Interest Rates and Real Estate Values:

The Diverging Effects of Real Rates and Expected Inflation

Abstract

A common belief is that higher interest rates reduce real estate values, but corroborating evidence is underwhelming. A sensible explanation, one that suggests heterogeneity across countries, is that mortgage interest deductibility for the U.S. personal income tax makes much of the real value of the mortgage principal tax deductible when inflation is high. This implies that nominal mortgage rates could be positively related to U.S. house prices. We find evidence consistent with this possibility; the inflation component of nominal interest is associated positively with U.S. real estate prices but negatively with those in Canada, a country without mortgage interest deductibility.

1. Introduction

Many journalists, homeowners, and real estate brokers seem to believe that higher mortgage interest rates reduce real estate values.[1] An increase in mortgage rates implies higher monthly payments for new borrowers, who are presumably less able to afford a home.[2]

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 (Gyurko and Linneman 1998; Huang and Hudson-Wilson 2007), implying that house prices should have a direct relationship with mortgage rates given the inflation component of interest rates.

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

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[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.)

[2] 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.

binding for most borrowers.) Indeed, for many Americans who itemize, mortgage interest is the single largest deduction on their income tax returns.[3]

To see why mortgage interest tax 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.[4] Clearly, if an increase in mortgage interest rates is caused by 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. A homeowner's tax deduction attributable to high inflation could easily exceed the deduction due to the real interest component.

2. Numerical illustration of the real tax benefit of mortgage interest deductibility

In this section, we present a simple numerical illustration of how nominal mortgage interest deductibility, which becomes much more than the real interest deduction in a high inflation environment, allows the borrower to essentially deduct a larger portion of the real value of the original principal over time. 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

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[3] 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

[4] 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.

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.[5] If conditions remain unchanged, this differential benefit of inflation tax deductibility continues for a number of years.[6]

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 (2007), 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

[5] 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.

[6] 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.)

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,[7] can be postponed almost indefinitely by real estate exchanges, or can be evaded in bequests.

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

As mentioned, our basic inferences are drawn from time series regressions of real excess REIT returns on changes in real interest rates and changes in expected inflation rate after controlling for real excess returns on a broad equity index and for the Fama/French (1992, 1993) and Carhart (1997) factors. We find that changes in real interest rates are negatively associated with real estate returns in both countries and have similar quantitative effects. The control variables also have similar influences in the two countries. Expected inflation, however, is very different. It is strongly negatively associated with Canadian real estate values. Its influence in the U.S. is positive in some specifications and insignificant in others. This evidence is consistent with a mitigating influence of mortgage tax deductibility in the U.S. acting through the inflation channel.

[7] 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.

3. 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 assume that the effective tax rates of mortgage lenders and borrowers can be captured by single values, τ_B for borrowers and τ_L for lenders.[8]

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

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

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:

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

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

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

[9] Again, for simplicity of illustration, this is a single number.

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

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

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

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

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

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

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

$$\eta_Q = -\frac{\partial Q/Q}{\partial y/y}. \tag{6}$$

If demand elasticity is sufficiently high ($\eta_Q>1$), the housing stock responds so much that tax collections actually move in the 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

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

While more inflation should unambiguously increase Canadian government tax revenue in accordance with (5) (or with (7) because τ_B=0 in Canada, given the reasonable assumption that η_Q<1), the effect in the U.S. clearly depends on whether lenders or borrowers 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.

Aggregate tax collections from mortgage lenders and home owners should have direct implications for how real estate values are likely to respond to changing inflation rates. Clearly, if there is a net drain from the housing sector to government, real estate values should decline and vice versa. As we have seen above, increased inflation in Canada unambiguously increases government revenue and should drive down real estate values. In the U.S., there is a mitigating influence and higher inflation could actually increase real estate values in some circumstances. At a minimum, the impact of inflation should be strictly less negative on house prices in the U.S. than in Canada. This leads directly to our basic empirical test: does inflation in Canada have a more deleterious influence on real estate values than it does in the U.S.?

In the short run, higher or lower aggregate tax collections from the housing sector should be capitalized into existing real estate values. The resulting altered values of existing single-family houses should induce changes in the value of other real estate substitutes such as apartments, vacant land and even commercial structures. Eventually, in the longer run, altered house values would presumably 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.

4. REIT prices: Legitimate substitutes for housing prices

Our main objective is to uncover the actual differential impact of mortgage rates on house prices in Canada and the United States. For this purpose, the ideal set of data would consist of (1) residential real estate prices in the two countries, (2) real interest rates and expected inflation rates embedded in mortgage yields, and (3) control variables unrelated to interest rate components. As usual, perfect data are not available. There are no high frequency 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.)

Nevertheless, there are some sensible empirical proxies. U.S. and Canadian TIPs and nominal bonds provide market consensus term structures for real interest rates and expected inflation, and daily values are available. For residential real estate, however, a long series of higher frequency returns is not available. In the following subsections, we provide several lines of justification for our use of REIT returns as a proxy for residential housing returns.

Before providing this justification, however, we should address the broader issue of whether real estate prices in general are representative of the housing market. One of the most venerable propositions in economics developed by Alfred Marshall is that the prices of *substitute goods* are related (Marshall, 1997). For instance, when the price of pears increases, so does the price of apples, even though the underlying cause (e.g., blight on pear trees) has no direct impact on apple trees. 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 relies on a basic underlying idea: that all types of real estate are substitutes. Single family housing is a substitute for apartments; even commercial real estate can be converted to other uses. Thus, any change in the value of one type of real estate should be well correlated with changes in values of other types.

4.1. Evidence for REITs as a proxy for residential real estate

The evidence of the relation between REITs and real estate prices is mixed. The extant literature shows the contemporaneous correlation between REIT and real estate returns is low (Mueller and Mueller, 2003; Brounen and Eichholtz, 2003). Most studies find REIT returns are highly related to stock returns (Goetzmann and Ibbotson, 1990; Ross and Zisler, 1991; Myer and Webb, 1994).

With US, UK, and Australia data, Hoesli and Oikarinen (2012) show that REIT market performance is much more closely related to the direct real estate market in a long run than to the general stock market. They argue the short-run correlation between the REIT and real estate markets is low due to a slow adjustment of real estate market prices to changes in fundamentals. In the long run, both markets should adjust to shocks in fundamentals and both prices should co-move in the long run since the fundamental assets in both markets are the same. Nishigaki (2007) also documents a long-run positive correlation between US REIT returns and house prices. On the other hand, Pavlov and Watcher (2009) find a statistically significant relationship between REIT and real estate returns only in the office sector. They explain that the value of a REIT is highly related to the value of the underlying properties during favorable economic conditions but it is dominated by the quality of management during a bust period. Unlike Hoesli and Oikalinen (2012), they do not look for leads and lags or for a potential long-run relation.

Given this mixed evidence from prior research on the relationship between real estate and REIT prices, we provide two different sets of additional tests examining the relationship between REITS and residential real estate. One set is based on the cointegration of REIT returns with housing price indexes, and the other shows a correlation between internet searches related to housing price changes and REIT returns. We believe this is ample additional evidence to justify our use of REITs as a proxy for residential real estate in our empirical work.

4.1.1. Evidence of cointegration of REIT and residential real estate returns

Alternative monthly indicators for the U.S. residential real estate market include the S&P/Case-Shiller® Home Price Indices[10] (SCS) and indexes from the Federal Housing Finance Agency (FHFA). The S&P/Case-Shiller® indices are three-month moving averages of actual prices of repeat sales of identical properties (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.

The FHFA indexes are based on repeated sales transactions of residential housing financed with mortgages purchased or securitized by Fannie Mae or Freddie Mac. Brunnermeier and Julliard (2008) used the series (an earlier version based on both sales and refinancing transactions and available only quarterly) in their paper on money illusion and house prices, and Cotter, et al (2015) employed it in their paper on geographic diversification changes around the 2008 crisis.

Figure 1 plots the FHFA national index (non-seasonally adjusted), the SCS national index and an equal-weighted index of REIT prices from January 1991 through December 2014. Both the FHFA and SCS indexes are obviously much less volatile and more serially correlated than REIT prices. During the 288 months from February 1991 through December 2014, the monthly log return volatilities of the three indexes (standard deviation in percent per month) are 0.609%, 0.712%, and 5.270% for the FHFA, SCS and EW REIT indexes, respectively. The respective first-order serial correlations in log returns are 0.564, 0.811, and 0.199. So REIT returns have almost nine times the volatility of FHFA returns and more than seven times the volatility of SCS returns but much less

[10] The indices are available from the S&P web site, www.indices.standardandpoors.com.

autocorrelation than do the real estate index returns. The SCS return autocorrelation in excess of the FHFA autocorrelation is most attributable to the index being a moving average.

We mimicked the SCS index construction method for the REIT data in an effort to make a "pseudo-REIT index" that would be more comparable to the SCS index. To accomplish this, we first took the equal-weighted average of U.S. 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 compared this pseudo-REIT index with the SCS® U.S. National Home Price Index monthly over the available sample, May 1991-December 2014.[11] The correlation between the two index levels is 0.867 with a p-value of 0.000, which suggests that they are trending similarly over time despite their wide divergence in volatility. The correlation between their monthly percentage changes (i.e., returns) is 0.137, again with a p-value of 0.000.

We then subjected the pseudo-REIT index and the SCS® National Index to a cointegration test. For both indexes, one cannot reject the hypothesis of a unit root at the 5% level of significance, so cointegration is an acceptable technique. The Dickey-Fuller test for a unit root in the residuals from the cointegrating regression, with a constant but without a trend, just rejects the null hypothesis at the 10% level. This implies that the indexes are cointegrated. Therefore, we can conclude that with a probability of roughly 90%, REIT prices and Case-Shiller residential prices have a stable long-run relationship. This is a sufficient and legitimate reason for using REITs as a proxy for residential real estate.

For the FHFA series, the null hypothesis of a unit root can be rejected at the 5% level. We therefore had no justification to look at its cointegration with the other indexes.

4.1.2. Evidence using Internet searches

[11] The data begin in January 1991, but three months are lost from taking the moving average and one month is lost by the single lag. The final month is lost in computing a monthly return.

Following recent studies that demonstrate how data from search engines provide a simple yet accurate measure of business activity, we find that Google searches related to housing prices are related to short-term REIT index values and returns. This accords with Wu and Brynjolfsson (2013), who show that a housing search engine index predicts future housing market sales and prices and it is consistent with McLaren and Shanbhogue (2011) and Beracha and Wintoki (2012), who document that search data accurately reflects the outlook of the housing market.

Following Chavet, Gabriel, and Lutz (2013) we form an index based on Google search queries related to housing prices. We focus on phrases that contain a housing related keyword along with words implying an increase or decrease in prices. Table 1 shows a list of search terms from those highlighted by Google containing a housing keyword and a direction of price movement. For each query term, Google Trends generates a search query index that is in a range of 0 to 100. The search query index increases when that term becomes more popular compared to other search terms. Each index from Google reaches a maximum value of 100 in the month that the popularity of the associated search term hits its peak. Zero values in the search query index represent months where so few searches occurred that a value for the index cannot be compiled. Google Trends allows only five search terms per time period, and the index of each term is based on the other search terms input during the same time. Therefore, at each time, we look for two terms that indicate two directions of housing price change. For instance, we look for "housing price up" or "housing price down" (or, "home price up" or "home price down", "real estate boom" or "real estate bust," etc.), so the indexes can be comparable. We calculate the housing price up and down indexes (HP Up and HP Down) as the equal-weighted index of queries indicating housing price up and down, respectively.

Figure 2 shows the HP Up and HP Down indexes both in levels and percentage changes. As expected, HP Up is greater during the housing run-up prior to 2006 and during the recovery years following the financial crisis years, and HP Down is greater during the crisis years of 2008 to 2009 (with 2007 and 2010 seemingly being as transition years). There is no obvious difference between HP Up and HP Down since 2010. We correlate these indexes and their returns with value-weighted and equal-weighted REIT indexes. The results, shown in Table 2, show a significantly positive (negative) correlation between HP Up (HP Down) and the REIT index and between the percentage change in HP Up (HP Down) and REIT returns. The result is persistent from 2004 to 2014, which covers both boom and bust periods.

4.2. Conclusion regarding the use of REITs as proxies for residential real estate

Given that we have monthly hosing index returns the question arises: Why not simply run tests using the index rather than a proxy? The problem is that the short-term fluctuations in the FHFA and SCS indexes are very small compared to the larger volatilities of almost all other market-based asset returns. While the long-term trends of these indexes might correspond to true housing values, the recorded monthly variation is so small that it would be able, at best, to be only weakly correlated with changes in the potential explanatory variables such as real interest rates and inflation. There is little variation to explain and, in fact, there is no significant explainable variation over monthly intervals.[12] If residential real estate data were marked to market in real time, it seems likely that the explained variation would be substantially higher.

Cotter and Roll (2015) provide a comprehensive analysis of REIT characteristics and compare them to the SCS indexes of residential real estate. Consistent with what we showed above, Cotter and Roll also find that SCS index returns do not display nearly as much variability as typical financial asset returns. They report further divergences in the real estate indicators where <u>only three</u> principal components explain 90% of REIT return variance whereas five to six components are required o explain 90% of the variance in SCS indexes. They show strong evidence that REITs are

[12] As we have verified in unreported tests.

forward looking and are able to help predict the SCS residential real estate indexes while the converse is not true; i.e., the SCS series cannot predict future REIT values.

A major advantage of using REITs to measure real estate returns is that REITs are marked to market continually because they trade actively. Residential real estate indexes, while reported at a specific point in time, do not represent a market price at that time point (because of, for example, the use of only repeated sales which are infrequent and the lace of a true transaction date). 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; Freddie Mac 2008.) Indeed, it seems likely that REIT prices track the true but unobservable values of residential real estate more closely than any other currently available indicia.

Overall, therefore, we have a very strong case that REIT prices are superior to <u>any</u> other available data on real estate values. REIT prices 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. Substitutability should be very good among all types of real estate. Indeed, this is borne out by the fact that REIT values and residential property values, as measured by the S&P/Case-Shiller indexes, are cointegrated over long periods. Hence, REITs offer the best and perhaps only hope of uncovering significant effects from interest rates over short observation intervals, when market reactions are likely to stand out most prominently. REITs have an additional advantage in our application: they are available in both the U.S. and Canada, unlike the S&P/Case-Shiller indexes or the FHFA indexes.

Given this supporting evidence, we employ observed market returns on real estate investment trusts (REITs) in both the U.S. and Canada to proxy for residential real estate returns. 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.[13]

As we show below, the impact of inflation on residential real estate, working through the tax deductibility of mortgage interest in the US and the non-deductibility in Canada, should be different in the two countries. Because residential and other real estate types are substitutes, inflation should also affect the values of Canadian and U.S. REITs differently, including REITs that own non-residential properties. Whatever the reason that the price of one good is influenced, the prices of substitutes follow. When substitutes are assets, the Marshallian effect is even quicker to operate since asset values anticipate the future. 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.

5. Empirical Procedures and Data

As mentioned earlier, the ideal set of data to investigate the differential impact of mortgage rates on house prices in Canada and the U.S. would consist of residential real estate prices in the two countries, real interest rates and embedded expected inflation rates in mortgage yields, and control variables unrelated to interest rate components. Perfect data are not available. There are no high frequency reliable price series for residential real estate and mortgage yields are nominal.

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 fifteen years. Since inflation-indexed bonds (TIPs) are linked to broad consumer price indexes, their yields are real.[14] Consequently, with enough points along the maturity spectrum for both TIPs and

[13] A better substitute REIT sample might include only REITs investing in multi-family residential properties. Unfortunately, the small sample of available REITs meeting that criterion made that alternative not feasible. There are only seven REITs in the U.S. and two in Canada with a sufficiently long series of usable data.

[14] 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).

nominal bonds, it is possible to derive frequent observations of the term structures of both real interest rates and expected inflation rates.

Many researchers have attempted to estimate the term structures of real yields and expected inflation from nominal yields alone. However, such estimates are plagued by an identification problem that necessitates various simplifying assumptions, which can produce results that seem to conflict with reality. For example, Ang, Bekaert and Wei (2008), estimate a flat term structure of real interest rates; it has "…no significant term spread," (p. 798.) But even casual observation reveals that the term structure of TIPs yields, a direct market-based measure of real yields, is generally upward sloping.

Hence, we use TIPs to obtain market-based consensus term structures for real interest rates and expected inflation. When at least four bonds are available, which is always the case for nominal bonds, a term structure is estimated using the three-factor model of Litterman and Scheinkman (1991) and the procedures in Roll (2004). This delivers estimates of the level, slope, and curvature of the term structures.[15]

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;

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

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.[16] The Legendre transformations are employed because they

[15]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.

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

are approximately orthogonal over the range –1 to +1.[17] 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 plus any risk premium. 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 possibility of risk premia in the difference between nominal and real yields would represent a problematic measurement error in some applications. In our case, however, it is unlikely to be a serious issue because we only use (monthly) changes in nominal less real yields (which, for simplicity, we call changes in expected inflation.) Risk premia seem unlikely to change much over monthly horizons. If they actually exist and change at all over such short periods, they simply inject a small measurement error into the data.

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

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[17] They are exactly orthogonal if continuous from –1 to 1. Curvature is positive if the term structure is concave downward.

in rates rather than levels in the empirical work below. Theoretically, changes in rates are the correct construct to explain real estate returns.

As argued earlier, the REIT prices are superior to any other available data on real estate values. Table 3 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.[18] We exclude any REIT that has less than 20 observations. 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[19] in both countries are used to convert nominal REIT returns and nominal market index returns into real returns.[20] Subsequently, we expand the specification to include the Fama/French (1992, 1993, 2015), Carhart (1997), and Hou, Xue, and Zhang (2015) factors as additional regressors.

6. Basic Empirical Results

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

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

where $R_{j,t}$ is the observed real (i.e., CPI adjusted) excess return[21] 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

[18] The maximum sample covered May 1998 through December 2014 inclusive.

[19] 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.

[20] 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.

[21] Real excess returns are computed as [1+nominal return - (1-month T-Bill rate)]/(1+Inflation rate)-1.

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 4 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.[22] The coefficients of response to changes in real interest rates and to market equity returns are, respectively, significantly negative in both countries, and significantly positive in the US, but insignificantly positive in Canada. For real interest rate changes, 98.55% of the coefficients are negative in Canada and 80.48% are negative in the U.S.; for market equity, the percentages of positive coefficients are 56.52% and 91.59%, respectively

But the slope coefficient for the change in expected inflation is strikingly different in Canada and the U.S. It is negative with a value of -15.25 on average in Canada with a t-statistic of -7.03 while it is positive, 1.46, in the U.S. with a t-statistic of 5.99. In Canada, 81.16% of the coefficients are negative while 76.28% 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.

[22]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, 333 and 69 respectively.

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 an average of about 15 percent in that month whereas U.S. REIT prices in the U.S. would tend to increase by almost 1.5 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.[23]

To further elucidate the empirical results, Figure 3 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.

7. Accounting for 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

[23] 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 30 percent in Canada and over 50 percent in the U.S. But this would be a very large change in real rates for a given calendar month.

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 Greene (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 KXM matrix of the coefficients in a system of M equations, each equation conforming to (9) with the same K explanatory variables, **X,** (TXK), 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

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

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 β_i, averaged over the M equations (equations being indexed by j),

$$\overline{\beta}_i = \frac{1}{M}\sum_{j=1}^{M}\hat{\beta}_{i,j}\ . \tag{11}$$

So the variance of the cross-sectional mean is

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

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

where $\text{diag}_i(.)$ 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

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

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,…M; and (c) obtained $\sigma_{j,k}$ from all concurrent observations between REIT j and REIT k.[24]

The resulting SUR t-statistics that account for cross-equation dependence are reported in the bottom line of Table 4. Those for the U.S. real interest rate and the expected inflation for the both Canada and the U.S. are smaller in absolute magnitude than the t-statistics reported earlier in the table, which are based on an assumption of cross-independence. They are larger for Canadian real interest rate changes and market excess returns for the U.S. Although statistical significance has fallen for some explanatory variables, all coefficients are significant except for real market excess returns in Canada. For the U.S., the significance of changes in expected inflation has decreased, but the t-statistic of 3.80 still indicates a material positive effect.

The results in Table 4 do not show the evident differences between the independent OLS and SUR levels of significance for some mean coefficients from (9). This reveals marginally positive correlation in estimation error across equations. The results do not strongly imply that the OLS residuals are positively correlated across equations. There is a possibility at least one common factor

[24]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.

is omitted; as a result, we later investigate whether an augmented factor model can ameliorate this phenomenon.

8. 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 <u>nominal</u> 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 5 presents the results for (14).

The coefficient for the market equity return, β_M, is virtually unaltered between regression (14), reported in Table 5, and regression (9), reported earlier in Table 4. 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 4. 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 and significant on average in OLS 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 0.39, a small fraction of the size of Canada's coefficient, -17.62. The adjusted R-square values in Tables 4 and 5 have similar magnitudes for both the U.S. and Canada. Notably, the t-statistic of the market equity beta in Table 5 for Canada is more than six times its value in Table 4.

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 was 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 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 constant 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.

8.1. The Fama-French/Carhart Four-Factor Model

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. 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.

For the U.S., the Fama/French and Carhart factors are available on Ken French's website; however, for Canada, these factors are not readily available. Thus, we apply the Fama-French factors to both US and Canada based on the empirical evidence that two economies are highly integrated (Pukthuanthong and Roll, 2009).

As reported in Table 6, the Fama/French and Carhart momentum factors are all statistically significant for the U.S. On average, U.S. REITs are positively sensitive to both the Size and Book/Market factors; even the SUR t-statistics exceed eight and twelve, respectively. The SUR T-Statistic is -7.88 for the momentum factor. This suggests that REITs and high momentum stocks are driven in opposite directions by some underlying latent influence.

None of the SUR t-statistics is smaller (in absolute magnitude) than the corresponding simple t-statistic that assumes cross-equation independence. This is comforting because there seems to be little evidence of an omitted common factor.

The results for Canada (lower panel of Table 6) are comparable to those of the U.S. The real interest rate, size, and momentum coefficients have the same sign, but the statistical significance is generally lower except for expected inflation, which is significantly negative for Canada, but insignificant for the US. The book-to-market factor is significant for Canadian REITs under SUR T-statistics, but insignificant under simple T-statistics.

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 -5.02 in Table 4 to -3.98 in Table 6, and the SUR t-statistic has decreased marginally from -4.47 to -4.64. For Canada, the coefficient has changed slightly from -36.19 to -37.45 between Tables 4 and 6; both are statistically significant.

The big contrast is again in the influence of expected inflation. For the U.S. the mean coefficient of 0.41 is now almost one fourth of its value in Table 4 and is not significant according to either t-statistic. For Canada, however, the mean of -11.84 is roughly the same magnitude as the mean coefficient of real interest rate changes; the corresponding t-statistic is -5.24, which is highly significant.

8.2. The Fama-French Five-Factor Model

Novy-Marx (2013) and Aharoni, Grundy, and Zeng (2013) among others find that stock returns are significantly related to profitability and investment after controlling for the three Fama-French factors. Fama and French (2014) propose the following five-factor model that adds factors to capture these anomalies as well:

$$E(r_t^i) = \beta_{MKT}^i \gamma_{MKT} + \beta_{SMB}^i \gamma_{SMB} + \beta_{HML}^i \gamma_{HML} + \beta_{RMW}^i \gamma_{RMW} + \beta_{CMA}^i \gamma_{CMA} \qquad (15)$$

where β_{MKT}^i, β_{SMB}^i, β_{HML}^i, β_{RMW}^i and β_{CMA}^i are the betas with respect to market, size, book-to-market, profitability, and investment factors, and $\gamma_{MKT}, \gamma_{SMB}, \gamma_{HML}, \gamma_{RMW}$ and γ_{CMA} are the corresponding risk premiums. The RMW factor is the difference between the returns on diversified portfolios of stocks with robust and weak operating profitability and the CMA factor is the difference between the returns on diversified portfolios of the stocks of low and high investment.

We apply the RMW and CMA factors available on Ken French's website and report results in Table 7. For the US, the results from the five-factor Fama-French regression are similar to those from four factors except for the inflation coefficient, which becomes significant at the 1% level for the OLS t-statistic and 5% for the SUR t-statistic. The RMW and CMA factors are not significant. For Canada, all coefficients have a similar magnitude and significance to those in Table 6 except for size, which becomes insignificant and book-to-market, which becomes positive and significant.

8.3. The q-factor Asset Pricing Model

Cochrane (1991) and Liu, Whited and Zhang (2009) present production-based asset pricing models in which productivity shocks are tied to the changes in the investment opportunity set, which is consistent with Merton's (1973) ICAPM framework. Since shocks to productivity are difficult to accurately measure, Hou, Xue, and Zhang (2015) (HXZ) propose an investment factor and a return-on-investment factor to capture productivity shocks. The q-factor model is specified as:

$$E(r_t^i) = \beta_{MKT}^i \gamma_{MKT} + \beta_{ME}^i \gamma_{ME} + \beta_{I/A}^i \gamma_{I/A} + \beta_{ROE}^i \gamma_{ROE} \tag{16}$$

where $\beta_{MKT}^i, \beta_{ME}^i, \beta_{I/A}^i$ and β_{ROE}^i are the betas with respect to market, size, investment and return-on-investment factors, respectively, and $\gamma_{MKT}, \gamma_{ME}, \gamma_{I/A}$ and γ_{ROE} are the corresponding risk premiums.

The investment factor captures the level of investment and the ROE factor captures the return on investment, i.e., profitability. HXZ construct the investment factor as the return difference between firms with low and high levels of investment and the ROE factor as the return difference between firms with high and low return on investment. They control for size when constructing the investment and ROE factors. Intuitively, investments and rates of return on investments are likely to reflect sensitivity to unanticipated productivity shocks, and these factors should capture the price impact of such shocks. HXZ argue that their factors better explain cross-sectional return differences across portfolios constructed based on various firm-level anomalies (such as book-to-market, size, momentum, and earnings surprise) than the Fama-French three-factor model or the Carhart four-factor model.[25]

The HXZ model is appealing since an underlying theory rather than empirical regularities suggests the factors. Also, HXZ's empirical approach employs a variety of different common factors and test portfolios. For instance, their tests of size and book-to-market use the 25 Fama-French size and book-to-market sorted portfolios, the test of momentum uses 10 portfolios formed based on momentum, and the test of Standardized Unexpected Earnings-surprises uses 10 SUE-sorted portfolios. However, all their tests employ portfolios and are subject to potential low dimensionality problems.

Our results from the HXZ model, reported in Table 8, are consistent with those from the five-factor model. The real interest rate is negative and significant for both US and Canada while inflation is positive for the US, but negative significant for Canada (both significant). I/A is positive and significant for the US but negative and significant for Canada. ROE is negative and significant for both US and Canada.

Based on these results, one can conclude with confidence that expected inflation has an impact on real excess returns for Canadian REITs and U.S. REITs. Contrary to popular belief, there is a strong positive effect of increasing interest rates on real estate when the underlying cause is inflation in the U.S. The popular belief is, however, valid in Canada. For both countries, there is a negative impact of increasing interest rates on real estate when the underlying cause is real interest rates.

As an aside, it would be interesting to ascertain whether changes in real interest rates pervasively impact <u>all</u> 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

[25] We thank Lu Zhang for providing the data of these factors.

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 randomly and repeated the calculations in Table 6. Perhaps to no surprise, the real interest rate change had no influence on these non-REIT stocks; the mean coefficient was 0.31 and the SUR t-statistic was 0.563.[26]

Returning to real estate, the results overall 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, are dominated by the first rather than the latter. Admittedly, 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 we control for market, size, book-to-market, and momentum.

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

9. 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 possibly have a positive impact on house prices. Moreover, previous research has found that house prices have boomed in periods of

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[26]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 slightly higher too, 0.30 in contrast to the 0.22 found for REITs.

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 actually positive 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 in the US, inflation increases REIT values significantly. The impact is positively significant in the U.S when we control for market excess returns, the Fama-French five-factor model and the Hou-Xue-Zhang four-factor model, but it is not significantly different from zero when the controls include the Fama-French/Carhart four factor model that is based on size, book-to-market, and momentum. 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

Terms Searched with Google Trends

The terms below are used in with Google Trends to tabulate the number of searches on a monthly basis in the United States from January 2004 to December 2014. ”HP Up” indicates terms that should be associated with positive movements on housing prices while “HP Down” would be related to negative movements.

HP Up	HP Down
Home price up	Home price down
Housing price up	Housing price down
House price up	House price down
Housing market up	Housing market down
Housing boom	Housing bust
Home boom	Home bust
Housing market boom	Housing market bust
Housing market incline	Housing market decline
Real estate market up	Real estate market down
Real estate price up	Real estate price down
Real estate boom	Real estate bust
Real estate bubble	
House price increase	House price decline
Home price increase	Home price decline

Table 2

Correlation between REIT indexes and Google derived housing price indexes

TRET_VW indicates value-weighted REIT returns; TIND_VW indicates value-weighted REIT index; TRET_EW indicates equal-weighted REIT returns; TIND_EW indicates equal-weighted REIT index; HP Up (HP Down) is an equal-weighted average of the number of searches for housing price up (down) keywords presented in the first (second) column of Table 1. %HP Up (%HP Down) is the percentage of change in HP Up (HP Down). The number of searches is on a monthly basis from January 2004 to December 2014 and collected from Google Trends. P-values are reported in parentheses under correlation coefficients.

	TRET_VW	TIND_VW	TRET_EW	TIND_EW
HP Up	0.2425	0.2605	0.2807	0.3367
	(0.0206)	(0.0126)	(0.0070)	(0.0011)
HP Down	-0.1803	-0.1172	-0.2155	-0.1273
	(0.0873)	(0.2685)	(0.0403)	(0.2293)
%HP Up	0.1759	-0.1037	0.1752	-0.1047
	(0.0953)	(0.3279)	(0.0967)	(0.3232)
%HP Down	-0.2384	0.1376	-0.2819	0.1282
	(0.0229)	(0.1933)	(0.0068)	(0.2260)

Table 3

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	69	Datastream	Jan 1997 – Dec 2014	333	UCLA Ziman Center for Real Estate	May 1998- Dec 2014
Nominal Bonds	120[27]	Bank of Canada Web Site	Jan 1997 – Dec 2014	11[28]	U.S. Treasury Web Site	Oct 1996 – Dec 2014
TIPs	7	Bloomberg	Jan 1997 – Dec 2014	55	Bloomberg	Jan 1997 – Dec 2014

Note: All observations are monthly.

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

[28] 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 4

Time Series Regressions of Real REIT Returns on Changes in Real Interest Rates and Expected Inflation Rates and 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 S&P Composite Index for Canada and the CRSP value-weighted index for the U.S. There are 69 Canadian Real Estate Investment Trusts (REITs) and 333 U.S. REITs in the cross-sectional sample. Any REITs that have lower than 20 observations are excluded. Data were monthly and the maximum time series sample period is May 1998 through December 2014 for the US and January 1997 through December 2014 for Canada.

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	-36.19	-5.02	-15.25	1.46	0.06	0.68	0.15	0.14
Median	-28.60	-5.57	-17.80	1.65	0.18	0.55	0.15	0.12
Std. Dev.	76.50	17.95	18.03	4.45	1.98	1.06	0.09	0.15
T-Statistic	-3.93	-5.10	-7.03	5.99	0.25	11.69	13.84	17.36
Skewness	-7.56	5.99	-2.59	1.31	-1.49	0.58	-0.11	0.68
Kurtosis	60.23	59.61	11.00	18.08	18.25	55.31	0.87	0.10
% > 0	1.45%	19.52%	18.84%	76.28%	56.52%	91.59%	92.75%	82.58%
SUR t-Stat.	-4.90	-4.47	-4.21	3.80	0.20	13.01		

Table 5

Time Series Regressions of Real REIT Returns on Changes in Nominal Interest Rates and 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 S&P Composite Index for Canada and the CRSP value-weighted index for the U.S. There are 69 Canadian Real Estate Investment Trusts (REITs) and 333 U.S. REITs in the cross-sectional sample. Any REITs that have lower than 20 observations are excluded. Data were monthly and the maximum time series sample period is May 1998 through December 2014 for the US and January 1997 through December 2014 for Canada.

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	-17.62	0.39	0.38	0.69	0.12	0.12
Median	-19.11	0.35	0.37	0.58	0.13	0.09
Std. Dev.	22.25	3.54	1.39	1.11	0.09	0.14
T-Statistic	-6.58	2.03	2.29	11.30	11.17	15.46
Skewness	-4.18	3.96	2.70	-2.15	-0.41	0.93
Kurtosis	24.56	40.40	22.07	65.30	-0.61	0.43
% > 0	8.70%	61.56%	63.77%	91.29%	88.41%	77.78%
SUR t-Stat.	-4.80	1.25	1.32	12.86		

Table 6

Time Series Regressions of U.S. Real REIT Excess Returns on Changes in Real Interest Rates and Expected Inflation Rates and with Fama/French and Carhart Momentum Factors 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 S&P Composite Index.) There are 333 (69) U.S. (Canadian) Real Estate Investment Trusts (REITs) in the final cross-sectional sample. Any REITs that have lower than 20 observations are excluded. The SMB, HML, and Momentum factors are the Northern America factors available from Ken French's website. Data were monthly and the maximum time series sample period is May 1998 through December 2014 for the US and January 1997 through December 2014 for Canada.

Cross-sectional statistic	β_r, Real interest rate changes	β_I, Expected inflation rate changes	β_M, Market equity real excess returns	β_{SMB}, Small-large size	β_{HML}, High-low book/Market	β_{Mom}, Momentum	Regression adjusted R-square
			U.S. (N=333)				
Mean	-3.98	0.41	0.62	0.56	0.69	-0.28	0.22
Median	-5.20	0.80	0.56	0.49	0.55	-0.16	0.22
Std. Dev.	19.38	5.47	0.86	1.68	1.21	1.25	0.18
T-Statistic	-3.75	1.38	13.21	6.10	10.35	-4.11	22.22
Skewness	6.44	-3.91	-2.68	7.85	1.22	-12.35	0.12
Kurtosis	63.67	44.37	40.98	102.59	17.30	192.31	-0.45
% > 0	23.42%	67.57%	91.29%	81.98%	86.79%	21.02%	88.89%
SUR t-Stat.	-4.64	1.39	14.11	8.51	12.12	-7.88	
			Canada (N=69)				
Mean	-37.45	-11.84	-0.45	0.95	-0.19	-1.37	0.20
Median	-29.94	-11.37	-0.23	0.79	0.02	-0.82	0.24
Std. Dev.	85.35	18.76	2.39	1.58	3.07	5.16	0.12
T-Statistic	-3.65	-5.24	-1.56	5.01	-0.52	-2.21	14.38
Skewness	-6.90	-3.56	-4.54	4.13	1.11	-5.87	0.02
Kurtosis	51.05	17.10	25.24	19.47	22.96	37.44	-0.19
% > 0	5.80%	23.19%	33.33%	85.51%	52.17%	28.99%	88.41%
SUR T-Stat.	-5.12	-3.17	-1.36	1.80	-34.83	-4.73	

Table 7

Time Series Regressions of U.S. Real REIT Excess Returns on Changes in Real Interest Rates and Expected Inflation Rates and with the Fama/French (2015) Five Factors 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 S&P Composite Index.) There are 333 (69) U.S. (Canadian) Real Estate Investment Trusts (REITs) in the final cross-sectional sample. Any REITs that have lower than 20 observations are excluded. The SMB and HML factors are the Northern America factors. The RMW and CMA factors are for the US and are applied to both US and Canadian data. All factors data are available on Ken French's website. Data were monthly and the maximum time series sample period is May 1998 through December 2014 for the US and January 1997 through December 2014 for Canada.

Cross-sectional statistic	β_r, Real interest rate changes	β_I, Expected inflation rate changes	β_M, Market equity real excess returns	β_{SMB}, Small-large size	β_{HML}, High-low book/Market	β_{RMW}, Robust-weak operating profitability	β_{CMA} Low-high investment	Regression adjusted R-square
				U.S. (N=333)				
Mean	-4.11	0.88	0.68	0.45	0.71	0.05	-0.16	0.22
Median	-5.22	0.91	0.60	0.43	0.64	0.02	-0.10	0.21
Std. Dev.	19.56	4.43	1.02	1.37	1.94	1.27	1.79	0.18
T-Statistic	-3.84	3.61	12.14	5.99	6.65	0.68	-1.65	21.57
Skewness	5.70	-0.95	2.18	5.56	2.03	0.32	-3.16	0.08
Kurtosis	51.23	18.41	51.75	63.51	56.58	11.59	36.63	-0.52
% > 0	20.12%	70.57%	91.59%	78.68%	77.78%	52.25%	42.94%	87.69%
SUR t-Stat.	-4.41	2.72	12.45	6.22	7.48	0.45	0.36	-
				Canada (N=69)				
Mean	-35.71	-14.81	-0.22	0.52	0.56	-0.62	-1.02	0.14
Median	-30.34	-17.60	-0.31	0.68	0.84	-0.51	-1.11	0.17
Std. Dev.	79.86	18.99	1.90	3.08	1.99	2.08	2.81	0.11
T-Statistic	-3.71	-6.48	-0.97	1.39	2.33	-2.46	-3.02	11.13
Skewness	-7.90	-2.34	-1.56	-3.71	-0.88	-1.71	-1.05	-0.69
Kurtosis	64.53	9.65	26.07	38.19	10.18	19.65	11.39	0.11
% > 0	4.35%	20.29%	30.43%	88.41%	66.67%	17.39%	30.43%	89.86%
SUR T-Stat.	-4.84	-4.12	-0.61	1.01	1.06	-0.75	-1.16	-

Table 8

Time Series Regressions of U.S. Real REIT Excess Returns on Changes in Real Interest Rates and Expected Inflation Rates and with the Hou, Xue, and Zhang (2015)'s Q Factors 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 S&P Composite Index.) There are 333 (69) U.S. (Canadian) Real Estate Investment Trusts (REITs) in the final cross-sectional sample. Any REITs that have lower than 20 observations are excluded. The SMB and HML factors are Northern American factors available from Ken French's website. Lu Zhang provides the investment and return on investment factors. Data were monthly and the maximum time series sample period is May 1998 through December 2014 for the US and January 1997 through December 2014 for Canada.

Cross-sectional statistic	β_r, Real interest rate changes	β_I, Expected inflation rate changes	β_M, Market equity real excess returns	β_{ME}, Small-big Size	$\beta_{I/A}$, Low-high Investment	β_{ROE}, High-low Return on investment	Regression adjusted R-square
U.S. (N=333)							
Mean	-5.02	1.21	0.57	0.23	0.60	-0.46	0.19
Median	-5.81	1.52	0.56	0.29	0.53	-0.08	0.16
Std. Dev.	17.40	4.43	0.78	0.83	1.95	2.21	0.18
T-Statistic	-5.27	4.98	13.27	5.08	5.58	-3.80	18.82
Skewness	5.76	-1.68	-3.99	-2.16	9.77	-12.85	0.32
Kurtosis	59.81	14.45	49.58	41.12	151.29	202.50	-0.31
% > 0	18.92%	75.38%	90.09%	77.78%	80.78%	40.84%	83.78%
SUR t-Stat.	-5.26	3.71	10.50	3.57	6.00	-5.49	-
Canada (N=69)							
Mean	-36.11	-14.67	-0.46	0.46	-0.77	-1.54	0.19
Median	-31.05	-14.04	-0.49	0.40	-0.67	-1.59	0.23
Std. Dev.	76.33	21.63	1.29	3.52	1.05	3.67	0.12
T-Statistic	-3.93	-5.63	-2.97	1.08	-6.06	-3.48	13.02
Skewness	-7.88	-4.69	1.50	2.51	-1.55	6.42	-0.69
Kurtosis	64.22	28.49	17.01	32.99	5.79	49.91	-0.18
% > 0	0%	10.14%	21.74%	72.46%	20.29%	4.35%	92.75%
SUR T-Stat.	-4.95	-4.06	-1.30	0.96	-1.02	-2.62	-

Figure 1

The Equal-Weighted USA REIT Price Index, the FHFA USA National Real Estate Price Index and the S&P/Case-Shiller® USA (10-city) National Home Price Index, 1991-2014

The nationwide residential real estate price indexes compiled by the Federal Housing Finance Agency (FHFA) and by S&P/Case-Shiller® are plotted monthly along with a price index constructed by equal weighting monthly returns on USA real estate investment trusts.

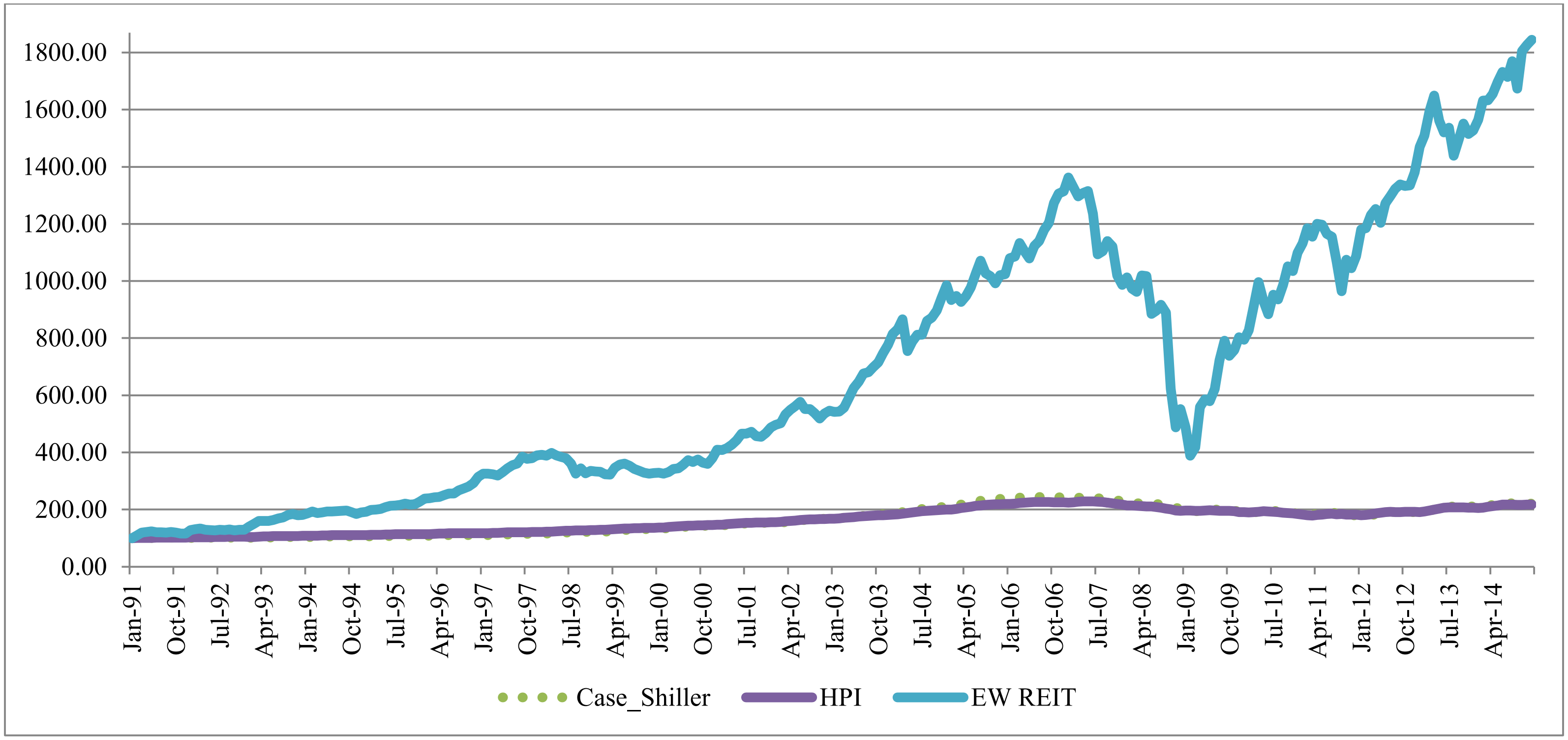
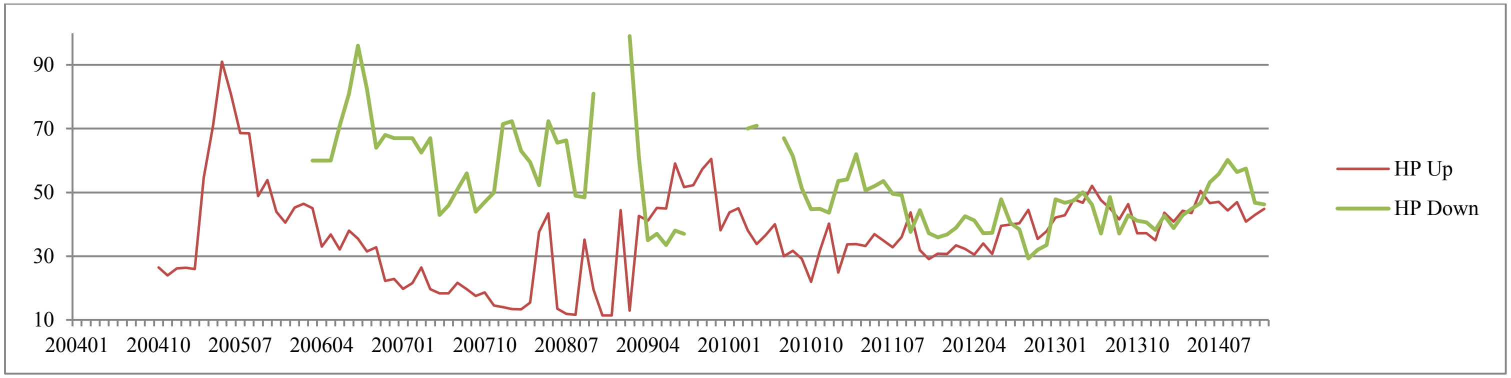


Figure 2

Housing price up (HP Up) and housing price down (HP Down) Google search indexes and their percentage changes

The Google trends derived housing price up (HP Up) and housing price down (HP Down) index levels are plotted in the top panel and their monthly percentage changes are plotted in the bottom panel. HP Up (Down) is an equal-weighted average of the number of searches for the terms shown in the first (second) column of Table 1. The number of searches is collected from the Google Trends on a monthly basis in the United States from January 2004 to December 2014.



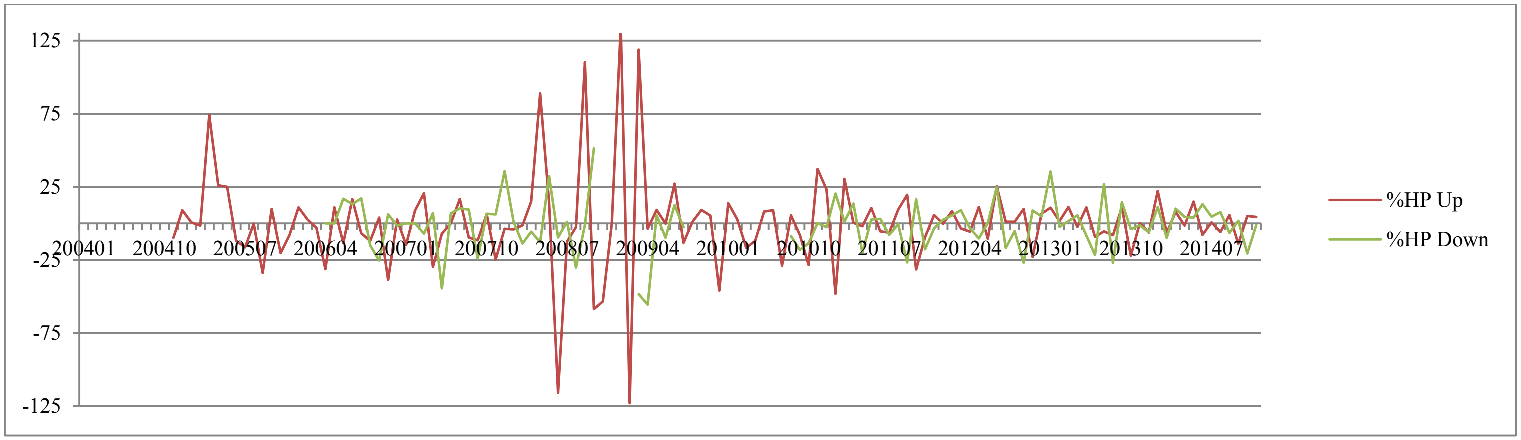


Figure 3

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