cov}(\hat{\boldsymbol{\beta}}_i, \hat{\boldsymbol{\beta}}_j) = \sigma_{i,j}(\mathbf{X}'\mathbf{X})^{-1}, \quad i, j = 1, \dots, M, \quad (10)$$

where $\sigma_{i,j}$ is the estimated covariance of the regression residuals between equations i and j ; (See Green [2000], page 617.)

We are interested in the standard error of the cross-sectional mean of a particular slope coefficient, say β_i , averaged over the M equations (equations being indexed by j),

$$\bar{\beta}_i = \frac{1}{M} \sum_{j=1}^M \hat{\beta}_{i,j}. \quad (11)$$

So the variance of the cross-sectional mean is

$$\text{Var}(\bar{\beta}_i) = \frac{1}{M^2} \sum_{j=1}^M \sum_{k=1}^M \text{Cov}(\hat{\beta}_{i,j}, \hat{\beta}_{i,k})$$

$$= \text{diag}_i [(\mathbf{X}'\mathbf{X})^{-1}] \frac{1}{M^2} \sum_{j=1}^M \sum_{k=1}^M \sigma_{j,k}, \quad (12)$$

where $\text{diag}_i(\cdot)$ denotes the i^{th} diagonal element of the argument matrix.

The SUR estimated t-statistic for the cross-sectional mean of the i^{th} coefficient would then simply be equation (11) divided by the square root of equation (12). Since the explanatory variables are the same in every equation, any one of the OLS estimated equations, say j , and the OLS standard error of the i^{th} coefficient can be used to obtain

$$\text{diag}_i [(\mathbf{X}'\mathbf{X})^{-1}] = [\text{standard error}(\hat{\beta}_{i,j})]^2 / \text{Variance}(\varepsilon_j). \quad (13)$$

Similarly, $\sigma_{j,k}$ can be obtained as the covariance of the OLS residuals from equations j and k .

The only difficulty in making SUR calculations for our data is that some firms do not have complete sample records; they were either listed after the beginning of the sample period or delisted before the end. This obliges us to compromise slightly because $\sigma_{j,k}$ can be estimated only from common observations. So, to approximate (12), we (a) calculated (13) using a firm with all sample observations; (b) obtained σ_j^2 for REIT j from the OLS standard error in its equation, $j=1, \dots, M$; and (c) obtained $\sigma_{j,k}$ from all concurrent observations between REIT j and REIT k .¹⁸

The resulting SUR t-statistics that account for cross-equation dependence are reported in the bottom line of Table 2. They are all smaller in absolute magnitude than the t-statistics reported earlier in the Table, which are based on an assumption of cross-equation independence. Although statistical significance has fallen for every explanatory variable, it remains adequate for everything except changes in U.S. expected inflation. For Canada, the significance of changes in expected inflation has decreased, but the t-statistic of -2.346 still indicates a material negative effect.

¹⁸ Note that the number of observations used in steps (b) and (c) could be different when there are fewer overlapping observations for j and k and both j and k lack a full sample of observations.

The differences between the independent OLS and SUR levels of significance for mean coefficients from (9) reveal positive correlation in estimation error across equations; this implies that the OLS residuals are positively correlated across equations. Evidently, there is at least one omitted common factor. We later investigate whether an augmented factor model can ameliorate this phenomenon.

Real Estate Real Returns and Nominal Interest Rates

For several reasons, it might be instructive to consider the response of real REIT returns to changes in nominal interest rates alone, instead of responses to the two components of nominal rates, real rates and inflation. This involves an alternative to (9),

$$R_{j,t} = \alpha_j + \beta_y(y_t - y_{t-1}) + \beta_M R_{M,t} + \varepsilon_{j,t}, \quad (14)$$

wherein $y \equiv r + I$ is the nominal interest rate. Essentially, regression (14) is the same as regression (9) with an equality constraint imposed on the first two coefficients, $\beta_r = \beta_I$ in (9). When these two coefficients are truly different, (14) is misleading since it forces an inappropriate constraint. Keeping this in mind, Table 3 presents the results for (14).

The coefficient for the market equity return, β_M , is virtually unaltered between regression (14), reported in Table 3, and regression (9), reported earlier in Table 2. For Canada, the coefficient of nominal interest rates, β_y , is negative and statistically significant, which is not surprising because both β_r and β_I were negative and statistically significant in Table 2. However, the mean value of β_y is not a simple weighted average of β_r and β_I , a point we will discuss in more detail below. For the U.S., β_y is negative on average but is not significant after accounting for cross-equation dependence; see the SUR T-statistic in the last row. Moreover, the mean value of the U.S. coefficient is -0.0115, only a sixth the size of Canada's coefficient, -.0665. For the U.S., the adjusted r-square has also been cut in half, which reflects the separate contributions of real interest rates and expected inflation that have now been suppressed.

Even without mortgage interest tax deductibility, there is little reason to think that real interest rates and expected inflation would have the same impact on real estate values.

Indeed, if inflation were tax neutral, it should have little effect on the real values of real estate since nominal housing prices would appreciate with inflation. In contrast, real interest rates should strongly influence real values of all assets and our empirical results suggest that they do for real estate. For the U.S., with even greater disparate effects of real interest and inflation, a specification such as (14) that supposedly checks for the influence of nominal interest rate effects is merely measuring whether real rates or inflation were more dominant during the particular sample period under study.

When they are actually different, imposing a constraint that real interest rates and expected inflation have the same influence implies that the estimated nominal interest rate coefficient is determined by the whichever constituent happens to be more volatile during the sample. This is implied logically by the following *reductio ad absurdum*: Assume, for sake of argument, that the effects of both real interest rates and expected inflation are actually constants over time but are different. Then imagine that real interest rates themselves do not change during a particular sample. In that case, the nominal interest rate's coefficient would be, by construction, the same as the expected inflation's coefficient; and vice versa, if real interest rates varied and expected inflation were unchanged during another sample, the nominal interest rate coefficient would be the real rate's coefficient. To the extent that the relative variation in real rates and inflation changes materially over time, it follows that any empirical estimate of the nominal rate's effect is highly sample specific. One should expect it to display considerable variation in successive sample periods and even a change in sign would not be an aberration.

Multi-Factor Estimation

Common current practice is to use a three- or four-factor model when examining asset returns. Moreover, the SUR estimation above suggests that some factor has been overlooked when real interest rate changes, expected inflation changes, and a broad market return are used as the only explanatory variables. To facilitate comparison with many other studies using U.S. data, we now present results from an augmented model that adds the Fama/French [1992, 1993] factors plus the Carhart [1997] momentum

factor.¹⁹ In addition to the broad market equity excess return, the two Fama/French factors are hedge portfolios, HML and SMB, which are, respectively, high minus low book/market stocks and small minus large sized stocks. The Carhart momentum factor is long stocks with high returns and short stocks with low returns over the previous twelve months. Since these latter three factors represent long/short (zero investment) positions, there is no need to correct them for inflation, unlike the REIT returns and the broad market return.

Unfortunately, we do not have access to the Fama/French and Carhart factors for Canada, so we are able to provide results only for the U.S.; these are reported in Table 4. The Fama/French and Carhart momentum factors are all statistically significant. It is interesting to note, however, that the SUR T-Statistics for every coefficient are below (in absolute magnitude) the corresponding simple T-Statistics that assume cross-equation independence. This suggests strongly that the augmented model, which now has six explanatory variables, still omits some common factor, perhaps a non-priced industry factor or worse, a heretofore unidentified pervasive priced factor. Hopefully, future research will shed light on this interesting issue.

On average, U.S. REITs are positively sensitive to both the Book/Market and Size factors; even the SUR T-Statistics exceed six. The SUR T-Statistic is -2.2 for the Momentum factor. We have no explanation for why REITs should be negatively sensitive to momentum and would welcome suggestions.

Real interest rate changes still have a significant negative impact on real REIT excess returns even after controlling for the additional factors. The coefficient has decreased in absolute magnitude from -.0644 in Table 2 to -.0426 in Table 4 and the SUR T-statistic has decreased marginally from -3.057 to -2.700. It would be interesting to ascertain whether changes in real interest rates pervasively impact all stocks, not just REITs. If they do, the full four-factor model so often used these days might be missing an important source of systematic risk; viz., changes in real interest rates.

¹⁹ The Fama/French and Carhart factors are available from the WRDS data base.

Finally, the change in expected inflation remains insignificantly different from zero. The average value of its coefficient is now negative, but very small, only $-.008$, and a majority of the REIT regressions have negative coefficients. Based on these results, one cannot conclude with confidence that expected inflation has any impact on real excess returns for U.S. REITs. Whenever changes in nominal interest rates are induced by revisions in the market's consensus belief about inflation, there seems to be little response in the real value of U.S. real estate. Contrary to popular belief, there is not a strong negative nominal interest rate effect on real estate when the underlying cause is inflation. There is, however, a strong negative effect when the underlying cause is real interest rates.

Overall, the results for the U.S. suggest that the supply and demand effects induced by the tradeoff between, (a) tax deductibility of mortgage interest and (b) compensation to lenders for the inflation tax on nominal interest, might be close to an offsetting wash. Of course, measurement error, both in expected inflation and in using REITs as proxies for residential housing, might have reduced empirical power and resulted in a finding of “no effect” when there really is some effect, albeit rather small.

For Canada, there is indeed a negative impact on real estate real values of increases in interest rates, either real or nominal. This seems consistent with the Canadian inflation tax on nominal interest and the lack of an offsetting tax benefit from mortgage interest deductibility.

Conclusions

The mortgage interest deduction in the United States effectively implies that homeowners in high inflation environments can deduct part of the real value of the principal of their mortgage loans over time. Nominal mortgage rates rise with inflation and are fully deductible for most homeowners while the real value of the outstanding principal declines over time. This suggests that increases in nominal interest rates caused by rising expected inflation could actually have a positive impact on house prices. Moreover,

previous research has found that house prices have boomed in periods of inflation, though they have also boomed in periods of low nominal interest rates, perhaps because real interest were also low at those times.

In Canada, mortgage interest is not tax deductible, so increases in nominal interest rates caused by increased inflation brings no corresponding tax benefit to homeowners. Although there are other differences between the Canadian and U.S. tax systems, it seems likely that none is more important for house prices than mortgage interest deductibility or the lack thereof.

Higher interest rates induced by inflation should, however, also reduce the real returns for mortgage lenders in both countries, so nominal mortgage yields might rise by more than the expected inflation increase to compensate lenders for the added tax burden. But this supply consideration is the same in the two countries, so whatever the overall impact of inflation on house prices might be, it seems likely to be less in the United States than in Canada.

We find empirical evidence that the effect of inflation on real house prices is indeed less in the U.S. We study real monthly returns on real estate investment trusts (REITs), which should be strongly correlated with real house prices because all types of real estate are substitutes. We impute real interest rates and expected inflation rates from nominal and indexed bonds in Canada and the U.S. and study the relation between REIT real returns and changes in these rates while controlling for broad equity movements.

Real interest rate changes have strongly negative and quite similar effects on REIT returns in both countries. In contrast, changes in expected inflation have very dissimilar effects; in Canada, increased inflation reduces REIT values significantly while the impact is not significantly different from zero in the U.S. Other empirical characteristics of REIT returns, such as the response to broad equity movements and explanatory power, are remarkably similar in the two countries, so we feel safe in concluding that some

underlying genuine cause, possibly mortgage interest deductibility, is responsible for the striking dissimilarity in the impact of inflation.

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Table 1

**Data Sources and Sample Information about Real Estate Returns (REITs),
Nominal Bonds, and Inflation-Indexed Bonds (TIPs)**

	Canada			United States		
	Maximum Number Available	Source	Maximum Period Available	Maximum Number Available	Source	Maximum Period Available
REITs	31	Andrei Pavlov ²⁰	Jan 1996 – Nov 2006	197	UCLA Ziman Center for Real Estate	May 1998- Jun 2004
Nominal Bonds	120 ²¹	Bank of Canada Web Site	Jan 1996 – Dec 2006	11 ²²	U.S. Treasury Web Site	Oct 1996 – Apr 2007
TIPs	4	Barclays	Jan 1997 – Apr 2007	24	Barclays	Jan 1997 – Apr 2007

Note: All observations are monthly.

²⁰ We thank Andrei Pavlov of Simon Fraser University for providing data on Canadian REITs.

²¹ The Bank of Canada provides constant maturity nominal yields every three months from three months to 30 years.

²² The U.S. Treasury gives 11 constant maturity nominal yields for maturities of 1, 3 and 6 months and 1, 2, 3, 5, 7, 10, 20, and 30 years. From February 19, 2002 until February 9, 2006, the 30-year bond was not issued and the data for that maturity are missing.

Table 2

**Time Series Regressions of Real REIT Returns
on Changes in Real Interest Rates and Expected Inflation Rates
with Real Returns on a Broad Equity Index as a Control**

Real interest rates and expected inflation rates are derived from nominal and real (inflation-indexed) term structures of interest rates in Canada and the United States using Treasury Bonds of each country. The market equity proxies are the Toronto Stock Exchange 300 for Canada and the CRSP value-weighted index for the U.S. There are 31 Canadian Real Estate Investment Trusts (REITs) and 197 U.S. REITs in the cross-sectional sample. Data were monthly and the maximum time series sample period was May 1998 through November 2006.

Cross-Sectional Statistic	β_r , Real Interest Rate Changes		β_I , Expected Inflation Rate Changes		β_M , Market Equity Real Excess Returns		Regression Adjusted R-Square	
	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
Mean	-0.1014	-0.0644	-0.0559	0.0196	0.1159	0.2563	0.0544	0.0495
Median	-0.1023	-0.0625	-0.0490	0.0162	0.1055	0.2048	0.0248	0.0399
Std. Dev.	0.0715	0.0764	0.0791	0.0573	0.1054	0.3062	0.0852	0.0624
T-Statistic	-7.900	-11.83	-3.932	4.806	6.120	11.74	3.553	11.13
Skewness	-0.567	-1.28	-0.355	-0.197	0.0286	2.213	1.232	0.4598
Kurtosis	-0.0817	5.86	-0.671	4.59	0.174	10.32	1.860	-0.2475
% > 0	6.452	18.78	25.81	70.56	93.55	88.83	74.19	77.16
SUR T-Stat.	-2.934	-3.057	-2.346	1.132	3.234	3.597		

Table 3

**Time Series Regressions of Real REIT Returns
on Changes in Nominal Interest Rates
with Real Returns on a Broad Equity Index as a Control**

Nominal interest rate term structure levels in Canada and the United States were estimated using Treasury Bonds of each country. The market equity proxies are the Toronto Stock Exchange 300 for Canada and the CRSP value-weighted index for the U.S. There are 31 Canadian Real Estate Investment Trusts (REITs) and 197 U.S. REITs in the cross-sectional sample. Data were monthly and the maximum time series sample period was May 1998 through November 2006.

Cross-Sectional Statistic	β_y , Nominal Interest Rate Changes		β_M , Market Equity Real Excess Returns		Regression Adjusted R-Square	
	Canada	U.S.	Canada	U.S.	Canada	U.S.
Mean	-0.0665	-0.0115	0.1148	0.2557	0.0501	0.0282
Median	-0.0558	-0.0130	0.1044	0.2040	0.0389	0.0171
Std. Dev.	0.0646	0.0405	0.1064	0.3061	0.0619	0.0517
T-Statistic	-5.734	-3.971	6.005	11.72	4.507	7.647
Skewness	-0.3081	0.1947	0.2934	2.120	0.7322	0.9349
Kurtosis	-0.7392	2.462	0.0859	10.01	-0.6335	0.5766
% > 0	12.90	31.47	93.55	88.83	80.65	63.45
SUR T-Stat.	-3.212	-0.824	3.214	3.431		

Table 4

**Time Series Regressions of U.S. Real REIT Excess Returns
on Changes in Real Interest Rates and Expected Inflation Rates
with Fama/French Factors and Carhart Momentum Factor as Controls**

Real interest rates and expected inflation rates are derived from nominal and real (inflation-indexed) term structures of interest rates in the United States using Treasury Bonds. The market proxy is the CRSP value-weighted index. There are 197 U.S. Real Estate Investment Trusts (REITs) in the cross-sectional sample. Data were monthly and the maximum time series sample period is May 1998 through November 2006.

Cross-Sectional Statistic	β_r , Real Interest Rate Changes	β_I , Expected Inflation Rate Changes	β_M , Market Equity Real Excess Returns	β_{HML} , High-Low Book/Market	β_{SMB} , Small-Large Size	β_{Mom} , Momentum	Regression Adjusted R-Square
Mean	-0.0426	-0.0080	0.4292	0.4098	0.5174	-0.0934	0.1637
Median	-0.0388	-0.0103	0.4010	0.3996	0.5525	-0.0788	0.1618
Std. Dev.	0.0769	0.0556	0.3408	0.3476	0.4563	0.2810	0.1168
T-Statistic	-7.783	-2.014	17.68	16.55	15.92	-4.664	19.67
Skewness	-1.108	0.1705	0.7824	-0.4882	-2.302	1.726	0.0878
Kurtosis	5.993	4.681	2.370	4.518	15.61	11.06	-0.2384
% > 0	24.87	35.53	93.91	94.42	92.39	28.93	91.88
SUR T-Stat.	-2.700	-0.601	6.538	6.474	6.461	-2.204	

Figure 1

Non-Parametric Density Estimates of the Cross-Sectional Distributions of T-Statistics for the Responses of Real Excess Returns on REITs to Changes in Real Interest Rates and Expected Inflation Rates in the USA and Canada

