

Canadian city housing prices and urban market segmentation

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Abstract. This paper provides a detailed empirical analysis of Canadian city housing prices. We examine the long-run relationship between city house prices in Canada from 1985 to 2005 as well as idiosyncratic relations between city prices and city-specific variables. The results suggest that city house prices are only weakly correlated in the long run and that there is a disconnect between house prices and interest rates. City-specific variables such as union wage levels and the issuance of building permits tend to be positively related to existing city house prices. Surprisingly, there is mixed evidence with respect to standard measures of economic activity such as per capita GDP and interest rates. JEL classification: C22, C32, R2

Prix des maisons dans les villes canadiennes et segmentation du marché urbain. Ce mémoire présente une analyse empirique détaillée des prix des maisons dans les villes canadiennes. On examine cette relation à long terme de 1985 à 2005 ainsi que les rapports idiosyncratiques entre ces prix et certaines variables caractéristiques de certaines villes. Les résultats montrent que les prix des maisons urbaines sont faiblement co-reliées à long terme et qu'il existe une déconnexion entre le prix des maisons et les taux d'intérêt. Certaines variables spécifiques à certaines villes comme les niveaux de salaires des syndiqués ou l'émission de permis de construction tendent à être positivement reliées aux prix des maisons existantes. Surprenamment, les résultats sont mixtes pour ce qui est des mesures d'activité économique comme le PIB per capita ou les taux d'intérêt.

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1. Introduction

Canadian house prices have increased at rapid and sustained rates throughout the past three decades. In this time there has been an increase in home-ownership rates, a larger fraction of household wealth held in the home, and an increase in household debt. Although the rise in Canadian house prices has been modest by international standards, economists in this country have been concerned about the consequences of large run-ups in housing prices followed by sharp declines. Since many more Canadians participate in the housing market than the stock market, the potential impact on household wealth understandably raises concern about its impact on the macroeconomy. Despite this widespread interest, surprisingly little work has been done on Canadian house prices using modern time-series methods. We take up this task by exploring, in a systematic fashion, long-run movements in Canadian house prices over the 1985 to 2005 period.

To preview the major findings of this research, our results indicate that city house prices are only weakly related in the long run. Specifically, we find a lack of cointegration between the average housing prices of seven major Canadian cities and the Canadian aggregate price using the system cointegration approach pioneered by Johansen (1988). This observation motivates an analysis of the impact of city-specific factors on local housing prices via fully modified ordinary least squares (FM-OLS) (Hansen and Phillips 1990). We find that only a few city-specific variables are consistently related to city house prices. These include union wages and the issuance of building permits. Interestingly, we find mixed evidence with respect to per capita GDP and mortgage rates, which, a priori, one would expect to find a positive and negative relationship, respectively. Beyond providing a detailed analysis of the Canadian market for the past two decades, we believe our results also contribute in two related ways to the current macro-housing literature. We identify a possible shortcoming in the use of the aggregate housing price index in monetary models and provide empirical support for recent work on regional macro housing models.

Importantly, we think that the lack of cointegration formally confirms what many academic and professional housing economists have been noting: local idiosyncratic factors dominate aggregate or common nation-wide factors. This suggests that studying the aggregate house price index alone is unlikely to lead to a deeper understanding of the Canadian housing market. It also suggests that in macroeconomic models where housing plays a role in households' savings problem, one may want to focus on city-level heterogeneity in house prices, and its impact on the redistributive effects of fiscal or monetary policy. Finally, the lack of cointegration between the Canadian aggregate house price index and individual city indices may cause some concern for those advocating its use as a monetary policy 'target.'

Canada is a geographically large country with heterogeneous economic, provincial, municipal, and demographic regions. These factors suggest that an

aggregate index may not be representative of any particular housing location, and that treating the Canadian housing sector as a single entity via an aggregate index may leave important individual city components lost or hopelessly confounded.¹ Table 1 shows some casual empirical evidence based on aggregate and city-level house price data to illustrate the issue. Over the period 1986–96, for example, the aggregate real house price index rose by nearly 11%, masking a great deal of regional heterogeneity. The year-over-year percentage increase in aggregate housing was driven primarily by one city (Vancouver), as the other city house prices experienced either real declines or virtually no change. Our more formal statistical methods based on FM-OLS attempt to shed light on the source of regional heterogeneity across Canadian cities.

The lack of cointegration across housing prices suggest that urban markets are indeed segmented in the long run. Although the ability to arbitrage between buying and renting accommodations in a fixed location may be feasible, house prices are much less likely to experience arbitrage across space (location) that is associated with tradable divisible commodities.² This suggests that one should examine housing markets at a municipal level to gain a good understanding of house price movements. The empirical housing literature has studied housing prices in a stationary environment at the city level dating back to Abraham and Hendershott (1996). These authors find that local variables such as construction costs, employment growth, and income growth are significant in predicting house prices across metropolitan housing markets in the United States.³ Using a dynamic factor approach Geweke (1977) and Del Negro and Otrok (2007) find that U.S. house prices have largely been driven by local factors, not national factors over shorter-run horizons. Glaeser and Gyourko (2006) and Nieuwerburgh and Weill (2007) have recently developed general-equilibrium models largely driven by regional wage shocks to help explain the dispersion in house prices across U.S. metropolitan areas. Consideration of local market segmentation can also improve our understanding of the transmission of aggregate shocks, such as an unanticipated change in the interest rate. Fratantoni and Schuh (2003), for instance, construct a VAR model that takes into account regional differences in housing markets, and they find that regional heterogeneity is important when tracing out the effects of a monetary policy shock. For example, the authors find that the response of aggregate income to a monetary shock is significantly less persistent in a VAR that includes regional house prices than in a standard VAR. Focusing on an aggregate house price index may also mask the nature and distribution effects

1 For example, using a VAR approach, Sutton (2002) predicts that aggregate house prices in Canada should have increased substantially over the period 1995–2002, owing principally to strong growth and relatively low mortgage rates. The actual index is rather flat and masks substantial variation at the provincial and municipal levels.

2 See Glaeser and Gyourko (2007) for a discussion of different arbitrage conditions in housing markets.

3 Subsequent U.S. city-level studies include Malpezzi (1999), Meen (2002), Capozza, Hendershott, and Mack (2004), Gallin (2006), among others.

of shocks. Our findings reinforce recent research that concentrates on regional factors.

The paper is organized as follows. In section 2, we discuss some related research and present a systems approach to cointegration following the methodology of Johansen (1988). This leads to a detailed examination of the individual municipalities in section 3. In section 4, we offer some concluding remarks and discuss extensions. Data descriptions are provided in the appendix.

2. A single Canadian housing market?

In this section, we use quarterly resale house-price data provided by Royal LePage (RLP) over the 1985Q4 to 2005Q2 sample period to examine whether city house prices are linked in the long run. The RLP city-housing indices are based on a Royal LePage quarterly survey of Canadian house prices based on seven types of housing in 250 well-defined neighbourhoods across Canada.⁴ Although the RLP data is quality adjusted in the sense that it follows houses of similar quality over time, it is not based on repeat sales that follow the same houses over time. Unfortunately, repeat-sales price indices for housing, such as those produced by Fannie-Mae, Freddie-Mac, or the Office of Federal Housing Enterprise Oversight in the United States, do not exist in Canada. These indices are likely more effective in controlling for variation in housing quality than the RLP index, and it is thus a shortcoming of our data. We do note, however, that both types of indices do not control for time-varying changes in neighbourhood quality, such as gentrification, which we maintain as a caveat to our empirical analysis throughout.⁵

The RLP aggregate price index is defined as a weighted average of house prices in Canada's major cities. For each city the nominal house price is deflated using the corresponding census metropolitan area (CMA) consumer price index less shelter (base 2005).⁶ This allows for differences in regional price fluctuations, which can be important (Davis and Oralo-Magné 2007). Figure 1 presents real house prices for seven Canadian cities: St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. These include the largest urban centres in Canada while geographically spanning the whole of the country. Table 1 presents real house prices and average growth rates for these seven cities and the Canadian aggregate price. From these preliminary statistics and figure 1, it is apparent that

4 Greater detail is provided in the appendix.

5 An alternative housing price measure is the Multiple Listing Service (MLS) series. MLS data is publicly available over a longer time period than RLP and for more cities. The MLS series, however, are not quality adjusted. See Holios and Pesando (1992) for a discussion of the MLS data. For completeness we conduct the same analysis presented in this section with MLS data and present the results in Bank of Canada Working Paper No. 2006-49. The two series are indeed highly correlated; therefore, it is not surprising that we reach similar conclusions.

6 The CMA is a slightly larger area than a city, for example it includes municipalities adjacent to the urban core of the city. However, it is, the closest consumer price data available.

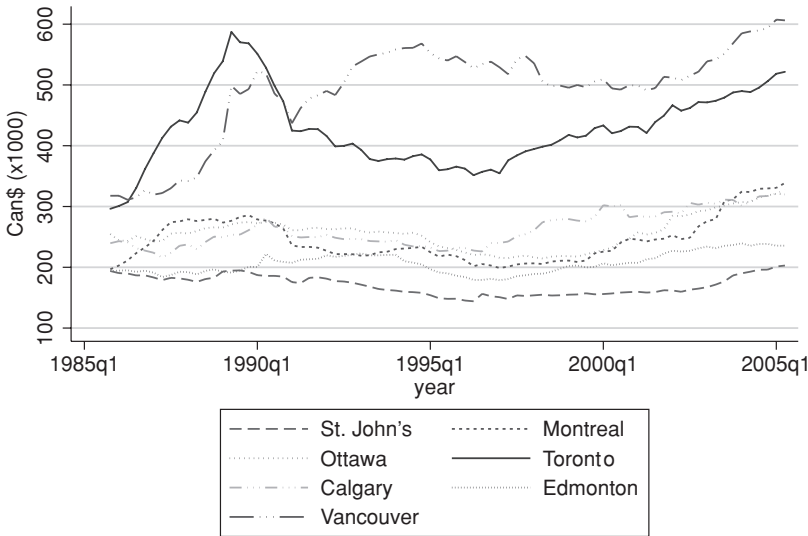


FIGURE 1 Royal LePage House Prices (Real Can\$, SA): 1985Q4–2005Q2
NOTE: Prices have been seasonally adjusted.

TABLE 1
Royal LePage housing prices (real Can\$): 1985–2005

| Year | STJ | | MON | | OTT | | TOR | |
|------|---------|--------|---------|--------|---------|--------|---------|-------|
| | Price | %Δ | Price | %Δ | Price | %Δ | Price | %Δ |
| 1986 | 188,381 | – | 217,579 | – | 246,294 | – | 325,036 | – |
| 1996 | 149,526 | –2.31% | 205,510 | –0.57% | 221,366 | –1.07% | 357,944 | 0.96% |
| 2005 | 202,097 | 3.35% | 334,738 | 5.42% | 320,486 | 4.11% | 520,002 | 4.15% |
| Year | CAL | | EDM | | VAN | | CAN | |
| | Price | %Δ | Price | %Δ | Price | %Δ | Price | %Δ |
| 1986 | 235,713 | – | 194,143 | – | 317,691 | – | 270,914 | – |
| 1996 | 231,302 | –0.19% | 180,880 | –0.71% | 534,526 | 5.20% | 299,875 | 1.02% |
| 2005 | 324,637 | 3.77% | 235,573 | 2.93% | 606,897 | 1.41% | 403,827 | 3.31% |

NOTES: STJ, MON, OTT, TOR, CGY, EDM, VAN, and CAN represent, respectively, St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, Vancouver, and the Canadian aggregate price. %Δ is the average annual growth rate in the nominal house price.

house prices in major Canadian cities have increased substantially over the past twenty years, with some very large increases in Toronto and Vancouver over the past decade, and that there is a great deal of intercity variability in house prices.

We test the time-series properties of real house prices by conducting three standard tests for unit roots: Augmented Dickey and Fuller (1979) (hereafter, ADF), Phillips and Perron (1988) (hereafter, PP), and Elliott, Rothenberg, and Stock

(1996) (hereafter, ERS).⁷ In all instances, we cannot reject the null hypothesis of a unit root at standard levels, suggesting all variables are $I(1)$. This observation motivates the use of cointegration methods for our analysis. More specifically, we apply the system cointegration approach developed in Johansen (1988), and refined in Johansen and Juselius (1990) to determine whether there is any evidence of a long-run relationship between the seven city house prices and the Canadian aggregate house price index (CAN). If city house prices are linked at low frequencies, one would expect to find evidence consistent with seven cointegrating vectors, with a single $I(1)$ variable driving the prices for the country. In the absence of such municipal price cohesion, we might need to study individual house markets, or at least a subset of the cities, to better understand their underlying dynamics.

Before turning to the results, we note that it has been well documented that ADF and Johansen-type tests for cointegration tend to under-reject and over-reject respectively the null hypothesis of no cointegration in favour of its cointegration alternative in finite samples. ADF (including PP) tests tend to fail to reject unit roots when they are false, and hence researchers interpret this as evidence against cointegration. Johansen-type tests tend to exhibit incorrect size, especially when the number of variables is large relative to the number of observations (Gregory 1994). In an effort to control for the latter problem, we use the small-sample correction for the trace statistic developed in Cheung and Lai (1993). Of course in one application, one does not know whether the null is true or not, but we do find confirmation from both the ADF and Johansen tests against cointegration, below. However, Gregory, Haug, and Lumuto (2004) find that this is not always the case in practice.

The results, reported in table 2 suggest the opposite of a highly integrated market, with no cointegrating vector present.⁸ The lack of cointegration in house prices is not particular to the use of the RLP indices as our measure of house prices. In earlier work, we arrive at the same conclusion using MLS quality-unadjusted house price data, which included more cities for a longer time period. The lack of cointegration suggests that the cities' average housing prices are not determined by some underlying, and unifying, national pricing model linking the cities into a single market. This lack of cointegration raises some concern as to exactly what the Canadian aggregate housing index is capturing. Studying aggregate price movements, for example, would not be a shortcut for understanding housing markets for Canada's large urban centres. Thus, the lack of long-run relationships among the city house prices presents a challenge in terms of understanding the Canadian house-price market. In contrast, the strong evidence of long-run relationships between house prices across Australian cities allows Abelson et al. (2005) to use the average Australian house price in their study of the Australian housing market.

7 The results are available on the paper's Web site at www.econ.queensu.ca/pub/faculty/gregory.

8 A constant and trend are included in the empirical model. However, our results are robust to changes in this specification.

TABLE 2
Cointegrating rank determination for RLP house prices

| H_0 | H_1 | Trace | Critical value | λ_{\max} | Critical value | λ |
|------------|------------|--------|----------------|------------------|----------------|-----------|
| $r = 0$ | $r \geq 1$ | 104.74 | 168.36 | 26.91 | 57.69 | – |
| $r \leq 1$ | $r \geq 2$ | 77.82 | 133.57 | 23.54 | 51.57 | 0.456 |
| $r \leq 2$ | $r \geq 3$ | 54.29 | 103.18 | 19.06 | 45.10 | 0.413 |
| $r \leq 3$ | $r \geq 4$ | 35.23 | 76.07 | 13.36 | 38.77 | 0.351 |
| $r \leq 4$ | $r \geq 5$ | 22.02 | 54.46 | 10.42 | 32.24 | 0.259 |
| $r \leq 5$ | $r \geq 6$ | 11.60 | 35.65 | 6.51 | 25.52 | 0.210 |
| $r \leq 6$ | $r \geq 7$ | 5.09 | 20.04 | 4.80 | 18.63 | 0.137 |
| $r \leq 7$ | $r \geq 8$ | 0.29 | 6.65 | 0.29 | 6.65 | 0.103 |
| $r \leq 8$ | $r \geq 9$ | – | – | – | – | 0.006 |

† Significant at the 1% level

Further evidence of this apparent urban market segmentation is presented in tables 3 and 4. The tables present all pairwise cointegration tests between the seven Canadian city house prices and the Canadian aggregate index. ADF test statistics are presented for the case of a constant only and a constant with a time trend, for the residuals from the pairwise regressions of RLP pricing data.⁹ The lack of pairwise cointegration in these tests cannot be accounted for by the presence of structural breaks. We perform Zivot and Andrews (1992) cointegration tests allowing for an unknown break in the mean of each of the pairwise regressions. Results are reported in table 5. The null hypothesis of no cointegration is not rejected except for one out of the 27 pairs at the 1% level. Given that we are performing 27 interdependent residual tests that we are interpreting together, the actual level of the type I error is not at all clear. This suggests, at best, very weak evidence of cointegration.

These results suggest that house prices in Canadian cities are not readily linked. This finding is not that surprising, given that house-price movements mainly reflect a diversified economy where regional growth is due to different sectors and cycles. In this respect, our evidence on city-level house-price movements is similar to the evidence on regional GDP movements documented in Wakerly, Scott, and Nason (2006) and on regional wage and employment fluctuations studied by Coe and Emery (2004). It is useful to note that our analysis is not akin to studying the relationship between an aggregate price index and its subcomponents, such as the price indices for single dwelling houses, condominiums, and so on. Rather, our analysis suggests regional house-price movements behave differently

⁹ These results are indeed robust to the method used. We report additional pairwise findings in the statistical appendix for the ADF and PP tests with and without trend. As well, pairwise findings based on the trace and λ -max tests also point to a lack of cointegration. Please see the paper's Web site for details.

TABLE 3
Pairwise cointegration tests for RLP house prices (constant)

| | MON | OTT | TOR | CAL | EDM | VAN | CAN |
|-----|--------|--------|--------|--------|--------|--------|--------|
| STJ | -2.658 | -2.332 | -1.964 | -1.020 | -1.362 | -0.450 | -2.309 |
| MON | - | -3.380 | -1.825 | -2.306 | -2.770 | -1.640 | -2.086 |
| OTT | - | - | -1.847 | -1.662 | -1.255 | -0.100 | -1.724 |
| TOR | - | - | - | -2.965 | -2.626 | -2.142 | -1.920 |
| CAL | - | - | - | - | -1.142 | -0.766 | -1.536 |
| EDM | - | - | - | - | - | -1.915 | -2.588 |
| VAN | - | - | - | - | - | - | -2.333 |

NOTES: STJ, MON, OTT, TOR, CGY, EDM, and VAN represent, respectively, St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. None of the test-statistics is statistically significant at the 1% level.

TABLE 4
Pairwise cointegration tests for RLP house prices (trend and constant)

| | MON | OTT | TOR | CAL | EDM | VAN | CAN |
|-----|--------|--------|--------|--------|--------|--------|--------|
| STJ | -2.609 | -1.525 | -0.671 | 0.500 | 0.079 | 0.010 | -0.632 |
| MON | - | -3.316 | -1.705 | -1.944 | -2.546 | -1.585 | -1.714 |
| OTT | - | - | -1.853 | -1.495 | -0.931 | -0.017 | -1.674 |
| TOR | - | - | - | -3.723 | -2.580 | -2.106 | -2.659 |
| CAL | - | - | - | - | -1.909 | -1.776 | -4.612 |
| EDM | - | - | - | - | - | -2.045 | -2.897 |
| VAN | - | - | - | - | - | - | -2.271 |

NOTES: STJ, MON, OTT, TOR, CGY, EDM, and VAN represent, respectively, St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. None of the test-statistics is statistically significant at the 1% level.

and thus offers support for recent spatial macroeconomic models of housing. Glaeser and Gyourko (2006) and Nieuwerburgh and Weill (2007), for example, posit that regional factors are drivers of local house prices. Our results also reinforce those in Del Negro and Otrok (2007). Using a dynamic factor model, the authors are unable to find a stable statistical relationship between short-run movements in U.S. state house prices from 1986 to 2005. Thus, our low-frequency analysis (abstracting from differences in countries) is complementary to their high frequency results, as both pieces of research indicate the absence of a statistical relationship between regional house prices at either time horizon. In the next section, therefore, we explore whether studying house price movements at the city level can improve our understanding of long-run house price behaviour in Canada.

TABLE 5
Pairwise unit root tests with unknown break in intercept for RLP house prices

| | MON | OTT | TOR | CAL | EDM | VAN | CAN |
|-----|-------|-------|-------|-------|--------|-------|-------|
| STJ | -4.39 | -2.96 | -2.53 | -1.21 | -1.41 | -1.39 | -2.45 |
| MON | - | -3.95 | -2.67 | -3.37 | -4.13 | -2.76 | -2.42 |
| OTT | - | - | -3.43 | -4.08 | -2.77 | -2.83 | -3.43 |
| TOR | - | - | - | -5.40 | -6.78* | -4.94 | -5.21 |
| CAL | - | - | - | - | -1.91 | -1.78 | -5.19 |
| EDM | - | - | - | - | - | -3.62 | -3.69 |
| VAN | - | - | - | - | - | - | -4.56 |

NOTES: STJ, MON, OTT, TOR, CGY, EDM, and VAN represent, respectively, St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. * denotest statistical significance at the 1% level. The break date for the Toronto-Edmonton pair is 1990Q2.

3. City-level housing-price determinants

The lack of long-run relationships for cross-city house prices prompts us to seek city-specific house-price determinants using single-equation methods in an effort to better understand Canadian house-price fluctuations.¹⁰ This is consistent with the theoretical modelling approach, for example, of Glaeser and Gyourko (2006), who argue that less than 8% of the variation in price levels and only about 25% of the variation of price changes can be accounted for by national year-specific fixed effects. Housing is therefore local in nature. Our empirical approach is to first use the Engle and Granger framework to test for the presence of cointegration between city house prices and a vector of other potentially relevant variables. Once we find evidence consistent with cointegration, we estimate elasticities via FM-OLS (Hansen and Phillips 1990) for valid inference.

As noted by Capozza, Hendershott, and Mack (2004), the recent literature on city-level housing prices has been largely based on an empirical methodology developed by Abraham and Hendershott (1996). This approach involves two steps: (i) estimate what is presumed to be a long-run cointegrating vector that relates cities' housing prices to local economic fundamentals and (ii) use the fitted values to assess how observed prices move in relation to the predicted long-run levels. The latter step allows one to investigate deviations from long-run house-price trends. Despite the popularity of this approach among housing economists, we do not pursue such an analysis for Canadian cities for two reasons. First, we note that the first step in the Abraham and Hendershott (1996) approach involves estimating a reduced form that is derived from the long-run equilibrium of the Capozza and Helsley (1989, 1990) open urban city model. The model predicts that housing prices across cities are linked in the long run as costless migration of

10 Since there is a natural normalization for the dependent variable (city housing prices), we use a single-equation approach for this part of our study.

households is assumed. Our cointegration results, however, suggest this is not the case for Canada. That is, housing prices across Canadian cities do not admit a fundamental long-run equilibrium relationship. Thus, the data do not support the model presented in Capozza and Helsley (1989, 1990) or the estimation method of Abraham and Hendershott (1996).

Second, empirical findings by Gallin (2006) has cast doubt on whether these recent studies obtain cointegration between cities housing prices and local fundamentals, through both time-series and panel-data methods. Gallin (2006) assesses cointegration between housing prices and income with $T = 27$ years of data on $N = 96$ metro areas in the United States. Given the rather large cross-section, their panel application makes sense. Unfortunately, since our panel includes only seven cities, we cannot confidently employ panel unit root tests in our city-level analysis below. At present, the understanding of these methods for studying macroeconomic data where there is a small dimension of N relative to T is a problem the theoretical literature is still investigating. As such, this research should be revisited as progress is made in refining such methods.

We begin our analysis by examining the time-series properties of the available and relevant data. Finding high-quality, comparable Canadian data at the municipal level is problematic.¹¹ Bearing this limitation in mind, we opt to use a city-specific union-wage index (UWI), the value of building permits (BP), the municipal labour force (LF), and net migration (MIG) as possible explanatory variables. These variables are readily available and consistently defined across the seven Canadian cities. Also included are the cost of financing, proxied by the five-year mortgage rate (R_t), and a measure of economic activity, per capita provincial gross domestic product, which we denote GDP. England and Ioannides (1997) study house-price movements in OECD countries and conclude that GDP growth is an important explanatory variable of aggregate house prices. Tsatsaronis and Zhu (2004) examine potential long- and short-term determinants of house prices in developed countries, including Canada, and conclude that inflation and interest rates are key determinants in explaining changes in aggregate house prices, although there are some differences across countries. Note that we have already controlled for regional inflation by studying real house prices. The UWI is an index of wages set in 16 trades engaged in construction in 20 metropolitan areas. The value of building permits issued, BP, is collected monthly by Statistics Canada and is used as a leading indicator of building activity. The building permit measure is the only one that displays strong seasonality, and thus we seasonally adjust it using dummy variables in a simple application of the Frisch-Waugh-Lovell theorem (Lovell 1963). City-level migration is derived by Statistics Canada using addresses stated on individual tax returns for consecutive years.

The primary objective of this set-up is to determine whether there is any role played by a common mortgage rate, once we control for local conditions through

11 Lampert and Pomeroy (1998) present an overview of Canada's housing system and its economic components and provide an excellent reference for Canadian real-estate-related data sources.

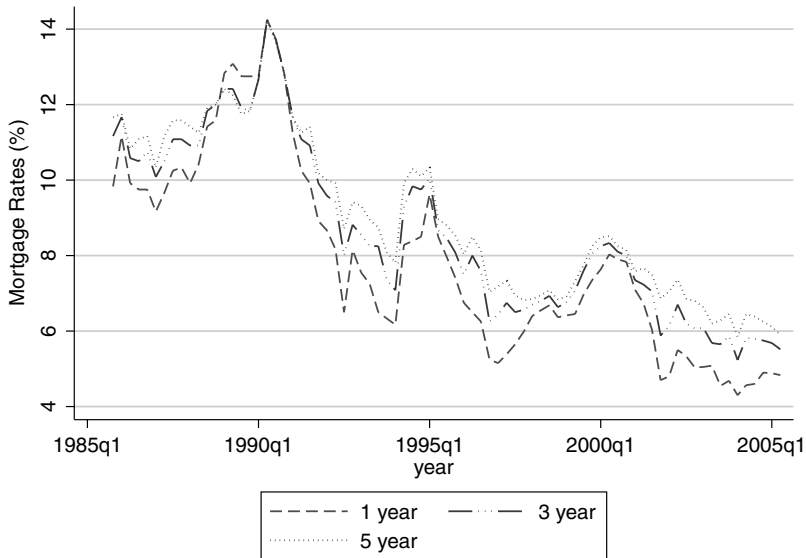


FIGURE 2 Mortgage rates: 1985Q4–2005Q2

these city-specific variables. We use the five-year mortgage rate as our proxy for the cost of home financing, since it is highly correlated with other maturities and over 50% of Canadian households use this term. The one-, three-, and five-year interest rates are plotted in figure 2. All three follow the same downward path throughout the sample. All data, except the interest rate, are in log form, so that the estimates on each of the independent variables can be interpreted as elasticities. As in section 2, we test the time-series properties of the data and cannot reject the hypothesis that they are non-stationary.¹²

Each of the variables in the regression analysis seem, a priori, economically reasonable as a reduced-form specification for explaining existing-house price movements in the seven Canadian cities we examine. We include the UWI to capture the labour costs of building a new house or improving an existing one. An increase in union wages, which includes wages to construction workers, should lead to a rise in the price of existing homes through either an increase in the price of new houses built or, more directly, via the cost of home improvements of existing houses, or both. We include building permits to capture costs associated with construction. Poterba and Engelhardt (1991) also consider construction costs when examining the determination of house prices in an efficient asset market. Arguments in the popular press have at least informally suggested that labour entry/exit has an impact on house prices. An increase in a city's labour force puts added pressure on demand for housing and therefore leads to house-price

12 The results are available on the paper's Web site.

TABLE 6
 RLP model: Residual stationarity tests

| Variable | ADF | <i>p</i> -value | PP | <i>p</i> -value |
|----------|-------|-----------------|-------|-----------------|
| STJ | -3.39 | 0.011 | -4.52 | 0.002 |
| MON | -3.15 | 0.023 | -3.74 | 0.004 |
| OTT | -3.66 | 0.005 | -4.23 | 0.001 |
| TOR | -3.95 | 0.002 | -3.44 | 0.010 |
| CAL | -2.87 | 0.050 | -3.39 | 0.011 |
| EDM | -4.10 | 0.001 | -5.25 | 0.000 |
| VAN | -4.81 | 0.000 | -5.00 | 0.000 |

NOTES: STJ, MON, OTT, TOR, CGY, EDM, and VAN represent, respectively, St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. ADF and PP test-statistics and the *p*-values are provided.

increases. The same can also be said for immigration. The price increases may be somewhat mitigated by the fact that an increased labour force tends to bid down wages and thereby puts downward pressure on house prices. However, to the extent that the union wages are sticky downward, this offsetting effect should be small. Case and Shiller (1989, 1990) find that changes in local demographics can significantly explain house prices. As mentioned, we include both the five-year mortgage rate to capture the interest cost of owning a home with a mortgage and a per capita provincial GDP measure to proxy economic activity. We would prefer a measure of per capita municipal GDP, but such a variable does not exist for the span of data in this paper.

To determine whether the variables under consideration are cointegrated, we obtain the residuals from the following linear regression (for each city *i*),

$$RLP_t^i = \beta_0^i + \beta_1^i UWI_t^i + \beta_2^i BP_t^i + \beta_3^i LF_t^i + \beta_4^i MIG_t^i + \beta_5^i GDP_t^i + \beta_6^i R_t^i + u_t^i, \quad (1)$$

and test whether the estimated residuals, \hat{u}_t^i , are I(0) or, in other words, whether there is cointegration between the variables in equation (1). The cointegration test results are presented in table 6 and indicate the presence of cointegration for all individual city house prices except Calgary, where there is only weak evidence of cointegration. On the basis of this, we use the FM-OLS estimator to estimate the long-run correlation of each regressor with each city house price with potentially the exception of Calgary. FM-OLS also permits us to conduct valid inference within a cointegrating framework, even in the presence of endogeneity and non-spherical residuals.

The estimation results are presented in table 7. The results are somewhat mixed, but there are consistent correlations across the cities. With the exception of Ottawa, the UWI also has a statistically significant positive effect on housing prices, with an elasticity ranging from 1.1 in Edmonton to 3.5 in Toronto. Building

TABLE 7
City-specific estimates via FM-OLS

| City | Regressors | | | | | | Test statistics | | |
|------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|-----------------|--------------|-------------|
| | UWI | BP | LF | MIG | GDP | R | L_c | <i>MeanF</i> | <i>SupF</i> |
| STJ | 0.123 (0.408) | 0.054 (0.036) | -1.262* (0.455) | 0.509* (0.107) | 0.623* (0.129) | -0.017 (0.010) | 1.13 | 13.76 | 25.87 |
| MON | 1.150* (0.543) | 0.118* (0.052) | 2.548* (0.947) | -0.323* (0.184) | 1.538* (0.782) | 0.005 (0.017) | 0.83 | 34.57 | 123.33 |
| OTT | -1.165* (0.556) | 0.076* (0.035) | 2.948* (0.423) | -0.075 (0.084) | -1.502* (0.552) | 0.017 (0.014) | 0.80 | 14.31 | 33.83 |
| TOR | 3.455* (0.641) | -0.077 (0.064) | 3.026* (0.573) | -0.274* (0.127) | 3.774* (0.974) | -0.044* (0.022) | 1.13 | 25.83 | 122.72 |
| CAL | -0.009 (0.402) | 0.006 (0.024) | 1.152* (0.276) | -0.026 (0.081) | -0.324 (0.443) | 0.033* (0.008) | 6.51 | 89.46 | 135.71 |
| EDM | 1.105* (0.182) | 0.104* (0.015) | 0.662* (0.259) | -0.059 (0.038) | -0.559* (0.184) | 0.017* (0.004) | 0.52 | 12.93 | 98.54 |
| VAN | 2.360* (0.284) | 0.216* (0.030) | -0.634 (0.500) | 0.021 (0.114) | 1.180* (0.548) | 0.037* (0.010) | 0.75 | 162.4 | 1259.2 |

NOTES: STJ, MON, OTT, TOR, CGY, EDM, and VAN represent, respectively, St. John's, Montreal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. Standard errors are in parentheses. * is significant at the 5% level. Asymptotic and finite-sample critical values for the break tests were estimated via simulation. The 1% asymptotic and finite-sample critical values for the L_c test are 2.933 and 3.908, respectively. Similarly, the 1% asymptotic and finite-sample critical values for the *SupF* test are 29.33 and 58.36, respectively. Lastly, the 1% asymptotic and finite sample critical values for the *MeanF* test are 16.64 and 28.082, respectively.

permits also appear to be positively related to house prices, but their influence is markedly modest relative to union wages. In Vancouver, for instance, a 1% increase in the value of home-building permits is estimated to increase house prices by only 0.22%, whereas a 1% increase in union wages is associated with a rise in existing-house prices of 2.36%.

The remaining candidate variables offer less consistency across the cities. We interpret the labour force and migration coefficients together, although the results appear conflicting. The variables are highly correlated, with increases in a cities labour force coming not only internally but externally, from individuals moving cities for employment opportunities. Except for St. John's, the coefficients on labour force are positive, suggesting entry puts upward pressure on house prices. The coefficients on migration are negative, which seems counter-intuitive. Labour force data are collected monthly and migration data annually; therefore it is the variation in the labour force that better explains house prices. Migration may be capturing the remaining effect, which happens to be negative for two cities and statistically insignificant for four cities. The effect of per capita GDP appears to be substantially different across cities. Point estimates range from -1.5 to 3.8. The correlation with house prices is positive in St. John's, Montreal, Toronto, and Vancouver, but negative in Ottawa, Edmonton, and Calgary (although it is not statistically significant for Calgary).

Finally, the five-year interest rate is statistically insignificant in only four cities, and for three of them, it is positive (Calgary, Edmonton, and Vancouver). The coefficient on the interest rate is negative and significant only in Toronto. The results associated with the interest rate are similar to those of other researchers who find it difficult to link mortgage interest rates to the housing market in linear models (Muelbauer and Murphy 1997). At this stage, the question remains as to how mortgage rates and housing prices are related in Canada. One possibility for future research would be to examine non-linear relationships between housing prices and interest rates.

As a final experiment, we test the stability of our city-level cointegration relationships using a series of tests proposed by Hansen (1992): The *Lc*, *MeanF*, and *SupF* tests. All three tests are developed under the assumption of cointegration, and they have the same null hypothesis of parameter stability but differ in their implicit alternative hypotheses. Specifically, the *SupF* test is useful in testing whether there is a sharp shift in a regime, while the *Lc* and *MeanF* tests are useful for determining whether the specified model captures a stable relationship. The results, reported on the right-hand side of table 7, again are mixed. As pointed out by Hansen (1992), the tests can be conflicting because they have power against different alternative hypotheses. The three tests suggest that the parameter estimates corresponding to St. John's and Ottawa are stable over the sample period, whereas the *SupF* and *MeanF* tests find evidence of unstable relationships for Montreal, Calgary, and Vancouver. Overall, these results suggest that we should interpret our results with some caution, since they may be unstable. Indeed, one might have been surprised if the long-run relationships had been constant, given the time period of estimation. We note that Hansen (1992) argues that the *Lc* test results may be viewed as a test for cointegration, against the alternative of no cointegration. Thus, our *Lc* test results corroborate the previous conclusion of cointegration among the variables under study. In particular, the finding of cointegration between Calgary real house prices and our set of explanatory variables is relatively weak, most likely due to one or more structural breaks.

4. Conclusion

In this paper, we have presented a detailed empirical investigation of Canadian house prices. We study long-run relationships between city house prices in Canada over the 1985 to 2005 sample period. We also examine idiosyncratic relations between city prices and city-specific variables. The results indicate that city house prices are only weakly related in the long run, and that there are only a few city-specific variables that are consistently related to city house prices. These include union wages and issuance of building permits.

Our conclusions, resulting from the lack of cointegration among city house prices, are similar, at least in spirit, to those reported in Coe and Emery (2004), Wakerly, Scott, and Nason (2006), and Del Negro and Otrok (2006). In particular,

Coe and Emery (2004) find that the Canadian labour market is relatively local in nature over the period 1971 to 2000. Wakerly, Scott, and Nason (2006) find that Canadian regional output fluctuations are driven by an economically important set of disaggregated propagation and growth mechanisms, and that studying regional output movements may improve our understanding of Canadian business cycles. Del Negro and Otrok (2007) find U.S. local-level house prices to be determined primarily by local factors and the influence of monetary policy to be only marginal. In a similar vein, our work suggests that studying aggregate housing-price indexes alone is unlikely to lead to a deeper understanding of the Canadian housing market. We think a better course for future research is to take into account local factors such as land availability, expected future economic activity, and institutions. Such analysis is likely to produce housing models based on city fundamentals that can be applied across a variety of urban centres.

Appendix: Data descriptions

RLP house-price data are provided by Royal LePage. In addition, Statistics Canada has provided an extensive list of data. Statistics Canada also produces a publication entitled *Useful Information for Construction* (2002), which provides catalogue numbers for key statistics collected by the agency that provide a detailed overview of the construction industry. Data are summarized below.

City house prices in 2005 dollars (source: Royal LePage)

- The quality-adjusted house price index is constructed by Royal LePage from their quarterly survey of Canadian house prices based on seven types of housing in 250 well-defined neighbourhoods across Canada. More specifically, the survey includes four types of detached homes (bungalow, executive two-storey, standard two-storey, and senior executive), standard and luxury condominiums, and townhouses. Each house type and its amenities are specifically described, permitting comparisons of value across time and regions. Important factors that influence real estate values include the property's average commuting distance to the city centre, regional variances such as property taxes, number of bedrooms and bathrooms, the square metres of interior and exterior living space, the presence or absence of a garage, and the construction style of the property. In the case of condominiums, parking and common area facilities such as pools and sauna are also included.
- Deflated using city-specific CPI less shelter.

Building permits (source: Statistics Canada)

- CANSIM Tables 026-0001 to 026-0008, and 026-0010 to 026-0012
- Monthly observations
- Issuance of building permits by municipality

Union-wage index (source: Statistics Canada)

- CANSIM Table 327-0003
- Monthly observations
- Union wages (hourly compensation) for the construction industry
- Survey of 20 metropolitan areas

Immigration/emigration (source: Statistics Canada)

- Product 91C0025
- Annual observations reported in April
- Derived using addresses stated on individual tax returns for consecutive years.

Labour force (source: Statistics Canada)

- CANSIM Tables 282-0001 to 282-0094
- Labour Force Survey/Employment data
- Monthly observations

Interest rates (source: Bank of Canada)

- One-, three-, and five-year average mortgage rates
- Monthly observations

Per capita gross domestic product (source: Canadian Conference Board)

- Gross domestic product and population data
- Quarterly observations

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