Canadian City Housing Prices and Urban Market Segmentation*

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September 12, 2008

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: C22, C32, R2
Keywords: Housing prices, Cointegration.

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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 macro-economy. 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 macro-economic 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 redistributional 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 1986-1996, for example, the aggregate real house price index rose by nearly 11 per cent, masking a great deal of regional heterogeneity. The year-over-year per cent 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) which 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)), Del Negro and Otrok (2006) find that U.S. house prices have largely been driven by local factors and 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 which includes regional house prices than in a standard VAR. Focusing on an aggregate house price index may also mask the nature and distribution effects of shocks. Our findings reinforce recent research that concentrates on regional factors.

[1]For example, using a VAR approach, Sutton (2002) predicts that aggregate house prices in Canada should have increased substantially over the period 1995 to 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 et al. (2004), Gallin (2006) among others.

The paper is organized as follows. In sections 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 neighborhoods 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 likely are 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 neighborhood 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 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, Montréal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. These include the largest urban centers 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 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.

[4]Greater detail is provided in the appendix.

[5]An alternative housing price measure is the Multiple Listing Service (MLS) series. MLS data is public availability 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 than a city, for example it includes municipalities adjacent to the urban core of the city. It is, however, the closest consumer price data available.

Table 1
Royal Lepage Housing Prices (Real Can$): 1985-2005

	STJ		MON		OTT		TOR	
Year	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%

	CAL		EDM		VAN		CAN	
Year	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%

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

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 et al. (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) 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 this latter problem, we use the small-sample correction for the trace statistic developed in Cheung and Lai

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

(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 et al. (2004) find that this is not always the case in practice.

The results, reported in Table 2 of the appendix, 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-adjusted 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 centers. 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.

Further evidence of this apparent urban market segmentation is presented in Tables 3 and 4 in the appendix. 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 per cent 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 et al. (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 prices indices for single dwelling houses, condominiums, etc. Rather,

[8]A constant and trend are included in the empirical model. Our results are robust, however, to changes in this specification.

[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 website for details.

our analysis suggests regional house price movements behave differently, 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 reinforces those in Del Negro and Otrok (2006). 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.

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 modeling approach, for example, of Glaeser and Gyourko (2006). Glaeser and Gyourko (2006) argue that less than 8 per cent of the variation in price levels and only about 25 per cent 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 et al. (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 no 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 households is assumed. Our cointegration results, however, suggest this is not the case for

[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.

Canada. That is, housing prices across Canadian cities do not admit a fundamental long-run equilibrium relationship. Thus, the data does not support the model presented in Capozza and Helsley (1989, 1990) nor 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 7 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 important explanatory variable of aggregate house prices. Tsatsaronis and Zhu (2002) 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 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

[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.

other maturities and over 50 per cent 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 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) and Case and Shiller (1990) find that changes in local demographics can significantly explain house prices. As mentioned, we include 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):

$$RLP_t^i = \beta_0^i + \beta_1^i UWI_t^i + \beta_2^i BP_t^i + \beta_3^i LF_t^i + \beta_4^i MIG_t + \beta_5^i GDP_t^i + \beta_6^i R_t + u_t^i, \tag{1}$$

and test whether the estimated residuals, $\hat{u}_i$, 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 in the appendix 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.

[12]The results are available on the paper's website.

The estimation results are presented in Table 7 of the appendix. 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 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 one per cent increase in the value of home-building permits is estimated to increase house prices by only 0.22 per cent, whereas a one per cent increase in union wages is associated with a rise in existing-house prices of 2.36 per cent.

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 not only coming 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 is 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, Montréal, Toronto and Vancouver, but negative in Ottawa, Edmonton, and Calgary (although 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 is 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, are again 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 Montréal, 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 et al. (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 et al. (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 (2006) 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 centers.

References

Abelson, P., R. Joyeux, G. Milunovich, and D. Chung. 2005. "Explaining House Prices in Australia: 1970 to 2003." *Economic Record* 81: 96–103.

Abraham, J. and P. Hendershott. 1996. "Bubbles in Metropolitan Housing Markets." *Journal of Housing Research* 7: 191–207.

Capozza, D. and R. Helsley. 1989. "The Fundamental of Land Price and Urban Growth." *Journal of Urban Economics* 26: 295–306.

———. 1990. "The Stochastic City." *Journal of Urban Economics* 28: 187–203.

Capozza, D., P. Hendershott, and C. Mack. 2004. "An Anatomy of Price Dynamics in Illiquid Markets: Analysis and Evidence from Local Housing Markets." *Real Estate Economics* 32: 1–32.

Case, K. and R. Shiller. 1989. "The Efficiency of the Market for Single Family Homes." *American Economic Review* 79: 125–37.

———. 1990. "Forecasting Prices and Excess Returns in the Housing Market." *AREUEA Journal* 18: 253–73.

Cheung, Y. and K. Lai. 1993. "Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration." *Oxford Bulletin of Economics and Statistics* 55: 313–29.

Coe, P.J. and J. Emery. 2004. "The Disintegrating Canadian Labour Market? The Extent of the Market Then and Now." *Canadian Journal of Economics* 37: 879–897.

Davis, M. and F. Oralo-Magné. 2007. "Household Expenditures, Wages, Rents." Working paper.

Del Negro, M. and C. Otrok. 2006. "99 Luftballons: Monetary Policy and the House Price Boom Across U.S. States." Forthcoming *Journal of Monetary Economics*.

Dickey, D. and W. Fuller. 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association* 74: 427–31.

Elliott, G., T. Rothenberg, and J. Stock. 1996. "Efficient Tests for an Autoregressive Unit Root." *Econometrica* 64: 813–836.

England, P. and Y. Ioannides. 1997. "House Price Dynamics: An International Empirical Perspective." *Journal of Housing Research* 6: 119–36.

Fratantoni, M. and S. Schuh. 2003. "Monetary Policy, Housing, and Heterogeneous Regional Markets." *Journal of Money, Credit, and Banking* 35: 557–89.

Gallin, J. 2006. "The Long-Run Relationship Between House Prices and Income: Evidence from Local Housing Markets." *Real Estate Economics* 34: 417–438.

Geweke, J. 1977. *The Dynamic Factor Analyis of Economic Time Series*, in D. Aigner and A. Goldberger eds., Latent Variables in Socioeconomic Models, 365–83.

Glaeser, E. and J. Gyourko. 2006. "Housing Dynamics." NBER working paper 12787.

———. 2007. "Arbitrage in Housing Markets." Mimeo.

Gregory, A. 1994. "Testing for Cointegration in Linear Quadratic Models." *Journal of Business and Economic Statistics* 12: 347–60.

Gregory, A., A. Haug, and N. Lumuto. 2004. "Mixed Signals Among Tests for Cointegraon." *Journal of Applied Econometrics* 31: 80–98E.

Hansen, B. 1992. "Testing for Parameter Instability in Linear Models." *Journal of Policy Modeling* 14: 517–33.

Hansen, B. and P.C.B. Phillips. 1990. "Statistical Inference in Instrumental Variables Regression with I(1) Processes." *Review of Economic Studies* 99–125.

Holios, A. and J. Pesando. 1992. "Monitoring Price Behaviour in the Resale Housing Market: A Note on Measurement and Implications for Policy." *Canadian Public Policy* XVIII: 57–61.

Johansen, S. 1988. "Statistical Analysis of Cointegrating Vectors." *Journal of Econometric Dynamics and Control* 12: 231–54.

Johansen, S. and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money." *Oxford Bulletin of Economics and Statistics* 52: 169–210.

Lampert, G. and S. Pomeroy. 1998. "Canada's Housing System: The Public Policy Environment for Housing in Canada." Manuscript.

Lovell, M. 1963. "Seasonal Adjustment of Economic Time Series." *Journal of the American Statistical Association* 58: 993–1010.

Malpezzi, S. 1999. "A Simple Error Correction Models of Housing Prices." *Journal of Housing Economics* 8: 27–62.

Meen, G. 2002. "The Time-Series Behaviour of House Prices: A Transatlantic Divide?" *Journal of Housing Economics* 11: 1–23.

Muelbauer, J. and A. Murphy. 1997. “Booms and Busts in the UK Housing Market.” *Economic Journal* 107: 1701–27.

Nieuwerburgh, S. and P.O. Weill. 2007. “Why Has House Price Dispersion Gone Up?” Working paper.

Phillips, P. and P. Perron. 1988. “Testing for a Unit Root in Time Series Regression.” *Biometrika* 75: 335–46.

Poterba, J. and G. Engelhardt. 1991. “Demographics and House Prices: The Canadian Evidence.” *Regional Science and Urban Economics* 21: 539–46.

Sutton, G. 2002. “Explaining Changes in House Prices.” *BIS Quarterly Review* (September): 45-55.

Tsatsaronis, K. and H. Zhu. 2002. “What Drives Housing Price Dynamics: Cross-Country Evidence.” *BIS Quarterly Review*.

Wakerly, E., B. Scott, and J. Nason. 2006. “Common Trends and Common Cycles in Canada: Who Knew So Much Has Been Going On?” *Canadian Journal of Economics* 39: 320–47.

Zivot, E. and D. Andrews. 1992. “Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis.” *Journal of Business & Economic Statistics* 10: 251–270.

Appendix

Figure 1. Royal Lepage House Prices (Real Can$, SA): 1985Q4-2005Q2

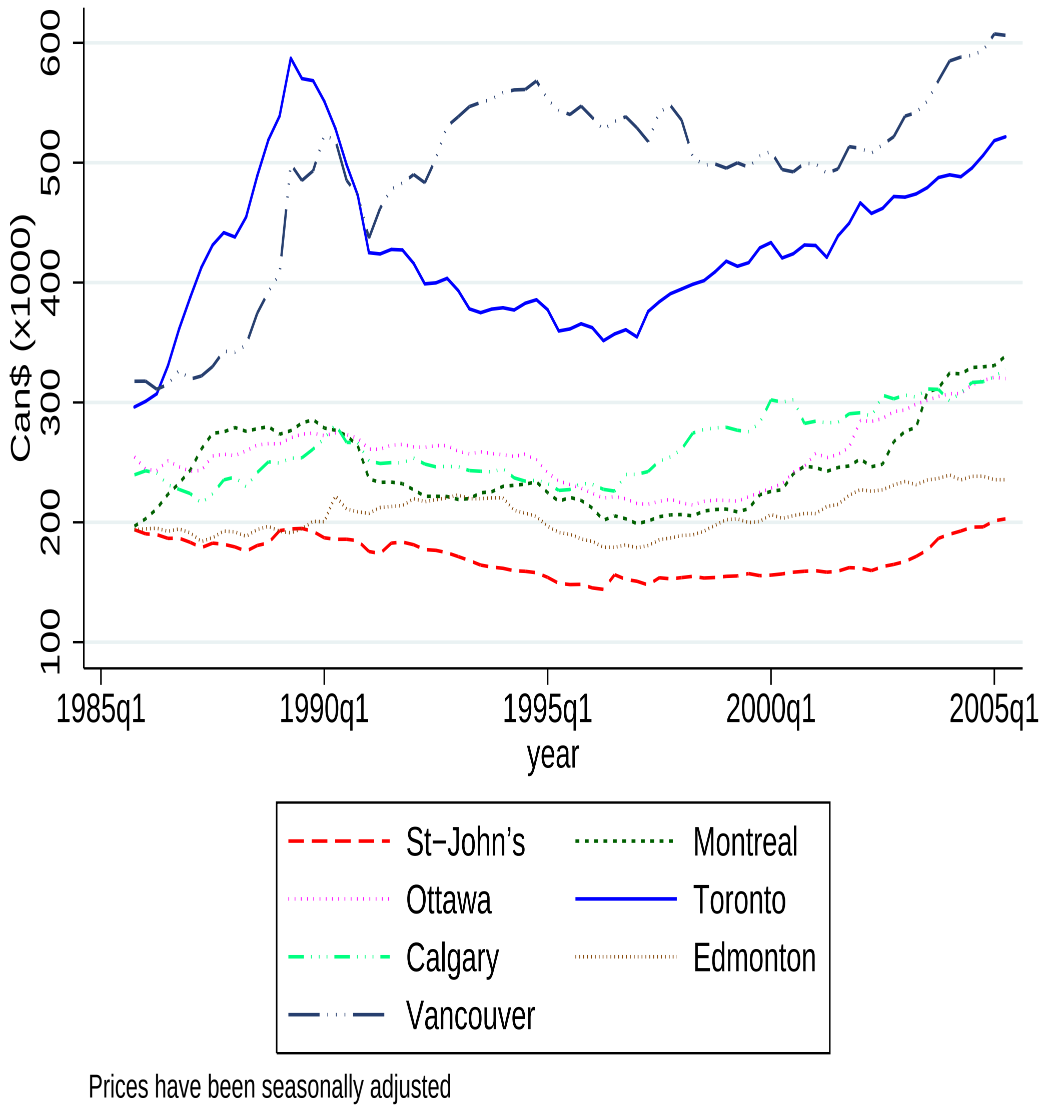

Table 2
Cointegrating Rank Determination for RLP House Prices

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 per cent level.

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, Montréal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. None of the test-statistics are statistically significant at the 1 per cent level.

Figure 2. Mortgage Rates: 1985Q4-2005Q2

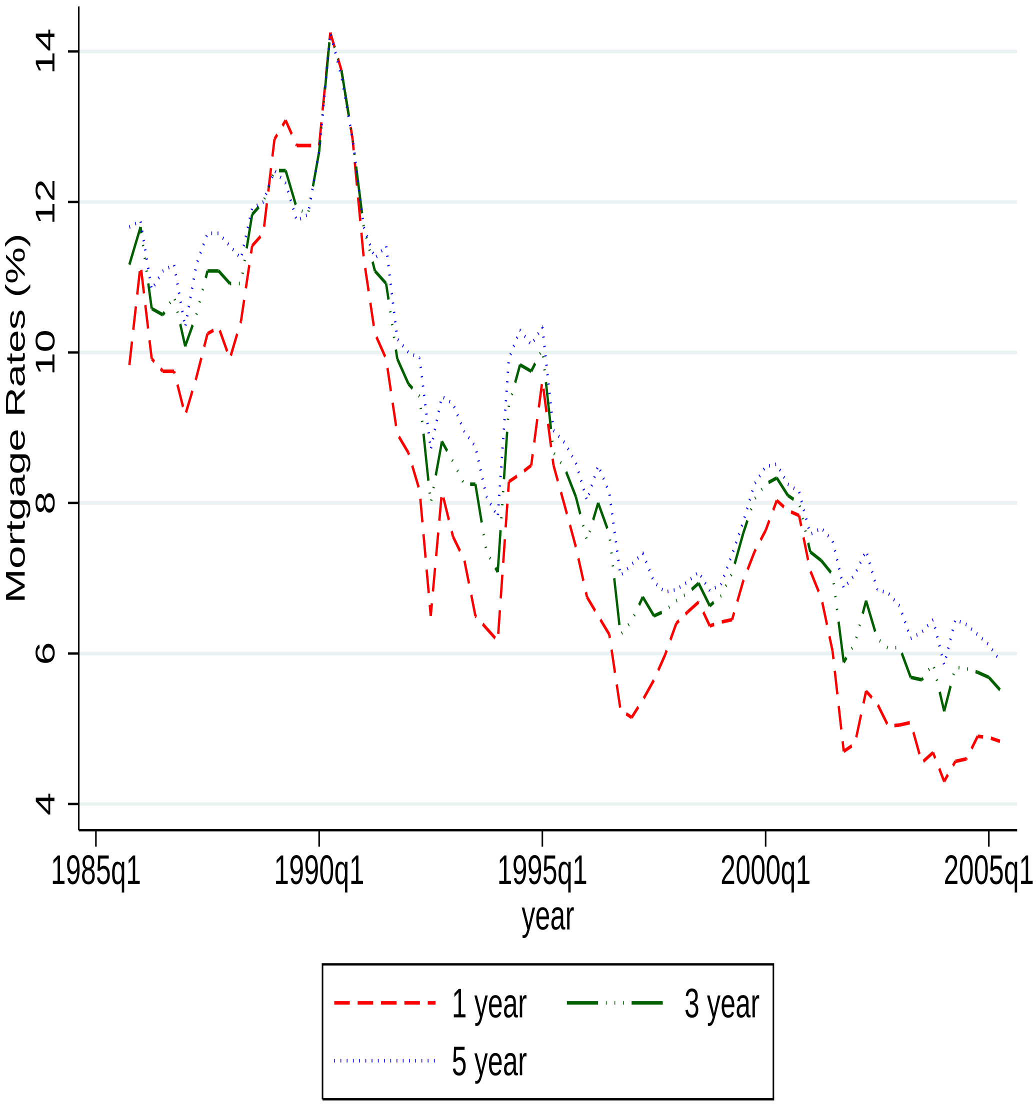

Table 4
Pairwise Cointegration Tests for RLP House Prices (Trend and Constant)

	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, Montréal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. None of the test-statistics are statistically significant at the 1 per cent level.

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, Montréal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. * denotest statistical significance at the 1 per cent level. The break date for the Toronto-Edmonton pair is 1990Q2.

Table 6
RLP Model: Residual Stationarity Tests

Variable	ADF	*p*-value	PP	*p*-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, Montréal, Ottawa, Toronto, Calgary, Edmonton, and Vancouver. ADF and PP test statistics and the *p*-values are provided.

Table 7
City-Specific Estimates via FM-OLS

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

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

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 price based on seven types of housing in 250 well-defined neighborhoods across Canada. More specifically, the survey includes four types of detach homes (bungalow, executive two storey, standard, two storey and senior executive), standard and luxury condominiums, 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 center, regional variances such as property taxes, number of bedrooms and bathrooms, the square meters 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