

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

by

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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.

Many journalists, homeowners, and real estate brokers seem to believe that higher mortgage interest rates reduce real estate values.<sup>1</sup> Presumably, an increase in mortgage rates implies higher monthly payments for new borrowers, who are less able to afford a home.<sup>2</sup>

But empirical support 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 a good hedge against actual inflation (e.g., Gyrko and Linneman, 1998; and Huang and Hudson-Wilson, 2007).

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: mortgage interest is fully deductible in the calculation of ordinary income taxes (below an upper constraint that is not binding for most borrowers.) Indeed, for

many Americans who itemize, mortgage interest is the single largest deduction on their income tax returns.<sup>3</sup>

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.<sup>4</sup> 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 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.<sup>5</sup> If conditions remain unchanged, this differential benefit of inflation tax deductibility continues for a number of years.<sup>6</sup>

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.

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.

Another 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,<sup>7</sup> can be postponed almost indefinitely by real estate exchanges, or can be evaded in bequests.

The next section provides a detailed analytic model of housing and mortgage demand and supply. It derives the variety of quantitative phenomena that one could conceivably see in real estate values and associated interest rates given the tax regimes of Canada and the United States.

## 1. 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 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  $\tau_B$  for borrowers and  $\tau_L$  for lenders.<sup>8</sup>

Let  $y$  denote the prevailing mortgage yield<sup>9</sup> and let  $I^e$  denote the anticipated rate of inflation. Then the after-tax expected real yield for mortgage lenders can be written

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

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. Hence, given perfectly elastic supply, the response of mortgage yields to inflation can be obtained by taking the total derivative of (1) and setting it to zero; i.e.,  $\partial\rho=0$ . After some manipulation, this results in the following expression for the response in nominal yields to expected inflation:

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

Since  $0 \leq \tau < 1$  and presumably  $\rho > 0$ ,  $\partial y/\partial I^e > 1$ ; 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  $\partial y/\partial I^e \approx 1.8$ ; 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  $\rho$  is unchanged), we obtain

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

where the elasticity,  $\eta_\rho$ , 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  $\eta_\rho$ , 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  $\eta_Q$  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  $\tau_B$  replacing the first  $\tau_L$ . Hence, for the U.S., the net change in tax collections from mortgage lending and borrowing following a change in expected inflation is

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

While more inflation should unambiguously increase Canadian government tax revenue in accordance with (5) (or with (7) because  $\tau_B = 0$  in Canada, given the reasonable assumption that  $\eta_Q < 1$ ), the effect in the U.S. clearly depends on whether lenders or borrower are more heavily taxed; i.e., on whether or not  $\tau_L > \tau_B$ . 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.

## **2. 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. As with many empirical studies, perfect 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.<sup>10</sup> 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, the latter being the difference between nominal and real rates.

The difference between nominal and real rates could also include an inflation risk premium, but we use only monthly changes in that difference in all empirical work. Monthly variation in the any risk premium should be relatively small. If it exists at all, it merely introduces measurement error that is likely to weaken the estimated influence of expected inflation. For simplicity, we refer to the nominal/real yield difference as “expected inflation.”

With some additional assumptions, it is possible to estimate the terms structures of real yields and expected inflation from nominal yields alone. An ingenious recent example is by Ang, Bekaert and Wei (2008), who estimate a term structure of real interest rates that has “...no significant term spread,” (p. 798.) TIPs real yields have generally exhibited a positive term spread, but this might be attributable to their shorter period of availability.

When at least four bonds are available, which is always the case for nominal bonds, we fit term structures with the three-factor model of Litterman and Scheinkman (1991) using the procedures in Roll (2004). This delivers estimates of the levels, slopes, and curvatures of both the real and nominal term structures.<sup>11</sup>

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

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

where  $Y_{j,t}$  is the (real or nominal) yield for the  $j^{\text{th}}$  bond on date  $t$ ,  $X_{L,j,t} = a_t + b_t D_{j,t}$  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  $j$ .<sup>12</sup> The Legendre transformations are employed because they are approximately orthogonal over the range  $-1$  to  $+1$ .<sup>13</sup> 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,  $\text{Level}_t$ ,  $\text{Slope}_t$ , and  $\text{Curvature}_t$ , 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.

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.

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.<sup>14</sup> 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 in the U.S. The broadest available consumer price indexes<sup>15</sup> in both countries are used to convert nominal REIT returns and nominal market index returns into real returns.<sup>16</sup> Subsequently, we expand the specification to include the Fama/French (1992, 1993) and Carhart (1997) factors as additional regressors.

There is one major advantage of using REITs to measure real estate returns; 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; and Freddie Mac, 2008.) 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.

When futures contracts on residential properties become more actively traded, perhaps this problem will be alleviated. At the moment, perhaps the best data directly about residential real estate is provided by Standard & Poor's corporation, which publishes the S&P/Case-Shiller<sup>®</sup> Home Price Indices monthly.<sup>17</sup> These indices are based on repeat sales of identical properties and are essentially three-month moving averages of actual sale prices lagged one month; (see Standard & Poor's, 2007), a procedure invented by

Case and Shiller (1987). Clearly, indices constructed in such a fashion could deviate materially from traded assets such as REITs.

We did attempt, however, to mimic the S&P/Case Shiller index construction method using REIT data in an effort to estimate their underlying correlation. To accomplish this, we took an equal-weighted average of US REIT returns, constructed a corresponding index of REIT levels, and then calculated a three-month moving average of the levels lagged one month. We then correlated the returns from this pseudo-REIT index with returns from the S&P/Case Shiller<sup>®</sup> U.S. National Home Price Index monthly over the available sample, 1998-2004. The result was a correlation coefficient of +0.174, which is significant at the 1% level. Although the correlation is rather modest, this seems hardly surprising given the methods employed. With residential real estate data marked to market in real time, it seems possible that the correlation would be substantially higher.

We also obtained after their recent release (in April 2008), monthly house price indexes from OFHEO, the Office of Federal Housing Enterprise Oversight. OFHEO indexes were employed by Brunnermeier and Julliard (2008) in their paper on money illusion and house prices, but the indexes were then available only quarterly. The recent monthly series are based on purchases only; i.e., they do not depend upon appraisals obtained during refinancings, as did the earlier quarterly data.

Unfortunately, the OFHEO indexes exhibit some disquieting characteristics. To illustrate, Figure 1 plots the OFHEO national index along with an equal-weighted index

of REIT prices over our sample period. The obvious difference is the very smooth appearance of the OFHEO index. Indeed, during these 74 months, (May 1998 through June 2004) the OFHEO index increased every single month, whereas REIT prices declined in 28 months, about 38% of the time.<sup>18</sup> The volatility of REIT returns was 3.57% per month while the volatility of returns from the OFHEO index was 0.288% per month, only 1/12 as much. Over the entire period of OFHEO monthly index availability, beginning in 1991 and extending through February 2008, the standard deviation of its monthly return was only slightly higher, 0.407% per month.

Asset returns with such miniscule volatility are suspicious because almost all known market-based asset returns have volatilities that are at least an order of magnitude larger. The long-term trend of the OFHEO index might roughly correspond to true real estate values, but monthly variation, being so small, is very weakly correlated with changes in real interest rates and inflation. There is little variation to explain and, in fact, no significant explained variation over monthly intervals.<sup>19</sup>

Overall, a very strong case can be made the REIT prices are superior to any other available data on real estate values. They are market-determined in real time and hence are based on the consensus beliefs of investors about real property values. True, they differ in some respects from residential real estate, but there are no reliable high frequency data for the latter. Since substitutability should be very good among all types of real estate, REITs offer the best hope of uncovering significant effects from interest

rates over short observation intervals. Of equal importance for us, they are available for both the U.S. and Canada, unlike the S&P Case/Shiller indexes or the OFHEO indexes.

### 3. 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 return<sup>20</sup> 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.

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.<sup>21</sup> 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 -5.59 on average in Canada with a t-statistic of -3.9 while it is positive, 1.96, 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.

The economic magnitude of the expected inflation effect is material; an increase in expected inflation of one percent per annum that occurs during a given month would drive REIT prices in Canada down by about 5.6 percent in that month whereas U.S. REIT prices in the U.S. would increase by almost two percent. This seems broadly consistent with the analysis in the theory section above because a one percent per annum change in

inflation would alter annual tax collections by some fraction of one percent and the net discounted present value would be capitalized into current real estate prices.<sup>22</sup>

To further elucidate the empirical results, Figure 2 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.

#### **4. 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  $\beta$  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  $\beta$  is given by

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

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

We are interested in the standard error of the cross-sectional mean of a particular slope coefficient, say  $\beta_i$ , 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

$$\begin{aligned} \text{Var}(\bar{\beta}_i) &= \frac{1}{M^2} \sum_{j=1}^M \sum_{k=1}^M \text{Cov}(\hat{\beta}_{i,j}, \hat{\beta}_{i,k}) \\ &= \text{diag}_i [(\mathbf{X}'\mathbf{X})^{-1}] \frac{1}{M^2} \sum_{j=1}^M \sum_{k=1}^M \sigma_{j,k}, \end{aligned} \quad (12)$$

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

The SUR estimated t-statistic for the cross-sectional mean of the  $i^{\text{th}}$  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  $i^{\text{th}}$  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  $\sigma_j^2$  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  $k$ .<sup>23</sup>

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.

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.

### 5. 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,  $\beta_M$ , 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,  $\beta_y$ , is negative and statistically significant, which is not surprising because both  $\beta_r$  and  $\beta_I$  were negative and statistically significant in Table

2. However, the mean value of  $\beta_y$  is not a simple weighted average of  $\beta_r$  and  $\beta_I$ , a point we will discuss in more detail below. For the U.S.,  $\beta_y$  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 -1.15, only a sixth the size of Canada's coefficient, -6.65. 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.

## **6. 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.<sup>24</sup> In addition to the broad market equity excess return, the two Fama/French factors are hedge portfolios, SMB and HML, which are, respectively, small minus large sized stocks and high minus low book/market 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 Size, Book/Market, and Momentum factors for Canada, so we are only able to provide results using the U.S. versions of these factors.<sup>25</sup> As reported in Table 4, the Fama/French and Carhart momentum factors are all statistically significant for the U.S. 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.

The qualitative results for Canada (lower panel of Table 4) are comparable to those of the U.S. Every mean coefficient has the same sign, but the statistical significance is much lower. This might be attributable partly to the much smaller sample size though it could also partly be blamed on using U.S. versions of SMB, HML, and Momentum as explanatory variables for Canadian REITs.

On average, U.S. REITs are positively sensitive to both the Size and Book/Market factors; even the SUR T-Statistics exceed six. The SUR T-Statistic is -2.2 for the momentum factor. This suggests that REITs and high momentum stocks are driven in opposite directions by some underlying latent influence.

Real interest rate changes still have a significant negative impact on real REIT excess returns even after controlling for the additional factors. For the U.S., the coefficient has decreased in absolute magnitude from -6.44 in Table 2 to -4.26 in Table 4 and the SUR T-statistic has decreased marginally from -3.057 to -2.700. For Canada, the coefficient has changed from -10 to -9 between Tables 2 and 4, but it is only marginally significant in the latter.

Finally, the change in expected inflation remains insignificantly different from zero. The average value of its coefficient is now negative, but very small, only -0.80 for the U.S., and a majority of the REIT regressions have negative coefficients. The coefficient for Canada is negative and more than twice as large in absolute value, but it is not significant. Based on these results, one cannot conclude with confidence that expected inflation has any impact on real excess returns for 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 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 negative effect when the underlying cause is real interest rates.

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. To investigate this possibility, we did a small pilot study using U.S. equities that were not REITs. We collected the same number of non-REIT stocks (197) randomly over the same time interval and repeated the calculations in Table 4. Perhaps to no surprise, the real interest rate change had no influence on these non-REIT stocks; the mean coefficient was 0.26 and the SUR T-statistics was 0.275.<sup>26</sup>

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.

## **7. 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 <sup>27</sup>	Jan 1996 – Nov 2006	197	UCLA Ziman Center for Real Estate	May 1998- Jun 2004
Nominal Bonds	120 <sup>28</sup>	Bank of Canada Web Site	Jan 1996 – Dec 2006	11 <sup>29</sup>	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.

**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	$\beta_r$ , Real Interest Rate Changes		$\beta_i$ , Expected Inflation Rate Changes		$\beta_M$ , Market Equity Real Excess Returns		Regression Adjusted R-Square	
	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
Mean	-10.14	-6.44	-5.59	1.96	0.1159	0.2563	0.0544	0.0495
Median	-10.23	-6.25	-4.90	1.62	0.1055	0.2048	0.0248	0.0399
Std. Dev.	7.15	7.64	7.91	5.73	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	$\beta_y$ , Nominal Interest Rate Changes		$\beta_M$ , Market Equity Real Excess Returns		Regression Adjusted R-Square	
	Canada	U.S.	Canada	U.S.	Canada	U.S.
Mean	-6.65	-1.15	0.1148	0.2557	0.0501	0.0282
Median	-5.58	-1.30	0.1044	0.2040	0.0389	0.0171
Std. Dev.	6.46	4.05	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**

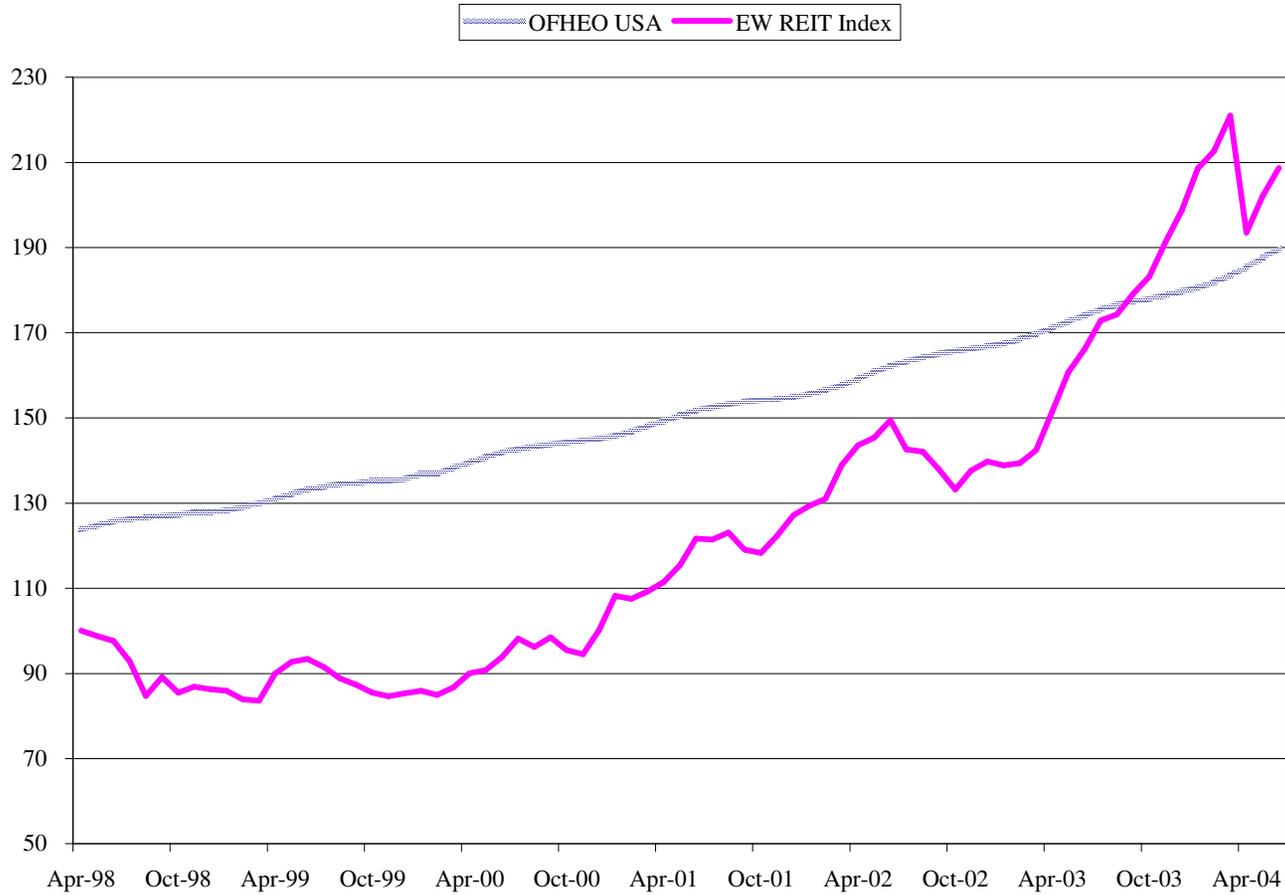
Real interest rates and expected inflation rates are derived from nominal and real (inflation-indexed) term structures of interest rates in Canada and the United States using Treasury Bonds. The U.S. (Canadian) market proxy is the CRSP value-weighted index (Toronto Stock Exchange 300 Index.) There are 197 (31) U.S. (Canadian) Real Estate Investment Trusts (REITs) in the final cross-sectional sample. The SMB, HML, and Momentum factors were U.S. only and they were used also in the Canadian regressions. Data were monthly and the maximum time series sample period is May 1998 through November 2006.

Cross-Sectional Statistic	$\beta_{r_t}$ , Real Interest Rate Changes	$\beta_{I_t}$ , Expected Inflation Rate Changes	$\beta_{M_t}$ , Market Equity Real Excess Returns	$\beta_{SMB_t}$ , Small-Large Size	$\beta_{HML_t}$ , High-Low Book/Market	$\beta_{Mom_t}$ , Momentum	Regression Adjusted R-Square
U.S. (N=197)							
Mean	-4.26	-0.80	0.4292	0.4098	0.5174	-0.0934	0.1637
Median	-3.88	-1.03	0.4010	0.3996	0.5525	-0.0788	0.1618
Std. Dev.	7.69	5.56	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
% > 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	
Canada (N=31)							
Mean	-9.00	-1.93	0.1125	0.1220	0.4168	-0.0941	0.0479
Median	-7.45	-2.26	0.1144	0.1328	0.3906	-0.0920	0.0409
Std. Dev.	8.35	7.35	0.1126	0.2035	0.3033	0.1432	0.0747
T-Statistic	-5.173	-1.2571	4.79	2.88	6.59	-3.15	3.075
% > 0	17.39	39.13	86.96	82.61	95.65	26.09	69.57
SUR T-Stat.	-1.791	-0.668	1.833	1.052	2.519	-1.264	

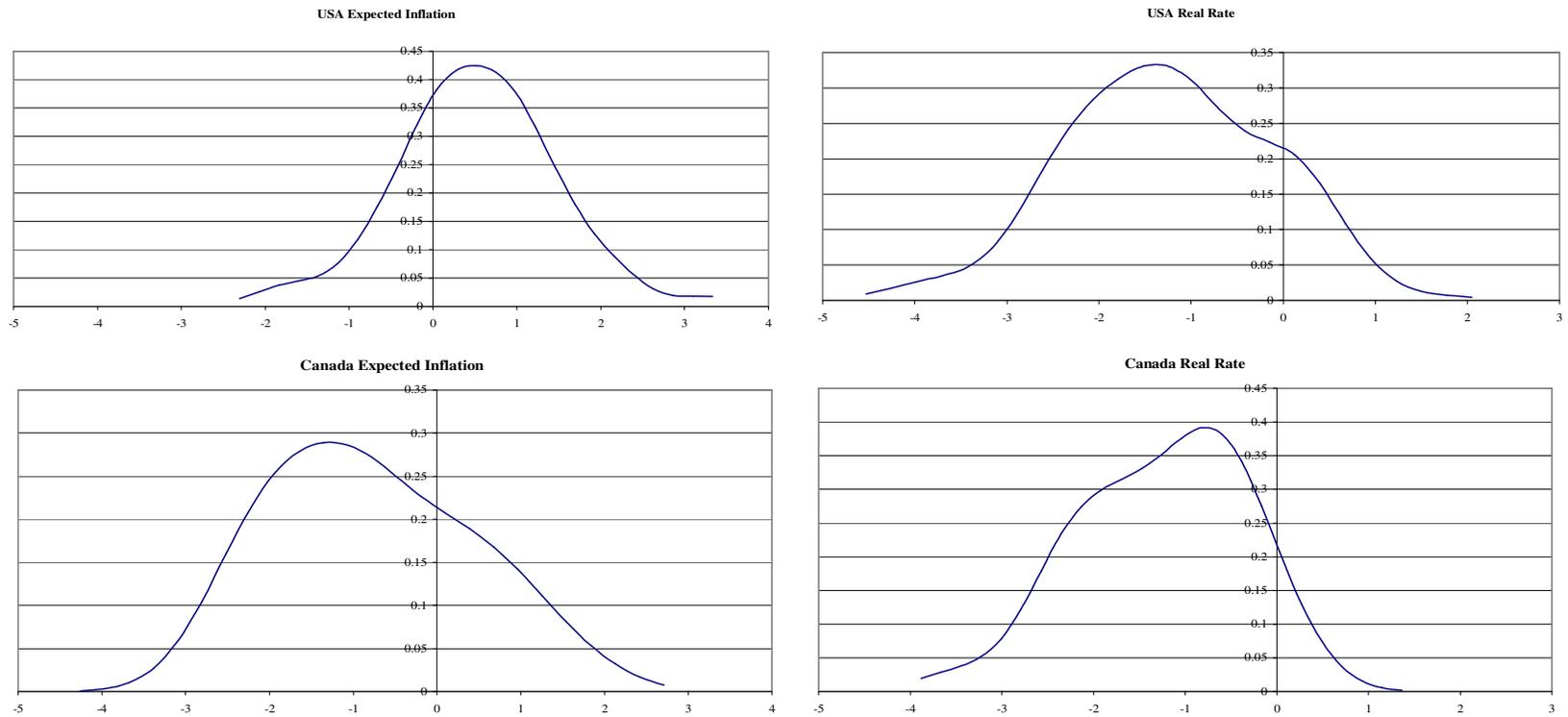
**Figure 1**

**OFHEO USA National Real Estate Price Index and Equal-Weighted USA REIT Price Index, 1998-2004**

The nationwide residential real estate price index compiled by the Office of Federal Housing Enterprise Oversight (OFHEO) is plotted monthly along with a price index constructed by equal weighting monthly returns on USA real estate investment trusts.



**Figure 2**  
**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**



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- <sup>1</sup> 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.)
- <sup>2</sup> In support of the public’s belief, irrational money illusion is offered by Brunnermeier and Julliard (2008) as an explanation for a negative relation between nominal interest rates and housing prices. They find empirical evidence that the house-price/rent ratio varies with nominal interest rates but with not real interest rates, which they interpret to signify widespread money illusion that would favor a policy of housing price stabilization.
- <sup>3</sup> In aggregate, mortgage interest deductions amount to the third largest decrement in Federal Treasury income revenues, after corporate pension fund and health contributions (see e.g., Geier, 2006 and <http://www.irs.gov/taxstats/indtaxstats/article/0,,id=133414,00.html>)
- <sup>4</sup> 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.
- <sup>5</sup> 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.
- <sup>6</sup> 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.)
- <sup>7</sup> 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.

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- <sup>8</sup> Of course, in reality, there is a plethora of effective tax rates among both lenders and borrowers, from which we abstract for illustrative purposes.
- <sup>9</sup> Again, for simplicity of illustration, this is a single number.
- <sup>10</sup> 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).
- <sup>11</sup> A decomposition of nominal yields into real yields and expected inflation is given in Roll (2004), which also contains time series plots of the real yield curve and the derived yield curve of expected inflation
- <sup>12</sup> For constant maturity nominal Treasury yields, the duration was estimated by assuming that the yield was valid for a bond selling at par.
- <sup>13</sup> They are exactly orthogonal if continuous from  $-1$  to  $1$ . Curvature is positive if the term structure is concave downward.
- <sup>14</sup> The maximum sample covered May 1998 through November 2006 inclusive.
- <sup>15</sup> 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.
- <sup>16</sup> 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.
- <sup>17</sup> The indices can be obtained from their web site, [www.indices.standardandpoors.com](http://www.indices.standardandpoors.com).
- <sup>18</sup> The first negative OFHEO return did not appear until more than two years later, in July 2006.
- <sup>19</sup> As we have verified in unreported tests.
- <sup>20</sup> Real excess returns are computed as  $[1 + \text{nominal return} - (1\text{-month T-Bill rate})] / (1 + \text{Inflation rate}) - 1$ .
- <sup>21</sup> 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.
- <sup>22</sup> Not surprisingly, the effect of real interest rate changes is larger. A one percent increase in real rates during a month would drive down REIT prices by 10 percent in Canada and over six percent in the U.S. But this would be a very large change in real rates for a given calendar month.

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<sup>23</sup> 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.

<sup>24</sup> The Fama/French and Carhart factors are available from the WRDS data base.

<sup>25</sup> The U.S. and Canadian stock markets are well integrated, so we thought the U.S. factors might work even in Canada. Of course, we do have the first Fama/French factor, the broad market's excess real return, for Canada and we use that alongside the U.S. SMB, HML, and Momentum factors.

<sup>26</sup> For this non-REIT sample, the expected inflation change was equally as insignificant while the market return and all three factors, SMB, HML, and Momentum, were all highly significant. The mean adjusted R-square was higher too, 0.28 in contrast to the 0.16 found for REITs.

<sup>27</sup> We thank Andrei Pavlov of Simon Fraser University for providing data on Canadian REITs.

<sup>28</sup> The Bank of Canada provides constant maturity nominal yields every three months from three months to 30 years.

<sup>29</sup> 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.