THE LONG-RUN DYNAMICS OF THE CANADIAN HOUSING MARKET: COINTEGRATION, REGIME SHIFTS, AND BUBBLES

by

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Abstract

This essay investigates the housing market of eight major Canadian cities, with a particular focus on the Greater Vancouver and the Greater Toronto areas. Using tests for cointegration and fully-modified OLS, the long-run dynamics of these markets are studied to determine whether or not current housing prices are supported by underlying economic fundamentals. Results indicate that most major Canadian cities experienced a substantial shift in their long-run cointegrating vector in the years preceding the 2008 financial crisis. Evidence shows that Vancouver's housing prices are still supported by economic factors today, whereas in Toronto housing prices have ceased to be cointegrated with fundamentals around 2002. These findings are reassuring in the case of Vancouver, but raise serious concerns about the stability and sustainability of housing prices in Toronto, where a bubble-like phenomenon seems to be present.

Résumé

Cet essai se penche sur le marché immobilier de huit grandes villes canadiennes, avec un intérêt particulier pour le marché du Grand Vancouver et celui du Grand Toronto. À l'aide de tests de cointégration, la dynamique de long terme de ces marchés est examinée afin de déterminer si les prix de l'immobilier actuels sont soutenus ou non par des facteurs économiques fondamentaux. Les résultats indiquent que la plupart des grandes villes canadiennes ont connu un changement important dans leur vecteur de cointégration de long terme dans les années précédant la crise financière de 2008. Il apparaît également que les prix de l'immobilier de Vancouver sont toujours soutenus par des facteurs économiques aujourd'hui, alors que, à Toronto, les prix ont cessé d'être cointegrés avec les fondamentaux en 2002. Ces résultats sont rassurants dans le cas de Vancouver, mais soulèvent de sérieuses inquiétudes quant à la stabilité et la soutenabilité des prix de l'immobilier à Toronto, où un phénomène s'apparentant à une bulle semble être présent.

Acknowledgements

The completion of this essay would not have been possible without the essential data provided by Brookfield RPS, the Real Estate Board of Greater Vancouver and the Canadian Real Estate Association. I want to express my sincere gratitude to these organizations for supporting young researchers like me, and for granting me their trust.

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Contents

1 Introduction

For more than seven years now, one of the Bank of Canada's (thereafter, *the Bank*) flagship publications, the *Financial System Review*, has indicated that imbalances in the housing market and household indebtedness are among the top vulnerabilities threatening the Canadian economy. If we account for the American housing market, this topic has been of central interest to the Bank for more than a decade. Analysts, scholars and regular citizens have also shown an interest in the housing market, either to improve their knowledge of the topic, to identify profitable opportunities, or simply to avoid making a bad economic decision.

Following the financial crisis of 2008, many experts have realized the devastating consequences that a collapsing housing market can have on the real economy. For many Canadian households, real estate represents the single largest investment they will make in their lifetime. Should housing prices drop substantially and suddenly, many families could end up with critical solvency problems. These price movements would put both the lower- and middle-class on the front line. Broader implications such as retirement, job loss, and wealth transfer could also arise. Banks would observe a rise in delinquency or default rates, forcing them to restrain credit and increase borrowing interest rates, which would in turn deepen the impact of a negative shock. It has been argued that housing prices can act as a financial accelerator (Kivedal, 2013). Higher prices lead to higher collateral values and wealth effects, which in turn stimulate borrowing and aggregate demand, including for housing, thus generating even higher prices in the market. The opposite is also true, and this is why a faltering housing market can rapidly turn into a generalized crisis.

If we abstract from the simple scenario of a nationwide recession, essentially two factors could lead to increased stress in the housing market in a foreseeable future.

The first one, a rise in long-term interest rates, has already started with the Bank of Canada increasing the overnight rate to 3/4 percent in July, and expecting above-potential growth in the near future. Although the Canadian economy is said to be "robust", mostly due to household spending, concerns are still present, as the average household debt is approaching 170% of average disposable income. Last May, Moody's Investors Service downgraded the credit ratings of Canada's "Big Six" banks precisely because of household indebtedness (Financial Post, 2017b). In particular, the growth rate of disposable income has been significantly lower than the one of residential mortgage credit in recent years (see Figure 1). Thus, as predictable as it may be, a rise in long-term interest rates could create a great deal of instability in the economy, as households have little financial flexibility to refinance mortgages and other loans.

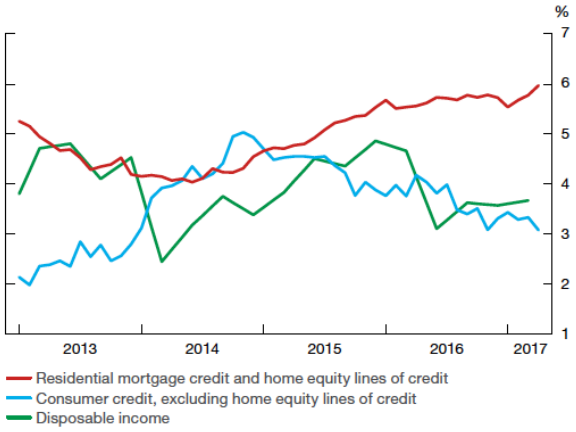


Figure 1 – Year-over-Year % change in Household Credit and Income (Bank of Canada, 2017)

The second factor that might rapidly affect housing and the economy appears far less predictable, certainly less controlled and potentially more devastating than rate hikes. Concerns about a housing bubble in Vancouver and Toronto regularly show up in the media and many institutions' periodic reports. With recent estimates suggesting that residential construction itself accounted for 7% of Canada's GDP in 2016 (Financial Post, 2017a), one can question how much of this production is in fact the result of speculation. The threat of a housing bubble in Canada also often

dominates discussion of fluctuations in the oil price, which many consider as the core of the Canadian economy (see Figure 2).

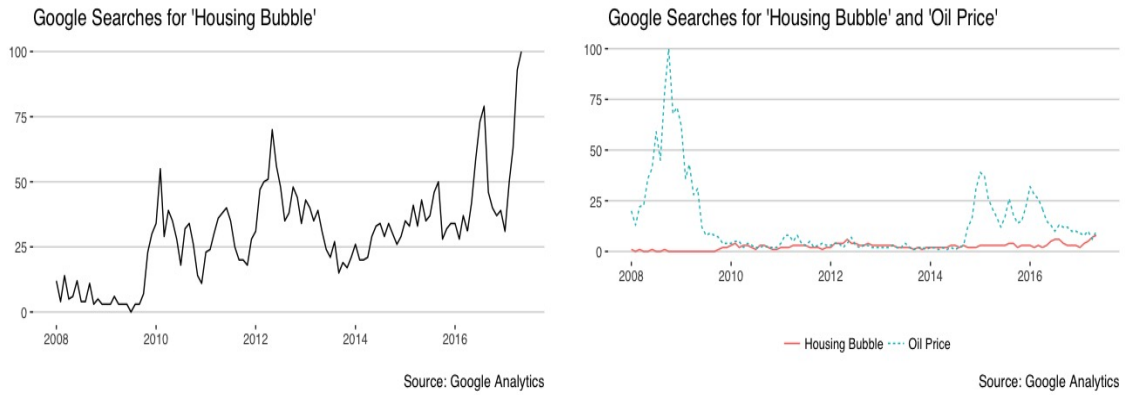


Figure 2 – Relative Google search frequencies of housing bubbles versus oil prices

Concerns regarding a housing bubble stem from different sources. First and foremost, erratic and sometimes highly volatile price increases have been observed in the Greater Vancouver Area (GVA) and the Greater Toronto Area (GTA) in recent years. This run-up in prices has lead municipal and provincial governments to implement foreign buyers taxes aimed at moderating price growth, while the federal government has put different measures in place to improve the quality of mortgages issued. For instance, the maximum loan-to-value limit for new mortgages was decreased from 95 to 90% on the portion of the house price above $500,000, and borrowers now have to qualify under maximum debt-servicing standards based on the higher of the mortgage contract rate or the Bank of Canada conventional five-year fixed mortgage rate (Bank of Canada, 2017). Media reported that part of this boom may be due to foreign investors, who buy properties in Canada to benefit from the stable economic and political environment the country has to offer. In the short-run, this raises concerns with respect to the capacity for Canadians to afford a home in these areas. In the longer run though, more and more people fear that these price increases will stop and that a sudden crash will follow, resulting in devastating damages.

One way to assess if a residential market behaves atypically is by looking at the evolution of average housing prices and rents in those "hot" areas. As can be seen from Figure 3, home prices in the GVA and GTA have increased substantially since the 90's, especially from 2002 onwards. Toronto prices appear to have increased at a sustained rate, whereas movements in Vancouver prices have been more volatile. The average rent has increased at what seems to be a very constant rate, potentially because of the different regulations that tend to limit sharp rises in rents and to create downward stickiness (Case and Shiller, 2003). What is striking is that the price-to-rent ratio in Toronto and Vancouver has been continuously on the rise since 2002, a phenomenon that we do not observe when looking at other markets (Calgary, Moncton, Regina, and Winnipeg all present a decrease in their ratio after 2002).

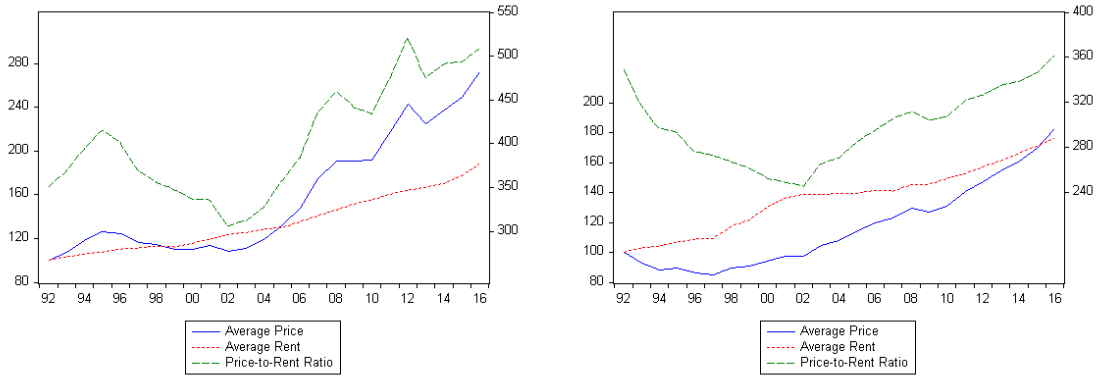


Figure 3 – Housing Prices and Rents in Vancouver (left) and Toronto (right). Price and rent indexes (1992 = 100), Price-to-Rent ratio on the right axis.

Whereas we believe this is concerning given that homes and rentals should at least be imperfect substitutes (Kivedal, 2013), we do not embrace the vision treating housing strictly as a financial asset. According to this point of view, the price-to-rent ratio should remain fairly constant because rents represent future capital gains and should thus be closely related to the price of the asset. This vision seems flawed because the housing market exhibits high transaction costs (both in time and money), homes are illiquid assets and because it is unclear whether or not households perceive

purchasing a house as an investment decision, especially outside of a bubble setting (Case and Shiller, 2003). Kivedal (2013) also rejects the efficient market hypothesis in the U.S. housing market. These four factors, together with regulations and price stickiness, leave little room for arbitrage and expose the housing market to potential divergence from fundamental economic variables.

This idea of underlying fundamentals driving the long-run movements of housing prices is at the core of this paper. One of the many ways to assess the presence of a bubble in a given market is to analyse if the prices are moving together with other variables that may reasonably affect demand or supply (e.g. income, construction costs). This paper investigates such relationships by using different methods related to the concept of cointegration, which is used to assess if different time series share a common long-run trend. Specifically, systematic pairwise cointegration tests are conducted, as well as tests for cointegration with regime shift. Based on these tests, we estimate long-run relationships in the GVA and GTA between home prices and a subset of factors by using fully-modified ordinary least squares for valid inference.

This paper contributes to the literature on the Canadian housing market by providing a systematic evaluation of the cointegration between housing prices and many alleged fundamentals, for several Canadian cities. Because the central issue of this essay, evaluating the presence of a housing bubble, cannot be tested directly, we conduct a thorough investigation of all the aspects surrounding the long-run dynamics of the housing market in order to build up evidence in favour or against the hypothesis of a bubble. Our results indicate that most major Canadian cities experienced an important shift in their long-run relationships between home prices and several fundamentals in the years preceding the 2008 crisis. Additional cointegration tests for Vancouver and Toronto show that Vancouver's housing prices are still supported by fundamentals today, whereas in Toronto a complete dislocation seems to have

occurred around 2002. This raises serious concerns about the stability and sustainability of today's housing prices in the GTA. Our estimates of excess-valuation in Vancouver range from 36% to 42%, and from 36% to 41% in Toronto.

The remainder of this paper is organized as follows. The next section outlines the literature studying the housing market and the assessment of bubbles. Next, a description of our dataset is provided, followed by a short review of the cointegration methodology. Section 5 presents cointegration test results with and without regime shift based on a pairwise approach. In section 6, multivariate cointegration tests are conducted for Vancouver and Toronto, and their respective cointegrating vectors are estimated. Finally, some concluding remarks are offered based on our overall findings.

2 Literature

What do we mean by "housing bubble"? One can at least say that a bubble, regardless of the market, is associated with strong, higher-than-usual, price growth, and that irrational speculative behaviour is likely to occur (Case and Shiller, 2003; Kivedal, 2013). By speculative, we mean a behaviour such that buying-decisions are not made entirely based on the utility provided by a given good, but are also based on expectations of higher prices in the future. Even in finance, where assets are traded specifically based on the prospect of selling an asset at profit in the future, irrational speculation can arise when investors acquire assets not because they believe the underlying "good" is promising, but because they believe the price will rise precipitously without reason. In particular, *herding* phenomena, where people copy the behaviour of others, without more reasoning, can increase the likelihood of a bubble.

On the other hand, rapid price increases do not systematically indicate the for-

mation of a bubble (Case and Shiller, 2003; Arshanapalli and Nelson, 2008). Just like food prices can jump suddenly due to a hurricane hitting a major production center, other events and trends in the fundamentals determining supply and demand can influence the price of the good. Even what looks like a burst, after what appears to be a run-up, can be supported by movements in the underlying factors. Most bubbles are only identified as such after they have burst, making preventive testing difficult.

Case and Shiller (2003) define a housing bubble as "a situation in which excessive public expectations of future price increases cause prices to be temporarily elevated". The authors explain that buyers may acquire properties that they would have normally considered too expensive because they think they will be compensated by further price increases. Stiglitz (1990) defines it as "a high price being high only because investors believe that the selling price is high tomorrow when fundamental factors do not seem to justify the high price". Thus, we have identified at least three components that are likely to be related to a housing bubble: strong and sustained price increases, purchasing decisions based on positive expectations about the future, and a dislocation between price variations and movements in the underlying fundamentals.

To understand why and how a divergence between housing prices and fundamental variables can arise, one must be aware of certain aspects particular to the real estate market. Whereas other goods and assets can easily be purchased, compared and transferred from one place to another, housing units are expensive, highly distinct, and fixed within a specific neighbourhood (Maclean, 1994). There is little room for arbitrage as the only way an individual can take advantage of lower prices is by moving to a particular area. Moreover, the stock of housing is typically constant in the short-run since contractors can only respond to a change in demand after a considerable lag. Many steps must be completed before new housing can be offered on the market, such as land acquisition, zoning change, getting a construction permit,

designing and constructing the property, and so on.

This short-run inelasticity of supply can exacerbate distortions in the market, especially in urban areas where land availability is a major concern (Dupuis and Zheng, 2010). Important transaction costs also contribute to a slow adjustment of the market. Evaluating the market value of a home based on several features, acquiring information about these features, visiting units, paying land transfer taxes, finding a mortgage, are just some examples of the many costs associated with completing a single transaction in the housing market. These steps can increase the probability of misjudging a house, as the amount of information required is large, complex, and likely to be noisy. Downwards stickiness of home prices and rents, due to regulations or psychological reluctance to decrease the sale price, is another phenomenon that makes it harder for the market to adjust to changes in demand (Case and Shiller, 2003).

In terms of identifying which "fundamentals" might have a substantial effect on the housing market, the literature has focused on both supply- and demand-side factors. On the demand-side, income (GDP), (un)employment, population growth, and mortgage rates are widely considered as important drivers of demand (Sutton, 2002; Case and Shiller, 2003; Arshanapalli and Nelson, 2008; Allen et al., 2009; Mallick and Mahalik, 2015). Intuition suggests that income, employment and population growth should increase the demand for housing, whereas mortgage rates and prices are expected to decrease the demand, assuming an absence of speculative behaviours. In a long-run analysis, Allen et al. (2009) found that labour force variables are positively significant in Montreal and Vancouver, that GDP is positively significant in Vancouver, Halifax and St-John's, and that interest rates are often significant but have a small impact in comparison to other factors. Using provincial data, Dupuis and Zheng (2010) found that demand is influenced by the employment rate, real mortgage

rates, consumer confidence and the stock market performance.

Other authors have incorporated credit-related variables such as money supply, private credit or debt (Goodhart and Hofmann, 2008; Oikarinen, 2009). These components are important since housing prices and borrowing can influence each other through several channels. High housing prices create wealth effects by providing a higher collateral to landlords, loosening their borrowing constraints, and by giving the impression that a household lifetime wealth has permanently increased. As the permanent income hypothesis states, if agents perceive that their lifetime income or wealth has increased, they will be likely to increase their consumption and their borrowing in order to smooth their utility across time. Oikarinen (2009) argues that housing prices can impact the supply of credit by inflating the value of banks' capital, making them more willing to grant loans.

Goodhart and Hofmann (2008) found evidence of significant interrelations between housing prices, private credit and money supply using robust Granger-causality tests for a sample of 17 industrialized countries over approximately 104 quarters. Oikarinen (2009) confirmed the existence of an interaction between real estate prices and household borrowing in Helsinki. His cointegration analysis also indicates that the link between housing prices, real income and the loan-to-GDP ratio has remained fairly constant across time, suggesting that this city did not experience bubble-like phenomena. These findings support the idea that credit conditions and indebtedness are important factors influencing the demand for housing.

On the supply-side, the pool of potential factors used in the literature is less diverse. Although Glaeser et al. (2008) argue that supply-side determinants are crucial to model the housing market, especially when investigating the likelihood of a bubble, most authors have had difficulty coming up with rich series for this side of the market.

Residential investment, the stock of dwellings and construction costs are typically the three supply variables used in the literature. However, obtaining the housing stock at a time frequency lower than annual often requires approximations based on end-year stock, and construction costs have been reported as being of poor quality (Dupuis and Zheng, 2010).

Many papers studying the Canadian market have relied on the construction union-wage index (UWI) to estimate construction costs since richer information such as a weighted-material-costs index or some measure of land availability do not exist for Canada. Promising developments have been made for other countries using satellite imagery to determine the land area that is available and flat enough to allow for construction (Glaeser et al., 2008). Still, these techniques seem limited as most urban units ought to be built upwards, making surrounding grounds steepness less relevant.

Another important aspect is the idea that the housing market may be quite different from one area to another within the same country. This belief has been around for a long time and is corroborated by several studies (e.g. Maclean (1994); Lampert and Pomeroy (1998); Case and Shiller (2003)). Nevertheless, many studies are still conducted using national data, sometimes to assess differences between countries, but sometimes simply because regional data is lacking. In an attempt to settle the question for Canada, Allen et al. (2009) conducted system and pairwise cointegration tests to determine if housing prices across Canadian cities were following a common long-run trend. Their results strongly indicate the absence of such a trend, both among the cities and between each city and the national price index. This raises important concerns about using a national price variable in the Canadian context.

The complexity of housing markets, the particular interactions between supply and demand, as well as the fact that cycles in this industry tend to be relatively

long (Cunningham and Kolet, 2011) have led researchers to use reduced-form and system approaches, both with and without error-correction components. Case and Shiller (2003) found that housing starts and income per capita are significant drivers of housing prices and prices growth. As they explain, their reduced-form model is subject to simultaneity, meaning that home prices and "independent" variables may influence each other. This may be the reason why housing starts are positively correlated with housing prices, as builders have an incentive to build more when prices are high. Changes in population and employment are sometimes significant, whereas the mortgage rate is mostly insignificant. They conclude that income explains most of the variations in U.S. home prices since 1985 in all but eight states. In these eight states, price growth has been more intense and their models systematically under-forecast the run-up in prices, providing evidence for a bubble-like phenomenon.

To avoid the simultaneity problem, some authors have opted for a system approach using vector-autoregression or seemingly unrelated regressions models (Sutton, 2002; Goodhart and Hofmann, 2008; Engsted and Pedersen, 2015). Results show that there are multiple interrelations between housing prices, monetary factors and the overall state of the economy, and that the effects of money and credit are especially strong when home prices are booming. Using orthogonalized impulse response functions, Sutton (2002) estimated that the Canadian housing market is relatively responsive to shocks to GNP and interest rates, but relatively unresponsive to changes in stock prices. Nevertheless, the model leaves a great deal of unexplained residuals in Canada compared to other countries. The Netherlands is the second country exhibiting as much unexplained residuals, suggesting that Canada's segmented housing market is not the sole cause of the problem, but that there are other elements behind the model's poor performance.

Finally, error-correction models have been widely used to assess supply-elasticity

and price disequilibrium. Kivedal (2013) found that U.S. housing prices had an explosive root before the 2008 crisis, and this result is robust to the decline in interest rates that preceded the burst. Hypothesis testing also rejects the efficient market hypothesis, supporting the idea that bubbles are likely to occur in the housing market.

Adopting a housing stock point of view, Dupuis and Zheng (2010) try to estimate a system of equations for the demand and supply of housing, but are constrained to estimating only the demand part as the supply equation doesn't show evidence of cointegration. Nonetheless, they did find evidence of two cointegrating vectors for their five variables (population, housing investment, housing stock, housing prices and a measure of financial wealth). They found that the short-run speed of adjustment of housing stock towards equilibrium is rather slow, in accordance with Caldera and Johansson (2013), and that the housing stock was 2% above equilibrium at the end of 2008. They also found that population growth is the main driver of housing stock, followed by the consumer confidence index on a smaller scale.

In the U.S. context, Arshanapalli and Nelson (2008) employ the cointegration test developed in Engle and Granger (1987) to assess the relationship between housing prices and alleged fundamentals in the years preceding the financial crisis. They found that even though many pairwise cointegration relationships can be found before the burst (e.g. income, unemployment), many of them vanished around 2005. This indicates that disappearing cointegration may be used as an early bubble detection system.

For the remainder of this paper, important findings to keep in mind are (1) that well-behaved housing markets should somewhat be related to macroeconomic fundamentals, (2) that the Canadian housing market is highly segmented, and (3) that periods preceding a bubble exhibit sustained and self-reinforcing price increases.

3 Data

The present paper investigates the Canadian housing market using a set of city- and provincial-level variables available on a monthly basis, from January 1980 to March 2017. The time span is approximative since the starting date of several series differs, although this will not be an issue for the most part of the analysis due to our pairwise approach. Most of the data come from Statistics Canada's CANSIM database, as well as a few public and private organizations (see details in Appendix A).

To limit the scale of the analysis and because most of the focus will be on the bubble phenomenon, a subset of major cities has been retained: Vancouver, Toronto, Calgary, Edmonton, Regina, Saskatoon, Winnipeg and Ottawa. Due to data limitations, especially for such a time span, cities from Quebec, Newfoundland and the Maritimes had to be excluded. Furthermore, previous analyses, as well as intuition, suggest that housing bubbles are a greater concern in the Western parts of Canada, and that the cities in those areas are likely to be more homogeneous and thus, comparable. A quick overview of the evolution of prices in the Atlantic provinces already suggests that they have not experienced such big price increases as in Middle- and Western-Canada.

Figure 4 presents the evolution of housing prices in our eight Canadian cities. Up to three different measures are shown (depending on availability), namely the average sale price from the Canadian Real Estate Association (CREA), the Multiple Listing Service composite price index (MLS®), and the Brookfield RPS composite price index. Scholars and analysts tend to prefer price indexes since these are usually quality-adjusted, meaning that a change in price will embody changes in the homes' characteristics (number of rooms, property's age, foundation types, etc.). On the other hand, Maclean (1994) argues that indexes based on repeat-sales are likely to

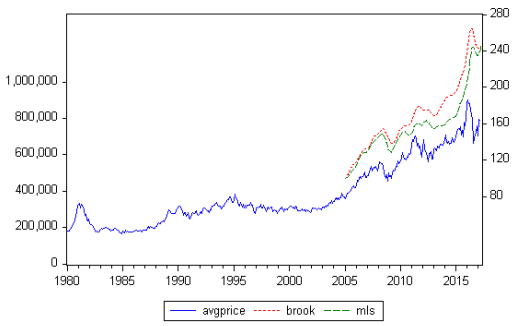
be biased since "*properties undergoing repeat sales may well differ in significant ways from the general stock of housing.*" Either way, the use of the average sale price was inevitable for this study as it is the only measure at our disposal that is available from 1980, the price indexes being available from January 2005 only. Statistical tests presented in section 5 provide evidence that the average price generally follows the price indexes movements in the long-run.

As can be seen, the majority of these cities have experienced a relatively rapid increase in housing prices from 2000 to 2007, just before the financial and sub-prime crisis. Cities in oil-producing provinces in particular experienced a sharp rise around 2007-2008, before stabilizing around a different level from 2010 onwards. Whereas some could argue that this is due to the average price measure because it tends to be more sensitive to seasonality and idiosyncrasies, the two quality-adjusted indexes appear to follow a similar pattern around this time, suggesting that this rise did occur for real.

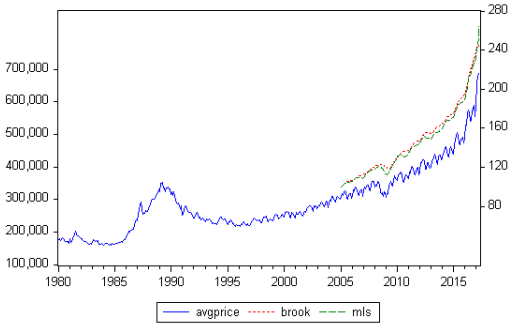
The market prices for Winnipeg and Ottawa, although prices did rise, exhibit an evolution far less exponential and sudden than in the other cities. These areas could thus be good candidates for a "control" group, although it is important to note that this paper does not formally adopt a treatment-control methodology.

With respect to the underlying factors influencing these markets, the following indicators have been selected, based on the literature and data availability.

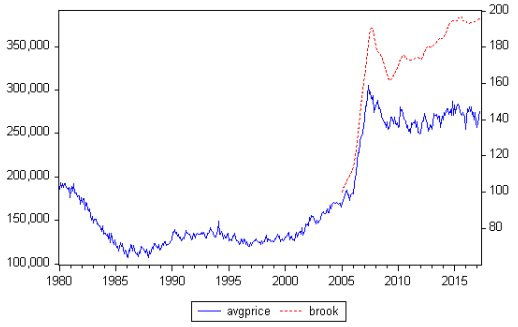
On the demand-side, we use employment and unemployment, (un)employment rates, population, aggregate labour income, average weekly earnings and the participation rate as proxies for economic activity. Estimates from the labour force survey are 3-month seasonally adjusted moving averages at the metropolitan-level from March 1987, whereas labour income and weekly earnings are available at the



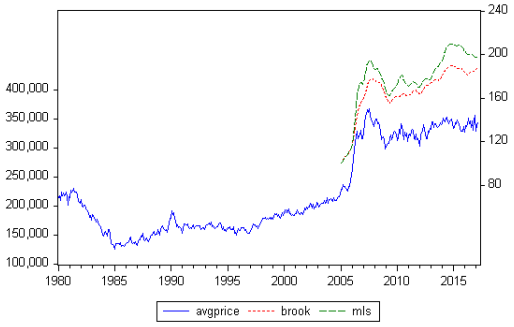
Vancouver



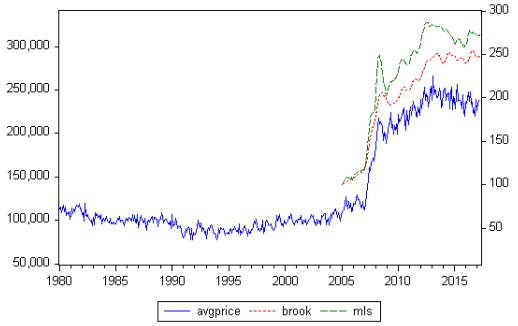
Toronto



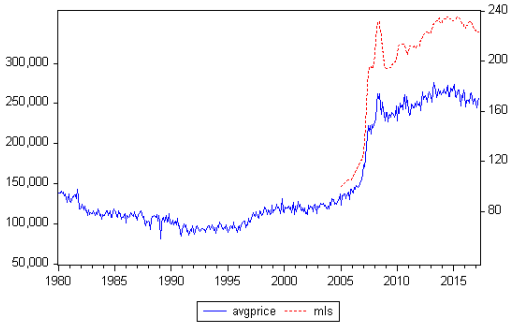
Edmonton



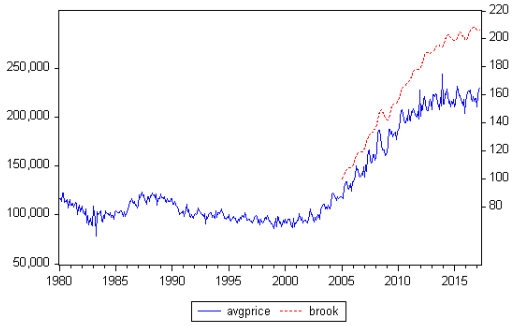
Calgary



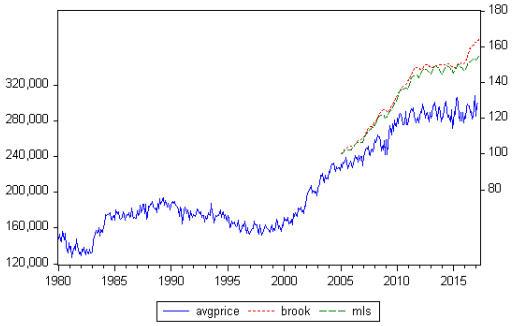
Regina



Saskatoon



Winnipeg



Ottawa

Figure 4 – Housing Prices

provincial level from January 1997 to December 2016 and January 2001 to March 2017 respectively. To account for credit conditions, we use the 5-year conventional mortgage rate, as well as the Bank of Canada total and mortgage household credit volume change, all three available at the national-level. Unfortunately, more detailed information about down-payments, lending practices and households finances are not publicly available, at least not on a monthly basis and for such a long time span.

On the supply-side, we follow the literature and use the construction union-wage index (UWI), the dollar volume of building permits issued, as well as the corresponding number of units. From the Canada Mortgage and Housing Corporation, we use the number of units started, under construction, completed, absorbed (sold) and unabsorbed on the market. From CREA, we use the number of units sold, the dollar volume of these sales and the number of new listings posted on the market. All the supply-side factors are available on a monthly basis and at the metropolitan-level.

Finally, the New Housing Price Index is considered. The price of recent constructions may certainly affect demand, especially if there is a shortage of dwellings, but it can also affect supply as it reflects the revenues that investors are likely to obtain.

Every nominal variable, including the housing price indexes, has been deflated using Statistics Canada's "All-items" monthly CPI at the metropolitan-level. Indexes have been rescaled afterwards to facilitate interpretation. The national mortgage rate is expected to reflect regional mortgage conditions reasonably well, as is common to assume in the literature (Lampert and Pomeroy, 1998; Allen et al., 2009). The Bank of Canada measures of credit are used to capture not only the credit conditions, but also the level of indebtedness in the economy. Hekman (1985) argues that national variables can provide accurate measures if they are moving in the same direction as regional variables, which we believe to be plausible in the case of credit conditions

since major cities are considered. The same argument holds to justify the use of provincial data for labour income and earnings.

For the Greater Vancouver Area, a few additional variables are available starting from January 2005, namely the number of active listings on the market each month, the average number of days a property had to be on sale before being sold, and another measure of the number of sales in a month. These data were provided by the Real Estate Board of Greater Vancouver and could be very useful for digging down on price dynamics. For instance, the number of active listings gives us a precise measure of housing supply for any given month, whereas our measure of new listings gives us only the number of properties added to the "pool" of available properties, regardless of how many were withdrawn from the market.

For the remainder of this paper, natural logarithms of the aforementioned variables are used unless otherwise noted (except for the interest rate, the (un)employment rates, the participation rate and the changes in credit volume, which are expressed in percentage). Coefficients can thus be interpreted as elasticities. Monthly dummies are used to control for seasonality.

4 A Brief Word on Cointegration

Many economic time series, such as GDP or employment, are said to be differenced stationary, meaning that the series can be made stationary after differencing it d times. Visually, stationary processes will have a lot of short-run movements (high frequencies), crossing the mean back-and-forth, whereas non-stationary processes will exhibit stochastic trends or slow movements.

Dealing with non-stationary time series can cause serious problems, the most famous being spurious regression. Indeed, looking at two series trending upward will cause most estimators to identify a strong relationship between the series, although there might be absolutely no real link between them. Still, it is possible to work with non-stationary series if they happen to be cointegrated. For instance, if we assume that y and x can both be made stationary after one differentiation (i.e. $\Delta x \; and \; \Delta y \; are \; I(0)$), a linear combination of them can be stationary if they share a common long-run trend

$$z_t = y_t - bx_t, \quad where \; z_t \sim I(0)$$

where b acts as a scaling factor, and the coefficients vector $[1, \; b]$ is called the *cointegrating vector*. This vector is such that the major part of the long-run components of x and y cancel each other out, leaving residuals free of low-frequency movements. In terms of the two initial series, this implies that they do not drift apart from each other too much, but instead evolve together in the long-run. The result is that the gap between the two series (z, after scaling), will not grow indefinitely, but will fluctuate around zero, implying that divergence from equilibrium will occur temporarily only. This concept extends to any number of series, the only caveat being that the cointegrating vector may not be unique.

In applied econometrics, the methodology developed in Engle and Granger (1987) to test for cointegration is relatively straightforward. First, a model with a non-stationary dependent variable is estimated by ordinary least squares (OLS) and the residuals are collected. Testing for the residuals' stationarity is similar to testing whether the series has a unit root or not. The Engle-Granger test uses an augmented Dickey-Fuller (ADF) test where the null hypothesis is that the residuals have a unit

root and the alternative is that the residuals are stationary. The number of lags included in the regression, to ensure that autocorrelation is suppressed, will be determined by the Bayesian Information Criterion (BIC) in our case. The null hypothesis is evaluated using non-standard τ and z statistics, for which the critical values have been estimated in MacKinnon (1996). These critical values depend on the sample size and the number of regressors included, but can easily be computed for our case using surface response estimates provided in MacKinnon (1996). A nonparametric approach using the Phillips-Perron test statistics was also developed in Phillips and Ouliaris (1990).

Using this methodology, it will be possible to assess if prices in our different housing markets are following what we believe to be fundamentals in the long-run. In particular, we contrast different periods within the same city, as well as cities between each other, to evaluate if the recent years exhibit the same long-run behaviour across time and regions, or if some systematic discrepancies can be identified. For instance, Arshanapalli and Nelson (2008) found that many cointegration relationships vanished in the U.S. housing market as the sample period approaches the financial crisis. Similarly, we would expect "hot" markets like Vancouver and Toronto to behave somewhat differently than markets like in Ottawa or Winnipeg.

5 Pairwise Approach

In the following subsections, pairwise Engle-Granger (EG) tests are conducted within our eight cities to examine if a dislocation from the alleged long-run determinants of housing prices can be observed prior to the 2008 crisis. The results indicate that a shift in the cointegrating vectors may have occurred in several cities, motivating the use of Gregory-Hansen (GH) tests, again within a pairwise framework.

A pairwise approach is selected since it allows for a more granular analysis of the fundamentals. When testing for cointegration using multiple independent variables together, rejecting the null hypothesis of no cointegration can be due to just a subset of factors being cointegrated, leading to incorrect conclusions. Moreover, using each factor individually keeps us from specifying any complex model immediately, giving us an agnostic point of view of the situation. Cointegration tests using an array of variables are conducted in section 6, but the pairwise analysis serves as a logical starting point.

5.1 Univariate Cointegration Tests

We begin our investigation by performing cointegration tests between the average housing price and employment, labour income, the number of dwellings permits were issued for (henceforth *dwellings*), the unabsorbed inventory (henceforth *inventory*), unemployment, the value of building permits (*permits*), the number of units started, the construction UWI, the NHPI, weekly earnings, the volume of sales, the number of units completed, the number of sales, the real mortgage rate, population, the number of new listings, and the change in mortgage and total household credit.

Employment and unemployment are expected to capture economic expansion (Case and Shiller, 2003), similarly to income and weekly earnings. Variables related to what we will call "construction" provide a snapshot of the state of the market, especially on the supply-side. Population captures changes in demographics, and finally "credit" variables account for the cost of financing and possibly indebtedness. Employment rate and other labour force rates were discarded since they tend to be stationary, making them unlikely to play any role in the long-run movements of home prices.

Average housing prices were tested for stationarity using ADF, Phillips-Perron and KPSS tests, and all three indicate that the series are $I(1)$ in every city (see Appendix B). To complete our pairwise analysis, we also test for cointegration between our measure of average prices and the MLS® and Brookfield RPS quality-adjusted indexes.

Presentation of the results is as follow. Table 1 shows the significance levels of the pairwise EG cointegration tests between average housing prices and each potential fundamental. Each row presents the results for a certain time frame in a given city, whereas each column corresponds to a specific factor. The periods considered were selected based on visual inspection of the housing price series in order to identify a "benchmark" period for each city, as well as one or two "boom" and "bust" periods. Periods will be determined endogenously in other sections. The use of monthly data gives us enough flexibility to create sub-samples while keeping a decent amount of observations. The first row always presents the results for the whole sample, whereas the last row always presents the results for the period where the price indexes are also available. This is also the only row where cointegration with the housing price indexes is tested to ensure a sensible comparison. For the time frames where certain factors didn't have a long enough series, *NA*'s are reported, and thus should not be considered as indicating an absence of cointegration.

For Vancouver, we observe that only the real mortgage rate appears to be cointegrated over the whole period. The latter only reappears in the most recent, more volatile period, and not for the benchmark period, indicating that the interest rate need not be associated with a calm or with an unstable market. The benchmark period does not exhibit a particularly high number of long-run relationships, with just the unabsorbed inventory and the volume of sales being cointegrated. When looking at the boom and bust periods from a long perspective, only one cointegration

remains, but a shorter perspective indicates that labour income and population were weakly cointegrated during the boom. The fact that the cointegration relationships change substantially depending on the starting date may indicate the presence of a regime shift in the data, which causes the relationships to break when considering a larger window. What is clear though, is that the recent period presents more cointegration with what we would expect to be important factors, such as employment, the interest rate and population. The cointegration with the NHPI suggests that new constructions have a larger role to play in the recent rise in prices. No housing price index appears to be cointegrated with the average price, revealing a mismatch between our measure and quality-adjusted indexes.

In the case of Toronto, far fewer factors appear to be cointegrated in general. Prices in the benchmark period do seem to be cointegrated with a few more construction-related variables, namely housing completions and sales volume, when compared with the 80's boom and the one preceding the financial crisis. Prices during the recent boom are only weakly cointegrated with sales volume. Including the burst period does not reintroduce any cointegration. Finally, the more recent period presents only one cointegration with sales volume, although average prices appear cointegrated with both housing price indexes.

Table 1 : Pairwise Cointegrations with Average Housing Prices

	Description	Emp	Inc	Dwel	Inventory	Unemp	Permits	Starts	UWI	NHPI	Earnings	Volume	Completions	Sales	Rate	Pop	New List.	Mortcredit	Totcredit	MLS	Brookfield
VANCOUVER																					
1980m1-2017m3	Whole sample														**						
1982m2-2002m1	Benchmark				**						NA	***									
1982m2-2008m2	Boom (long)											***									
1982m2-2010m2	Burst (long)											***									
2001m1-2008m2	Boom (short)		*													*					
2001m1-2010m2	Burst (short)																				
2005m1-2017m3	Recent period	*								*					**	**					
TORONTO																					
1980m1-2017m3	Whole sample											***			*						
1991m9-2002m10	Benchmark										NA	**	***								
1980m1-1998m2	80's boom		NA								NA										
1993m1-2006m12	Boom											*									
1993m1-2009m3	Burst																				
2005m1-2017m3	Recent period											**								***	***
CALGARY																					
1980m1-2017m3	Whole sample									***		**			**		**				
1985m2-1997m10	Benchmark		NA								NA	**	**					**	**		
1982m2-2004m1	Build up									**			***								
1982m2-2007m6	Boom									**		*									
1982m2-2009m6	Burst									**		*					*				
2005m1-2017m3	Recent period			*		*	*	*	*	*			*	*	*		*	*		**	**
EDMONTON																					
1980m1-2017m3	Whole sample																				
1984m1-2001m7	Benchmark		***								NA						**				
2004m7-2007m7	Boom																				
1986m1-2010m7	Burst		*									*					**				
2005m1-2017m3	Recent period		*		*	*		*					*	*			**	*		NA	***

Seasonal dummies included in the first-step regression. The symbols "", "**", and "***" indicate rejection of the null hypothesis at the 10%, 5% and 1% level respectively, using the ADF test*

Table 1 : Pairwise Cointegrations with Average Housing Prices (continued)

	Description	Emp	Inc	Dwel	Inventory	Unemp	Permits	Starts	UWI	NHPI	Earnings	Volume	Completions	Sales	Rate	Pop	New List.	Mortcredit	Totcredit	MLS	Brookfield
WINNIPEG																					
1980m1-2017m3	Whole sample		*	**			***				**										
1984m1-2002m1	Benchmark		***								NA							*			
2002m10-2012m6	oom w/out burs		**							**	**	**					*				
2005m1-2017m3	Recent period					**				***	*	***						*		NA	***
OTTAWA																					
1980m1-2017m3	Whole sample										***	***		***	**						
1984m1-2001m1	Benchmark									***	NA		*								
2000m6-2008m3	Boom								***	*	*	**						**	**		
2000m6-2010m1	Burst										**	***									
2005m1-2017m3	Recent period											*						**		***	***
REGINA																					
1980m1-2017m3	Whole sample						**		***	***		***		*							
1980m1-2005m1	Benchmark		***					**	NA	**	***		*								
1980m1-2008m3	Boom								NA	**		***									
2005m1-2017m3	Recent period								***	*		**									***
SASKATOON																					
1980m1-2017m3	Whole sample								***			***		*	**						
1980m1-2005m1	Benchmark	**	***			***			NA		***	**									
1980m1-2008m4	Boom					**						***									
2005m1-2017m3	Recent period								***												NA

Seasonal dummies included in the first-step regression. The symbols "", "**", and "***" indicate rejection of the null hypothesis at the 10%, 5% and 1% level respectively, using the ADF test*

The cities of Calgary and Edmonton display an interesting behaviour with respect to boom and bust periods. Both exhibit fewer or weaker cointegration during their boom period than during their benchmark period, with Edmonton in particular not showing any cointegration during its boom prior to 2008. New listings, a measure of housing supply, is often cointegrated with prices in both cities outside of the boom periods. Calgary also presents one period of cointegration with credit-variables at the 5% level, and several periods of cointegration with the NHPI. The latter possibly reflects the strong economic expansion that Alberta has known in the last decades. Including the bursts in the time frame did not re-establish as many relationships as we would have expected, although in Edmonton labour income and new listings reappear as cointegrated. Both recent periods exhibit substantial cointegration, suggesting that one should not be worried about those markets. Price indexes are cointegrated with our measure of average housing prices.

Winnipeg exhibits several cointegrations regardless of the period, which is consistent with the fact that we do not observe any strong price jumps in this area. The period qualified as "boom" exhibits cointegration with fundamentals such as earnings and income, indicating that the rise in prices was adequately supported. The NHPI is cointegrated in the more recent period, suggesting that it is the new constructions that are driving the prices up. Moreover, labour income is not cointegrated in the recent period, replaced by mortgage credit and unemployment. This indicates that the market is still supported by fundamentals, but that they have changed and that credit has possibly taken the place of income and earnings to finance housing purchases. Results for Ottawa indicate that the boom was supported by some fundamentals, but that credit played a larger role, as well as wages in the construction industry. Including the burst suggests that credit has become less important and has been replaced by earnings for housing purchases. However, the recent period presents

very few cointegrations, which raises some concerns with respect to the sustainability of prices in this area. Both price indexes are cointegrated with our measure of average housing prices.

Finally, in Regina and Saskatoon, benchmark periods present a great deal of cointegration, namely with employment, unemployment, income and earnings. Both boom periods show the loss of several of these relationships, although credit availability does not become cointegrated whatsoever. This suggests that the booms were not supported by a larger reliance on credit. The recent periods, which encompass the bursts, are very similar to the boom periods, and we do not retrieve as many fundamentals as during the benchmarks, suggesting that these markets are still unstable. Relationships with price indexes are also weak, with only average prices in Regina following the Brookfield RPS index.

This exercise shows that the premise according to which cointegration relationships should be stronger during stable periods and weaker during booms, is only partly verified. Indeed, this idea appears more convincing in the case of Edmonton, Calgary, Winnipeg, Saskatoon and Regina, but not quite in the GVA and GTA.

In terms of assessing the presence of a housing bubble in Vancouver and Toronto, we observe that the recent period still presents a few cointegrations in Vancouver, suggesting that price growth is at least partly supported by fundamentals, whereas in Toronto prices seem to be completely unsupported. The fact that in Vancouver the NHPI has recently become cointegrated is consistent with what can be read in the media with respect to the expensive houses being built in this area. In contrast, the striking lack of cointegration relationships in Toronto raises some doubts about the sustainability of home prices in this area.

Generally, the fact that the cointegration relationships change substantially across

time for most cities points towards a shift in the underlying regime driving the housing prices. This issue is examined in the following section using the Gregory-Hansen test for cointegration with one regime shift.

5.2 Different Regimes?

The presence of a cointegration may be difficult to test when the cointegrating vector changes substantially over a given sample, despite the fact that a *genuine* cointegration exists. Our previous results suggest that this might be the case for Vancouver and Toronto, but a visual inspection of the other price series makes this concern relevant for other cities as well because of the sharp rise in prices that we observe around 2005. To cope with this issue, we turn to the Gregory-Hansen test for cointegration with one regime shift (Gregory and Hansen, 1996). This procedure tests for a cointegration in the presence of one unknown regime shift using modified τ, z_α and z_t statistics. A regime shift is defined as a change in the intercept and the slope coefficients in the cointegrating vector. The main advantage of this test is that it identifies the potential breakpoint *endogenously*, which is arguably superior to a visual inspection. It has been shown that such tests have greater power than regular cointegration tests when there is a structural break in the data. This means that the probability of rejecting the null hypothesis of no cointegration is greater.

Table 2 presents the results of our GH tests. As we can see, there seems to be more variables cointegrated with one regime shift in the Vancouver area, particularly with factors that did not appear as cointegrated in Table 1. For instance, construction permits and the corresponding number of dwellings appear to be cointegrated, as well as other important factors such as population, credit and earnings. Most breaks seem to have occurred around the 2005-2008 period, with only a few statistics detecting

Table 2 : Gregory-Hansen Regime Shift Test Results

	Vancouver						*Toronto*					
	ADF	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**	**ADF**	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**
Employment	-4.63	3-1-2005	-37.77	8-1-1998	-4.48	8-1-1998	-3.35	9-1-1995	-31.35	3-1-1995	-3.46	9-1-1995
Dwellings	-4.70*	10-1-2005	-41.91*	9-1-2007	-4.91*	9-1-2007	-2.57	7-1-2012	-20.43	6-1-2008	-2.92	6-1-2008
Unabsorbed	-3.79	10-1-2006	-24.66	9-1-2005	-3.67	9-1-2005	-2.85	7-1-2010	-18.95	6-1-2010	-2.94	7-1-2010
Unemp	-3.96	2-1-2009	-27.43	5-1-2009	-3.87	5-1-2009	-3.39	11-1-2008	-28.04	11-1-2008	-3.54	11-1-2008
Permits	-5.07**	10-1-2007	-64.75**	9-1-2007	-6.17**	9-1-2007	-2.84	8-1-2011	-57.30**	9-1-1995	-5.65**	9-1-1995
Starts	-3.38	6-1-2007	-34.52	6-1-1998	-4.50	11-1-1997	-2.58	4-1-2010	-20.64	4-1-1989	-3.12	12-1-2008
UWI	-4.01	10-1-2007	-32.92	6-1-2008	-4.20	6-1-2008	-2.90	6-1-2008	-13.51	2-1-1991	-2.23	2-1-1991
NHPI	-3.38	10-1-2005	-19.26	10-1-2005	-3.35	10-1-2005	-4.63	7-1-1992	-39.74	12-1-1991	-4.51	12-1-1991
Volume	-4.80*	7-1-2007	-65.44**	12-1-1985	-5.92**	12-1-1985	-2.78	8-1-2011	-76.82**	4-1-1986	-6.38**	4-1-1986
Completions	-3.61	4-1-1998	-60.04**	11-1-1998	-5.97**	11-1-1998	-2.86	9-1-2009	-34.40	5-1-1990	-4.21	5-1-1990
Sales	-3.93	8-1-2007	-28.63	1-1-2007	-3.84	1-1-2007	-2.55	8-1-2011	-36.34	4-1-1986	-4.12	4-1-1986
Rate	-4.17	11-1-1987	-23.94	5-1-1989	-3.76	7-1-2011	-3.29	5-1-2011	-22.45	5-1-1986	-3.29	7-1-2011
Population	-4.83*	10-1-2004	-35.92	12-1-1996	-4.68*	11-1-2004	-3.30	8-1-1998	-30.37	9-1-1995	-3.47	9-1-1995
New List.	-3.56	10-1-2007	-31.54	1-1-2009	-4.06	1-1-2009	-2.22	5-1-2010	-45.83*	12-1-2010	-4.92*	12-1-2010
Mortcred	-4.81*	3-1-2005	-38.26	3-1-2005	-4.48	3-1-2005	-4.07	11-1-2008	-32.73	4-1-2009	-3.78	4-1-2009
Totcred	-4.77*	3-1-2006	-39.98	10-1-2004	-4.82*	10-1-2008	-4.31	11-1-2008	-35.58	11-1-2008	-4.00	11-1-2008
Earnings	-4.60	7-1-2008	-54.63**	10-1-2011	-5.95**	10-1-2011	-4.70*	10-1-2014	-38.08	10-1-2014	-4.67	10-1-2014
Income	-4.79*	1-1-2003	-38.12	1-1-2000	-4.55	10-1-2009	-4.24	3-1-2008	-68.08**	4-1-2009	-6.22**	4-1-2009

	Calgary						*Edmonton*					
	ADF	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**	**ADF**	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**
Employment	-5.97**	12-1-2005	-58.7**	11-1-2005	-5.71**	11-1-2005	-5.15**	11-1-2005	-50.51**	3-1-2006	-5.3**	3-1-2006
Dwellings	-5.38**	10-1-2005	-82.69**	1-1-2006	-7.15**	1-1-2006	-6.81**	11-1-2005	-86.44**	6-1-2006	-7.28**	6-1-2006
Unabsorbed	-4.7*	9-1-2005	-39.4	1-1-2003	-4.45	9-1-2005	-4.59	12-1-2005	-38.15	11-1-2005	-4.48	11-1-2005
Unemp	-4.28	12-1-2005	-30.71	12-1-2005	-4.09	12-1-2005	-4.59	12-1-2005	-36.47	11-1-2005	-4.42	11-1-2005
Permits	-5.51**	6-1-2006	-77.92**	1-1-2006	-6.84**	1-1-2006	-6.25**	11-1-2005	-81.74**	6-1-2006	-7.04**	6-1-2006
Starts	-6.33**	11-1-2005	-106.51**	12-1-2005	-8.21**	12-1-2005	-5.94**	7-1-2006	-83.76**	8-1-2006	-7.18**	8-1-2006
UWI	-4.41	3-1-1986	-22.55	6-1-2005	-3.52	6-1-2005	-3.96	8-1-2009	-24.24	11-1-2005	-3.82	11-1-2005
NHPI	-6.87**	8-1-2001	-80.48**	6-1-2001	-6.7**	6-1-2001	-4.27	11-1-2005	-41.5	12-1-2005	-4.72*	12-1-2005
Volume	-4.55	10-1-2006	-79.3**	7-1-1985	-6.48**	7-1-1985	-3.99	5-1-2004	-91.43**	12-1-1985	-6.97**	12-1-1985
Completions [a]	-4.49	02-1-2005	-194.46**	11-1-2005	-11.42**	11-1-2005	-5.31**	12-1-2005	-164.56**	10-1-2006	-10.35**	10-1-2006
Sales	-3.86	6-1-2006	-34.16	7-1-1985	-4.16	7-1-1985	-3.9	7-1-2005	-39.07	7-1-1985	-4.46	7-1-1985
Rate	-4.14	9-1-2005	-32.55	6-1-2005	-4.13	6-1-2005	-3.96	11-1-2005	-25.42	7-1-2005	-3.77	8-1-2005
Population	-6.09**	12-1-2005	-59.86**	12-1-2005	-5.8**	12-1-2005	-5.16**	11-1-2005	-50.53**	6-1-2006	-5.3**	6-1-2006
New List.	-3.95	8-1-2004	-57.69**	7-1-1985	-5.68**	7-1-1985	-4.44	7-1-2004	-67.08**	7-1-1985	-6.1**	7-1-1985
Mortcred	-4.38	12-1-2005	-33.45	6-1-2005	-4.26	6-1-2005	-5.99**	6-1-2006	-51.55**	3-1-2006	-5.87**	6-1-2006
Totcred	-5.58**	12-1-2005	-44.97*	12-1-2005	-5.49**	3-1-2006	-6.94**	3-1-2006	-66.45**	3-1-2006	-6.89**	3-1-2006
Earnings	-5.81**	1-1-2006	-50.09**	6-1-2006	-5.57**	1-1-2006	-5.59**	6-1-2006	-42.9*	6-1-2006	-5.42**	6-1-2006
Income	-5.81**	1-1-2006	-55.53**	12-1-2005	-5.59**	1-1-2006	-5.18**	5-1-2006	-46.05*	6-1-2006	-5.17**	6-1-2006

The symbol "*" represents rejection of the null hypothesis at the 10% level, and "**" represents rejection at the 5% level or lower.
[a] Levels were used for Calgary and Edmonton.

the breaks in the 80's or 90's. In Toronto, the picture is substantially different. We observe some cointegration relations around the late 80's or mid-90's, as well as a few more recently. The formers are likely to be related to the boom Toronto experienced in the late 80's. There is thus little evidence for cointegration with regime shift in the case of Toronto. For the other cities, we observe many more cointegrations now that we have allowed for a regime shift, probably because of the sharp rise in prices that occurred around 2005. These findings suggest that the overall dynamic of the

Canadian housing market has changed substantially, most tests indicating that this change would have occurred just before the financial crisis.

Table 2 : Gregory-Hansen Regime Shift Test Results (continued)

	Regina						*Saskatoon*					
	ADF	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**	**ADF**	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**
Employment	-6.1**	6-1-2007	-97.11**	6-1-2007	-7.71**	6-1-2007	-7.83**	6-1-2007	-112.53**	1-1-2007	-8.48**	1-1-2007
Dwellings	-6.52**	9-1-2007	-121.66**	8-1-2007	-8.83**	8-1-2007	-4.89*	8-1-2007	-107.17**	6-1-2007	-8.29**	6-1-2007
Unabsorbed	-5.63**	10-1-2006	-60.94**	12-1-2006	-5.88**	12-1-2006	-4.86*	7-1-2006	-39.04	6-1-2006	-4.57	6-1-2006
Unemp	-7.1**	6-1-2007	-82.07**	6-1-2007	-6.93**	6-1-2007	-7.9**	2-1-2007	-106.09**	2-1-2007	-7.89**	2-1-2007
Permits	-7.15**	9-1-2007	-144.45**	8-1-2007	-9.81**	11-1-2007	-5.78**	8-1-2007	-139.99**	6-1-2007	-9.64**	6-1-2007
Starts	-6.98**	9-1-2007	-148.5**	6-1-2007	-9.81**	6-1-2007	-5.36**	7-1-2006	-80.97**	1-1-2007	-7.05**	1-1-2007
UWI	-7.07**	8-1-2013	-48.62**	11-1-2014	-7.33**	3-1-2012	-6.83**	9-1-2008	-43.22*	9-1-2008	-6.18**	9-1-2008
NHPI	-8.48**	9-1-1992	-229.6**	9-1-1991	-12.67**	9-1-1991	-5.29**	7-1-1996	-112.69**	11-1-1996	-8.25**	11-1-1996
Volume	-7.6**	7-1-2008	-132.61**	6-1-1987	-8.58**	6-1-1989	-6.61**	12-1-2006	-129.07**	7-1-1985	-8.41**	7-1-1985
Completions [a]	-6.1**	06-1-2007	-143.48**	11-1-1989	-9.53**	11-1-1989	-6.83**	6-1-2006	-153.76**	5-1-1994	-10.06**	5-1-1994
Sales	-5.23**	9-1-2007	-70.32**	8-1-2007	-6.42**	8-1-2007	-4.91*	1-1-2006	-59.32**	7-1-1987	-5.55**	7-1-1987
Rate	-5.66**	6-1-2007	-85.46**	6-1-2007	-7.07**	6-1-2007	-5.9**	12-1-2006	-54.58**	1-1-2007	-5.53**	1-1-2007
Population	-5.83**	6-1-2007	-84.62**	6-1-2007	-7.2**	6-1-2007	-6.74**	6-1-2007	-90.04**	1-1-2007	-7.58**	1-1-2007
New List.	-5.45**	6-1-2007	-86.72**	7-1-1997	-7.01**	6-1-2007	-5.05**	8-1-2005	-73.53**	7-1-1997	-6.44**	7-1-1997
Mortcred	-5.79**	12-1-2006	-73.14**	12-1-2006	-6.51**	12-1-2006	-4.75*	9-1-2006	-34.99	7-1-2006	-4.42	9-1-2006
Totcred	-6.49**	5-1-2007	-86.08**	4-1-2007	-7.32**	4-1-2007	-5.53**	12-1-2006	-44.96*	9-1-2006	-5.36**	1-1-2007
Earnings	-9.42**	8-1-2007	-100.09**	6-1-2007	-8.2**	6-1-2007	-9.97**	4-1-2007	-129.18**	4-1-2007	-9.94**	4-1-2007
Income	-9.18**	8-1-2007	-122.4**	6-1-2007	-9.06**	6-1-2007	-9.98**	2-1-2007	-140.01**	2-1-2007	-9.96**	2-1-2007

[a] Levels were used for Regina.

	Winnipeg						*Ottawa*					
	ADF	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**	**ADF**	**BrkAdf**	**Za**	**BrkZa**	**Zt**	**BrkZt**
Employment	-4.11	12-1-2004	-37.79	11-1-2004	-4.57	11-1-2004	-5	3-1-1996	-60.64**	1-1-2001	-5.85**	1-1-2001
Dwellings	-5.34**	6-1-2007	-146.6**	10-1-1996	-10.1**	10-1-1996	-3.95	2-1-2005	-36.7	1-1-2005	-4.51	1-1-2005
Unabsorbed	-4.26	6-1-2006	-33.62	10-1-2001	-4.16	10-1-2001	-5.2**	1-1-2003	-43.7*	1-1-2003	-4.85*	1-1-2003
Unemp	-5.44**	5-1-2005	-48.58**	5-1-2005	-5.2**	5-1-2005	-4.58	10-1-2003	-36.36	11-1-2002	-4.28	11-1-2002
Permits	-7.03**	6-1-2007	-207.74**	12-1-1996	-12.57**	12-1-1996	-5.18**	2-1-2005	-42.27*	1-1-2005	-4.84*	1-1-2005
Starts	-4.9*	6-1-2006	-99.52**	4-1-1996	-7.83**	4-1-1996	-3.25	7-1-2005	-46.97*	1-1-2005	-5.06**	1-1-2005
UWI	-4.27	6-1-2006	-30.66	6-1-2006	-4.04	6-1-2006	-4.6	2-1-1991	-38.48	4-1-2002	-4.59	4-1-2002
NHPI	-7.25**	8-1-1987	-140.87**	12-1-1987	-9.34**	12-1-1987	-3.74	7-1-2009	-24.53	11-1-1990	-3.65	9-1-2002
Volume	-5.78**	11-1-2008	-103.89**	12-1-1992	-7.41**	12-1-1992	-3.33	5-1-2005	-91.01**	10-1-2010	-7.04**	1-1-2009
Completions	-4.82*	6-1-2006	-73.65**	10-1-1994	-6.45**	10-1-1994	-4.83*	6-1-2003	-64.13**	3-1-2004	-6.05**	3-1-2004
Sales	-4.03	6-1-2007	-38.92	6-1-2007	-4.62	6-1-2007	-5.07**	12-1-2005	-53.51**	11-1-2008	-5.34**	11-1-2008
Rate	-4.79*	6-1-2005	-54.13**	6-1-2005	-5.46**	6-1-2005	-4.26	12-1-1985	-31.85	11-1-2002	-4.15	11-1-2002
Population	-4.04	5-1-2005	-37.84	5-1-2004	-4.52	5-1-2005	-5.59**	8-1-2001	-77.16**	7-1-2001	-6.73**	7-1-2001
New List.	-4.47	6-1-2006	-50.29**	6-1-2006	-5.25**	6-1-2006	-3.63	2-1-2004	-48.1**	6-1-1999	-5.11**	6-1-1999
Mortcred	-6.65**	6-1-2006	-80.06**	6-1-2005	-6.8**	6-1-2005	-5.96**	6-1-2003	-61.18**	6-1-2003	-5.86**	6-1-2003
Totcred	-6.85**	6-1-2006	-79.29**	4-1-2006	-6.87**	4-1-2006	-6.31**	10-1-2008	-55.32**	11-1-2008	-6.4**	11-1-2008
Earnings	-7.11**	2-1-2013	-79.25**	2-1-2013	-7.08**	2-1-2013	-6.63**	3-1-2011	-56.14**	5-1-2011	-6.44**	3-1-2011
Income	-6.76**	12-1-2003	-72.06**	12-1-2003	-6.52**	12-1-2003	-4.19	10-1-2001	-30.94	9-1-2001	-4.04	9-1-2001

The symbol "*" represents rejection of the null hypothesis at the 10% level, and "**" represents rejection at the 5% level or lower.

What is striking is that even though we have allowed for a regime shift, we still cannot find several cointegration relationships for the cities of Vancouver and Toronto, whereas for the other cities this methodology reveals a great deal of cointegration. This raises serious doubts about whether or not the GVA and GTA housing prices have *ever* been cointegrated with more than a handful of fundamentals. If this is the case, assessing the presence of a bubble in those markets will be even more difficult, as the markets do not seem to be following any particular factor in the long-run.

In the next section, we push our investigation further by moving towards multivariate cointegration tests. Since the pairwise method reveals few cointegration relations in the GVA and GTA, we test for cointegration in these areas when multiple independent variables are specified. Despite the fact that the pairwise approach allows for a more granular perspective, it is possible that some selected factors may be cointegrated with average housing prices when taken together. If the opposite is true, then little evidence will remain in favour of any cointegration in Vancouver and Toronto. We do not dig deeper into the other cities as these markets were relatively more tranquil, and because substantial cointegration can be found when a regime shift is allowed.

6 Two Outliers: Vancouver and Toronto

6.1 Multivariate Analysis

We pursue our investigation of the long-run relationships in the Vancouver and Toronto housing markets by performing additional Gregory-Hansen tests, but this time using four covariates (the maximum amount of covariates for which critical values have been computed in Gregory and Hansen (1996)). Since we are restricted in the amount of factors for which we can use the test, we selected the following six variables based on the literature and our previous results:

a) Employment
b) Unemployment
c) Permits
d) Mortgage rate
e) Construction wages
f) Population

Employment and unemployment are both selected to capture overall economic expansion, and are thus not included in the tests together. Hence, we can run the tests eight times for each city, i.e. with (un)employment and three of the remaining four factors. Although this procedure is arguably singular, it provides a good idea of where a significant cointegration might have occurred, as can be seen from Tables 3 and 4.

Table 3 : Multivariate Gregory-Hansen Tests for Vancouver

Model		ADF	BrkAdf	Za	BrkZa	Zt	BrkZt
Employment, excluding:							
V.1	Mortgage rate	-7.69**	10-1995	-94.39**	03-1993	-7.53**	03-1993
V.2	Permits	-5.71	04-2004	-57.89	04-2004	-5.62	04-2004
V.3	UWI	-8.25**	06-1905	-108.16**	11-2005	-8.18**	11-2005
V.4	Population	-8.46**	08-2004	-121.87**	10-2008	-8.92**	10-2008
Unemployment, excluding:							
V.5	Mortgage rate	-7.37**	02-2006	-97.33**	11-2007	-7.77**	11-2007
V.6	Permits	-5.41	03-2002	-51.02	03-2002	-5.34	03-2002
V.7	UWI	-8.60**	10-2005	-117.44**	11-2005	-8.60**	11-2005
V.8	Population	-7.32**	12-2003	-85.12**	12-1994	-7.13**	12-1994

"*" represents rejection of the null hypothesis at the 10% level, and "**" represents rejection at the 5% level or lower.

Table 4 : Multivariate Gregory-Hansen Tests for Toronto

Model		ADF	BrkAdf	Za	BrkZa	Zt	BrkZt
Employment, excluding:							
T.1	Mortgage rate	-4.67	03-2003	-135.16**	02-2002	-8.68**	02-2002
T.2	Permits	-6.17	03-2003	-80.14	08-2000	-6.43	02-2004
T.3	UWI	-3.37	01-2003	-101.87**	08-2000	-6.97**	08-2000
T.4	Population	-6.57**	01-2005	-106.14**	08-2000	-7.34**	05-2003
Unemployment, excluding:							
T.5	Mortgage rate	-4.39	02-2002	-133.73**	02-2002	-8.71**	02-2002
T.6	Permits	-5.42	11-2002	-85.35**	04-2004	-6.76**	04-2004
T.7	UWI	-3.46	08-1999	-103.99**	11-2000	-7.09**	11-2000
T.8	Population	-6.62**	05-1997	-91.60**	11-2002	-6.52**	10-1996

"*" represents rejection of the null hypothesis at the 10% level, and "**" represents rejection at the 5% level or lower.

Based on the model with employment, we can identify a significant cointegration with regime shift in Vancouver around the mid-90's and between August 2004 and

October 2008. The first period is too small to allow for statistical analysis, but the second period suggests that "something" happened prior to the financial crisis. The model using unemployment tells a similar story, this time with a regime shift probably occurring between December 2003 and November 2007.

In Toronto, the model with employment identifies a significant cointegration with regime shift between August 2000 and January 2005. Using unemployment, the break seems to have occurred between November 2000 and April 2004 (discarding the breaks in the 90's). Again, these results point towards a regime shift occurring somewhere before the financial crisis, although earlier than in Vancouver.

Our final objective being to determine only *one* specific date for our cointegration regime shift, we retain the models yielding significant test results and a large enough time frame (that is, models 3, 4, 5, 7, 8 for Vancouver, and models 1, 3, 4, 5, 6, 7 for Toronto). We continue the analysis by estimating our models explicitly using appropriate regression techniques. Since regressions with $I(1)$ variables cannot be estimated by OLS, inference being inadmissible with these standard errors, we use fully-modified OLS to ensure valid inference, even in the presence of endogeneity and serial correlation (Phillips and Hansen, 1990).

6.2 Restricted FM-OLS Cointegration Tests

Table 5 presents five long-run models for Vancouver and six for Toronto, together with Engle-Granger and Phillips-Ouliaris *p-values* of the τ and z statistics. These models are said to be "restricted" because they are still limited to a maximum of four covariates in order to be coherent with the previous GH test results. Models extending to more factors are assessed in the next section. For now, we are not

Table 5 : Restricted FM-OLS Cointegration Tests

VANCOUVER

Model	(V.3)		(V.4)		(V.5)		(V.7)		(V.8)	
Breakpoint	2005m1		2004m8		2006m2		2005m10		2003m12	
Test p-values	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
EG Tau	0.0490**	0.0854*	0.0272**	0.0070**	0.5787	0.0135**	0.0385**	0.0363**	0.1050	0.1149
EG Z	0.0122**	0.1240	0.0050**	0.0060**	0.3353	0.0179**	0.0082**	0.0336**	0.1185	0.0877*
PO Tau	0.0001**	0.1130	0.0001**	0.0073**	0.1102	0.0142**	0.0000**	0.0481**	0.1240	0.0036**
PO Z	0.0000**	0.1851	0.0000**	0.0069**	0.0670*	0.0210**	0.0000**	0.0530*	0.1500	0.0045**

TORONTO

Model	(T.1)		(T.3)		(T.4)		(T.5)		(T.6)		(T.7)	
Breakpoint	2002m2		2000m8		2003m5		2002m2		2004m4		2000m11	
Test p-values	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
EG Tau	0.0780*	0.1366	0.0000**	0.9791	0.0213**	0.7611	0.1680	0.1337	0.2198	0.4495	0.6703	0.9768
EG Z	0.0068**	0.0246**	0.0000**	0.7777	0.0035**	0.3760	0.0106**	0.0243**	0.1862	0.1714	0.3918	0.7063
PO Tau	0.0000**	0.2277	0.0000**	0.6200	0.0000**	0.7421	0.0001**	0.2230	0.2875	0.3571	0.0003**	0.8089
PO Z	0.0000**	0.0569*	0.0000**	0.2263	0.0000**	0.3572	0.0000**	0.0561*	0.2636	0.1181	0.0002**	0.3401

Constant and seasonal dummies included. P-values reported.

focusing on the coefficients of these regressions, as we have not yet identified which model and breakpoint are appropriate.

When we look at the test results for Vancouver, we see that we are starting to narrow down our options seriously. For the models using employment (3 and 4), August 2004 appears to be the best breakpoint to ensure that cointegration remains before and after the regime shift. This is important in order to assess how the cointegrating vector has changed, since a non-cointegrated regression would be prone to spurious regression problems. For the models using unemployment (5, 7 and 8), the best candidate for a breakpoint is October 2005, as little evidence of a cointegration prior to the other potential breaks is found.

In Toronto, models 1 and 5 appear to provide the best breakpoint for the specifications with employment and unemployment respectively. This breakpoint would be February 2002 for both types of model. However, we note that overall the results are not as in favour of cointegration as in Vancouver, with many test statistics not rejecting the null hypothesis of no cointegration, especially in the second regime. This

is consistent with our previous results from the GH tests, and it reinforces our doubts about Toronto's housing market.

6.3 Estimating the Cointegrating Vectors

Ideally, one would like to use all our potential factors in the analysis together. Based on the results from the previous section, we choose August 2004 and October 2005 as breakpoints for a regime shift analysis in Vancouver, and February 2002 for our breakpoint in Toronto. Our analysis so far has tried to remain as agnostic as possible in terms of model specification. Now, we extend our previous models by using a full set of covariates that are strongly supported by the literature. This will provide estimates of the cointegrating vectors in our two metropolia, allowing us to examine how they have changed. Specifically, our models take the following forms

$$Avg.\ Price_t = \beta_0 + \beta_1 E_t + \beta_2 P_t + \beta_3 BP_t + \beta_4 UWI_t + \beta_5 R_t + \gamma S + \epsilon_t \qquad (1)$$

$$Avg.\ Price_t = \beta_0 + \beta_1 U_t + \beta_2 P_t + \beta_3 BP_t + \beta_4 UWI_t + \beta_5 R_t + \gamma S + \eta_t \qquad (2)$$

where E_t and U_t are (un)employment, P_t is population, BP_t is building permits, UWI_t is the construction-wage index, R_t is the five-year conventional mortgage rate, and S is a vector controlling for monthly seasonality. Tables 6 and 7 report the results of these extended estimations. The second panel adds *mortgage credit* to test the importance of credit-variables. Additionally, we include a TSX/S&P composite index of stock market performance for Toronto. Since it is Canada's financial hub, this variable could help explaining the long-run dynamics of this city's housing prices (adding this factor to Vancouver was tested but results were virtually unchanged).

This variable represents the composite price of the index on a monthly basis. For simplicity, the models have been re-numbered from 1 to 4 for each city.

Table 6 : Extended FM-OLS Cointegration Models for Vancouver

Panel A

Model 1 Break in 2004m8			Model 2 Break in 2005m10		
	Pre-	Post-		Pre-	Post-
Employment	0.5501	2.3366**	Unemployment	0.0347	0.0762
	(0.3595)	(0.0009)		(0.5315)	(0.3935)
Population	0.2370	-0.2930	Population	0.7005**	2.3587**
	(0.6475)	(0.7267)		(0.0000)	(0.0000)
Permits	0.1737**	0.1213**	Permits	0.1928**	0.0876**
	(0.0000)	(0.0001)		(0.0000)	(0.0066)
UWI	0.3510	1.7982**	UWI	-0.4841	-0.3184
	(0.3806)	(0.0000)		(0.1289)	(0.6478)
Mortgage Rate	0.0325**	-0.0102	Mortgage Rate	0.0349**	0.0027
	(0.0000)	(0.5166)		(0.0000)	(0.8803)
Test p-values			*Test p-values*		
EG Tau	0.0604	0.0252	EG Tau	0.1292	0.0815
EG Z	0.0139	0.0238	EG Z	0.0418	0.0837
PO Tau	0.0003	0.0281	PO Tau	0.0005	0.1085
PO Z	0.0001	0.0297	PO Z	0.0004	0.1308

Panel B

Model 3 Break in 2004m8			Model 4 Break in 2005m10		
	Pre-	Post-		Pre-	Post-
Employment	0.4118	1.0465	Unemployment	0.0246	0.1936**
	(0.5063)	(0.1441)		(0.6885)	(0.0167)
Population	0.2439	1.5053*	Population	0.5794**	3.0589**
	(0.6432)	(0.0925)		(0.0000)	(0.0000)
Permits	0.1853**	0.0821**	Permits	0.2009**	0.0551*
	(0.0000)	(0.0044)		(0.0000)	(0.0514)
UWI	-0.0114	1.7126**	UWI	-0.7548**	-0.2211
	(0.9806)	(0.0000)		(0.0433)	(0.7134)
Mortgage Rate	0.0310**	-0.0105	Mortgage Rate	0.0328**	0.0064
	(0.0000)	(0.4661)		(0.0000)	(0.6821)
Mortgage Credit	-0.0058*	0.0214**	Mortgage Credit	-0.0044	0.0273**
	(0.0745)	(0.0014)		(0.2238)	(0.0001)
Test p-values			*Test p-values*		
EG Tau	0.1064	0.0255	EG Tau	0.2360	0.0327
EG Z	0.0278	0.0236	EG Z	0.0904	0.0338
PO Tau	0.0008	0.0268	PO Tau	0.0019	0.0389
PO Z	0.0005	0.0273	PO Z	0.0013	0.0478

Constant and seasonal dummies included. "" represents rejection of the null hypothesis at the 10%* level, and "**" represents rejection at the 5% level or lower.

For Vancouver, all models confirm that a long-run relationship exists between the average housing price and building permits, although the impact of the latter

has decreased recently, sometimes by more than 70%. The mortgage rate had a positive but small impact in the first regimes, challenging the belief according to which increasing mortgage rates should have a strictly negative influence on demand, and thus home prices. Nevertheless, this factor looses cointegration in the recent regimes, suggesting that central banks now have little influence on housing prices whatsoever. Population seems to be the main driver of prices, except in model 1 where employment plays the largest role. Unemployment, on the other hand, does not seem to be a good predictor of housing prices in the long-run. Models using employment indicate that the construction-wage index has become cointegrated in the recent period, with a substantial positive impact on prices.

Mortgage credit proves to be a significant predictor in Vancouver's recent regimes, with a positive influence on housing prices. This suggests that households might be relying more heavily on credit in order to meet their financial obligations in terms of housing. When we look at the test statistics for cointegration, we observe that all models and regimes present a decent amount of evidence supporting a cointegration in Vancouver. This is particularly true for the specifications using employment instead of unemployment, with a break in the cointegration in August 2004.

In Toronto, population also plays a much larger role today, with employment and unemployment being good predictors only prior to 2002. In particular, the unemployment variable has the expected negative sign in the first regime. The coefficient on building permits has decreased through the regimes, but not as much as in Vancouver. Surprisingly, the construction-wage index has a significant, but negative coefficient. When looking at the wage series, we notice that the index has not been trending upwards continuously since the 90's, contrarily to the housing price series. This is likely to explain the negative coefficient found. The mortgage rate has a behaviour similar to Vancouver's, with a small positive impact in the past, but insignificant in

Table 7 : Extended FM-OLS Cointegration Models for Toronto

Panel A

Model 1 Break in 2002m2			Model 2 Break in 2002m2		
	Pre-	Post-		Pre-	Post-
Employment	1.3134**	-0.3996	Unemployment	-0.0972**	0.0116
	(0.0000)	(0.3723)		(0.0000)	(0.8614)
Population	-1.5208**	3.8836**	Population	0.0729	3.4538**
	(0.0000)	(0.0000)		(0.5749)	(0.0000)
Permits	0.1076**	0.0507**	Permits	0.1205**	0.0529**
	(0.0000)	(0.0216)		(0.0000)	(0.0182)
UWI	-1.0666**	-2.7470**	UWI	-2.1584**	-2.5636**
	(0.0004)	(0.0000)		(0.0000)	(0.0000)
Mortgage Rate	0.0093**	-0.0063	Mortgage Rate	0.0052	-0.0080
	(0.0003)	(0.3360)		(0.1174)	(0.2521)
Test p-values			*Test p-values*		
EG Tau	0.0000	0.3152	EG Tau	0.2084	0.3657
EG Z	0.0000	0.0761	EG Z	0.0135	0.0937
PO Tau	0.0000	0.4329	PO Tau	0.0001	0.4864
PO Z	0.0000	0.1375	PO Z	0.0000	0.1624

Panel B

Model 3 Break in 2002m2			Model 4 Break in 2002m2		
	Pre-	Post-		Pre-	Post-
Employment	1.2856**	-0.4667	Unemployment	-0.1118**	0.0239
	(0.0000)	(0.2964)		(0.0000)	(0.7397)
Population	-1.1671**	3.9719**	Population	0.4051**	3.4264**
	(0.0000)	(0.0000)		(0.0464)	0.0000*
Permits	0.0808**	0.0535**	Permits	0.1020**	0.0571**
	(0.0000)	(0.0125)		(0.0000)	(0.0091)
UWI	-0.7833**	-2.6234**	UWI	-1.6679**	-2.4899**
	(0.0082)	(0.0000)		(0.0000)	(0.0000)
Mortgage Rate	0.0104**	-0.0091	Mortgage Rate	0.0051	-0.0117
	(0.0000)	(0.2557)		(0.1249)	(0.1415)
Mortgage Credit	0.0049**	0.0039	Mortgage Credit	0.0063**	0.0031
	(0.0040)	(0.3259)		(0.0029)	(0.4467)
TSX/S&P	-0.0352	-0.0204	TSX/S&P	-0.0613	-0.0007
	(0.2292)	(0.6898)		(0.1338)	(0.9888)
Test p-values			*Test p-values*		
EG Tau	0.0002	0.6060	EG Tau	0.0027	0.5933
EG Z	0.0001	0.2283	EG Z	0.0012	0.2203
PO Tau	0.0001	0.7187	PO Tau	0.0020	0.7053
PO Z	0.0000	0.3427	PO Z	0.0008	0.3307

Constant and seasonal dummies included. "" represents rejection of the null hypothesis at the 10%* level, and "**" represents rejection at the 5% level or lower.

the recent period.

Mortgage credit and the TSX/S&P composite index have little importance in Toronto. When we look at the test statistics, we notice that all models appear cointegrated with housing price in the *first* regime, although cointegration is mostly

rejected in the second regime. In contrast with Vancouver, where the cointegration changed but remained present, Toronto's market does not seem to remain cointegrated in the recent period. This confirms our previous doubts, and suggests that a bubble-like phenomenon might be present in this city.

In line with this, it is important to distinguish between a *bubble*, and an *excess-valuation* relatively to the pre-crisis period. In Vancouver, despite the facts that the price series shows a substantial and sustained growth in recent years, and that few factors appear to be cointegrated when taken individually, the prices do seem to follow some selected variables in the long-run when these are considered together. To support the claim of a bubble, one would need to find significant long-run links in the past that vanished recently, which doesn't seem to be the case in Vancouver. On the other hand, Toronto corresponds quite well to this description, with a substantial and sustained growth in prices, few individual cointegration relationships, and a multivariate cointegration that disappears during the pre-crisis boom.

To answer the question "*how much would housing cost today if the long-run relationships wouldn't have changed?*", forecasts over the second periods were computed using the first regime estimates for all models. Figures 5 and 6 show that average prices would be substantially lower than actual prices. In Vancouver, results indicate that recent prices are 36 to 42% higher on average than what is predicted by the first regime cointegrating vector. In Toronto, this excess-valuation varies from 36 to 41%. These results are in line with those in Head and Lloyd-Ellis (2016) in the case of Vancouver, but are quite superior for Toronto (the authors find at most 18% excess-valuation in Toronto). Still, the fact that the shift in the cointegrating vector has had a tremendous impact on today's prices is manifest.

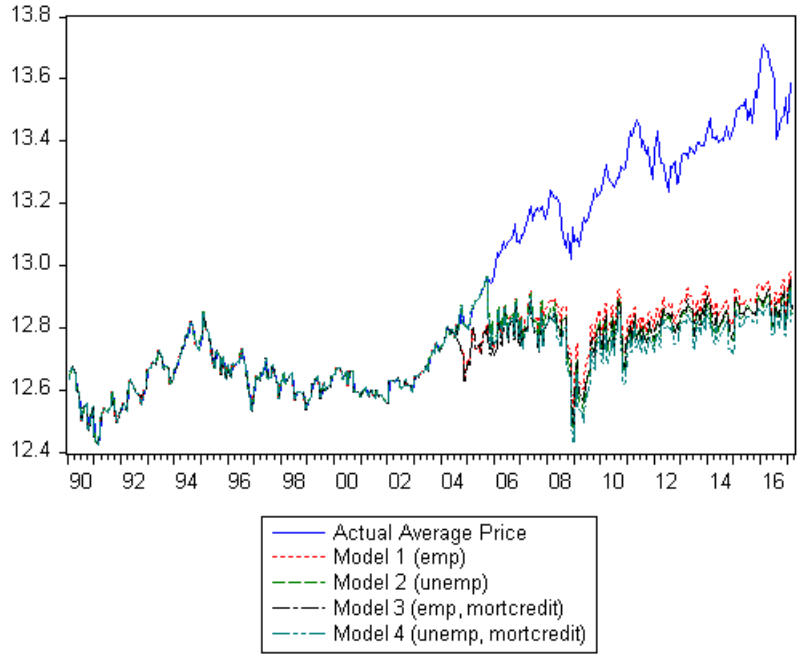


Figure 5 – Excess-valuation in Vancouver

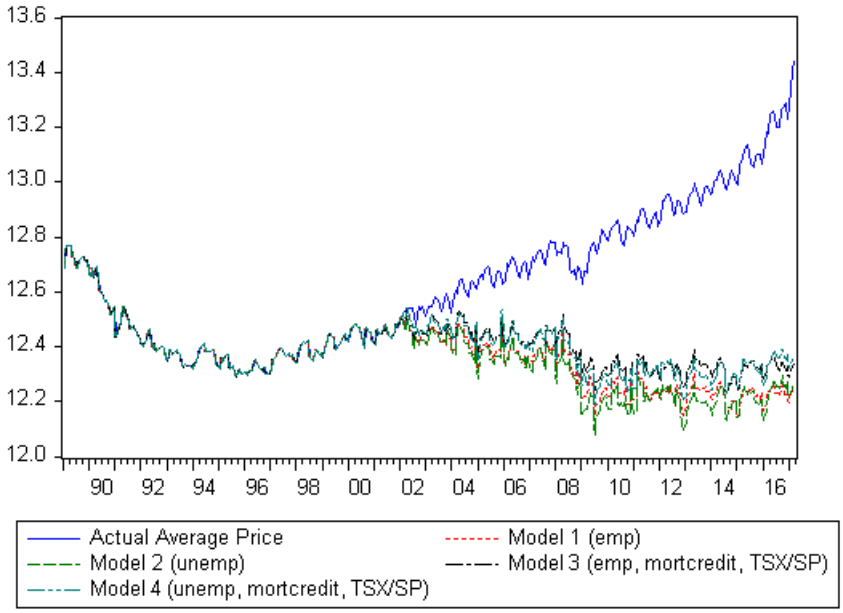


Figure 6 – Excess-valuation in Toronto

6.4 Comparing with the Housing Price Indexes

To conclude this study, we ran a few additional models using our two quality-adjusted price indexes as the dependent variable. Doing so restricts our analysis to the post-2005 period due to data availability, but it will serve as a good robustness check for our second regime estimates of the cointegrating vectors. Tables 8 and 9 present the estimation results.

Table 8 : Models w/ Housing Price Indexes for Vancouver

Estimation period: 2005m1-2017m3

	MLS	Brookfield	MLS	Brookfield
Employment	5.2431**	4.0910**	4.3914**	3.1410**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Population	-2.7112**	-1.1821**	-1.5514**	0.1191
	(0.0001)	(0.0433)	(0.0347)	(0.8379)
Permits	0.0297	0.0365*	0.0044	0.0087
	(0.2029)	(0.0702)	(0.8464)	(0.6339)
UWI	0.8513**	0.7431**	0.7614**	0.6620**
	(0.0101)	(0.0092)	(0.0139)	(0.0076)
Mortgage Rate	-0.0047	-0.0014	-0.0056	-0.0028
	(0.6992)	(0.8917)	(0.6261)	(0.7574)
Mortgage Credit			0.0133**	0.0154**
			(0.0122)	(0.0003)
Test p-values				
EG Tau	0.0904	0.0411	0.9710	0.6844
EG Z	0.0320	0.0167	0.8384	0.0659
PO Tau	0.6565	0.4962	0.7993	0.4542
PO Z	0.6018	0.4825	0.7633	0.4489

Constant and seasonal dummies included. "" represents rejection of the null hypothesis at the* 10% level, and "**" represents rejection at the 5% level or lower.

For Vancouver, the role of employment appears to be confirmed and reinforced, even when adding mortgage credit to the regression. In contrast, population now seems to have a *negative* long-run influence on housing prices, a rather puzzling finding. Building permits and the mortgage rate are mostly insignificant, which is in line with our previous models. Construction-wages and mortgage credit seem to have a significant positive influence on home prices, again confirming our other results. Other variables such as labour income, the NHPI, and the average number of days before a sale, were added to the models, but the effect was only to remove

any evidence of cointegration. With respect to the latter, the *p-values* of the tests presented in the table show that the specification without mortgage credit presents some evidence of cointegration, whereas models including mortgage credit do not seem to be cointegrated.

Table 9 : Models w/ Housing Price Indexes for Toronto

Estimation period: 2005m1-2017m3

	MLS	Brookfield	MLS	Brookfield
Employment	-0.4697	-0.2389	-0.4760	-0.2568
	(0.2435)	(0.5121)	(0.2531)	(0.4939)
Population	3.7448**	3.5448**	3.7361**	3.5456**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Permits	0.0247	0.0118	0.0245	0.0113
	(0.2334)	(0.5297)	(0.2425)	(0.5495)
UWI	-3.0363**	-2.7019**	-3.0176**	-2.6587**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Mortgage Rate	-0.0078	-0.0042	-0.0088	-0.0054
	(0.2968)	(0.5315)	(0.2449)	(0.4249)
Mortgage Credit			0.0004	0.0008
			(0.9188)	(0.7998)
Test p-values				
EG Tau	0.9375	0.9301	0.9797	0.9773
EG Z	0.7278	0.7962	0.8723	0.9150
PO Tau	0.9767	0.9654	0.9934	0.9898
PO Z	0.8708	0.8885	0.9529	0.9608

Constant and seasonal dummies included. "" represents rejection of the null hypothesis at the* 10% level, and "**" represents rejection at the 5% level or lower.

In Toronto, the picture is substantially different. Employment doesn't seem to be significant, but instead population has the strongest positive influence. Building permits and the mortgage rate are not significant, just like mortgage credit. The construction-wage index appears to be significant, but with a negative coefficient. Although surprising, this result is in line with what was found when using the average housing price as the dependent variable. However, it is important to note that not a single specification for Toronto shows evidence of cointegration. Adding our TSX/S&P index or other potential factors couldn't change this result either.

As discussed in the previous section, cointegration in Toronto for the recent period has very little support based on the tests conducted. Despite the fact that our

dataset includes many variables, it has been impossible so far to gather convincing evidence that housing prices in Toronto have been supported in the long-run by some underlying fundamentals.

In our review of the literature, we identified three criteria in favour of a bubble-like phenomenon, namely (1) strong and sustained price increases, (2) purchasing decisions based on positive expectations about the future, and (3) a dislocation between price variations and movements in the underlying fundamentals. Although the second criterion was not addressed in this essay, one must recognize that Toronto's housing market meets the two other criteria fairly clearly. In particular, the fact that evidence supports a cointegration prior to 2002, but not after, underlines the idea of a *dislocation* in this city. In contrast, although Vancouver's housing market appeared dislocated from any fundamentals when studied individually, a convincing amount of evidence shows that home prices were and are still supported by a subset of factors in the long-run. What changed, however, is the nature of the cointegrating relationship, which is now more influenced by employment, population and credit, and independent of the mortgage rate.

7 Concluding Remarks

Several conclusions can be drawn from the research presented in this essay. First, evidence shows that the housing markets in Regina, Saskatoon, Winnipeg, Calgary, Edmonton, and Ottawa have been and are still characterised by prices supported by long-run economic determinants, although many relationships appear to have changed in the years preceding the 2008 financial crisis. This is coherent with the sharp rise in prices that can be observed around 2005 in most of these cities.

In Vancouver, cointegration with underlying factors is rather weak when these are considered individually, but a reasonable amount of evidence shows that prices in Vancouver are adequately supported today. Again, the cointegrating vector changed substantially before and after August 2004, with employment playing a much larger role in the long-run dynamics of housing prices today.

In contrast, housing prices in Toronto appear only weakly cointegrated with economic variables prior to February 2002, and completely non-cointegrated after this date. Adding an index of stock market performance did not improve the results, in line with findings in Sutton (2002). It is possible that this striking lack of cointegration in Toronto is due to a misspecification problem. However, such results were not found for any other of our eight cities, even though many variables were tested. Based on the criteria identified in the literature to detect a price bubble, it is indisputable that Toronto's housing market shows many symptoms of a bubble-like phenomenon.

More generally, population seems to have a much bigger impact on housing prices in Vancouver and Toronto today than prior to the financial crisis. Lack of data prevents us from identifying precisely if this is due to population density issues, excessive immigration (in terms of level and wealth), or other reasons. The sustained rise in single-person households experienced in the last decade may also contribute to building-up housing prices, as more units are required for the same amount of people (Statistics Canada, 2017). Our findings show that the mortgage rate is a relatively minor factor in the determination of housing prices, and that it is not cointegrated any more in most of our eight cities. This reinforces the argument according to which central banks are now devoid of means to stabilize the housing market.

Regarding the importance of credit-variables, our results suggest that they play a small but significant long-run role in many regions. Of course, using more specific

provincial or municipal data on credit conditions and households indebtedness would provide a much better picture. Since indebtedness is an important concern in Canada, future research should put more efforts in including credit-factors when studying the housing market in Canada.

Finally, it is still unclear as to *why?* the cointegrating vectors shifted so much. Future research should definitely assess this question, since discovering what triggered this change could certainly help governments and regulators in designing efficient policies to ensure stable housing markets across Canada.

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Appendix A. Data Sources

ID	Variable	Units	Frequency	Start	End	Level	Source
1	MLS price index	Index	monthly	2005-01-01	2017-04-01	metro + agg	MLS
2	Dollar Volume	$	monthly	1980-01-01	2017-04-01	metro	CREA*
3	Unit Sales	Units	monthly	1980-01-01	2017-04-01	metro	CREA
4	New listings	Units	monthly	1980-01-01	2017-04-01	metro	CREA
5	Avg Price	$	monthly	1980-01-01	2017-04-01	metro	CREA
6	Building permits	$ x 1000	monthly	1989-01-01	2017-03-01	metro	CANSIM 026-0006
7	Permit dwellings	Units	monthly	1989-01-01	2017-03-01	metro	
8	Population	Units x 1000	monthly	1987-03-01	2017-04-01	metro	
9	Labour Force	Units x 1000	monthly	1987-03-01	2017-04-01	metro	
10	Employment	Units x 1000	monthly	1987-03-01	2017-04-01	metro	CANSIM 282-0090, 282-0116, 282-0135. 3 months MA
11	Unemployment	Units x 1000	monthly	1987-03-01	2017-04-01	metro	
12	Unemp. rate	%	monthly	1987-03-01	2017-04-01	metro	
13	Participation rate	%	monthly	1987-03-01	2017-04-01	metro	
14	Emp. rate	%	monthly	1987-03-01	2017-04-01	metro	
15	CPI all items	Index	monthly	1980-01-01	2017-03-01	metro	CANSIM
16	New Housing Price Index	Index	monthly	1981-01-01	2017-03-01	metro	CANSIM
17	Construction Union Wages	Hourly wage $	monthly	1981-01-01	2017-03-01	metro	CANSIM
18	Labour Income	$	monthly	1997-01-01	2016-12-01	prov	CANSIM
19	Weekly Earnings	$	monthly	2001-01-01	2017-03-01	prov	CANSIM
20	Unabsorbed inventory	Units	monthly	1988-06-01	2017-04-01	metro	CANSIM 027-0038
21	Housing starts, completions	Units	monthly	1980-01-01	2017-04-01	metro	CANSIM 027-0048
22	Average rent	$	annual	1987	2017	metro	CANSIM 027-0040
23	Total Household credit	Annualized 3 month % change	monthly	1990-01-01	2017-04-01	agg	BOC**
24	Mortgage lending credit	Annualized 3 month % change	monthly	1990-01-01	2017-04-01	agg	BOC
25	Active listings	Units	monthly	2005-01-01	2017-04-01	Vancouver	REBGV***
26	Avg Days on the market	Days	monthly	2005-01-01	2017-04-01	Vancouver	REBGV
27	Nb of sales	Units	monthly	2005-01-01	2017-04-01	Vancouver	REBGV
28	Price index	Index	monthly	2005-01-01	2017-04-01	metro	Brookfield RPS
29	5 yr mortgage rate	Rate	monthly	1980-01-01	2017-04-01	agg	CANSIM
30	TSX/S&P index	Price Level	monthly	1980-01-01	2017-04-01	agg	Investing.com

* Canadian Real Estate Association ** Bank of Canada *** Real Estate Board of Greater Vancouver.

Appendix B. Unit Root Tests

Unit Root Tests

	Vancouver				Toronto			
	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)
ADF (p-values)	0.8938	0.0000	0.4710	0.0000	0.9750	0.0383	0.6444	0.1125
PP (p-values)	0.8529	0.0000	0.2657	0.0000	0.9908	0.0000	0.9205	0.0000
KPSS (statistics)	2.3910	0.0487	0.2450	0.0331	2.0888	0.2314	0.2372	0.0997
KPSS 1% C.V.	0.7390	0.7390	0.2160	0.2160	0.7390	0.7390	0.2160	0.2160

	Edmonton				Calgary			
	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)
ADF (p-values)	0.9600	0.0000	0.2622	0.0000	0.9312	0.0000	0.2946	0.0000
PP (p-values)	0.9551	0.0000	0.3623	0.0000	0.9407	0.0000	0.3071	0.0000
KPSS (statistics)	1.7510	0.6359	0.4976	0.1613	1.9726	0.3849	0.4392	0.1178
KPSS 1% C.V.	0.7390	0.7390	0.2160	0.2160	0.7390	0.7390	0.2160	0.2160

	Regina				Saskatoon			
	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)
ADF (p-values)	0.9398	0.0000	0.6334	0.0000	0.9694	0.0000	0.4939	0.0000
PP (p-values)	0.9442	0.0000	0.6076	0.0000	0.9514	0.0000	0.3804	0.0000
KPSS (statistics)	1.7636	0.4115	0.4115	0.0887	1.8692	0.4677	0.5916	0.1095
KPSS 1% C.V.	0.7390	0.7390	0.2160	0.2160	0.7390	0.7390	0.2160	0.2160

	Winnipeg				Ottawa			
	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)	Level (C)	Diff (C)	Level (C+T)	Diff (C+T)
ADF (p-values)	0.9766	0.0008	0.8537	0.0017	0.8961	0.0000	0.6690	0.0000
PP (p-values)	0.9077	0.0000	0.4983	0.0000	0.8502	0.0000	0.2064	0.0000
KPSS (statistics)	1.7088	0.3080	0.3807	0.1752	2.2327	0.1176	0.4040	0.0881
KPSS 1% C.V.	0.7390	0.7390	0.2160	0.2160	0.7390	0.7390	0.2160	0.2160