Forecasting Canadian Housing Prices: Assessing the Forecasting Performance of ARIMA and GARCH Models

Andrew Lis
6533405

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Supervisor: Maral Kichian

ECO6999

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Abstract

This paper contributes to the existing literature on the Canadian real estate market by analyzing the forecastability of Canadian real estate prices with a particular focus on the regional markets of Vancouver, BC and Toronto, ON. Using a multitude of Canadian real estate data sets, a number of time-series forecasting models are estimated employing a rolling estimation methodology to generate Single-Step-Ahead and Multi-Step-Ahead forecasts. Mean Squared Prediction Errors and Mean Absolute Prediction Errors are then calculated and used to qualitatively compare the relative forecasting performances of the various models for each particular data set. The results suggest that no single model performs best across all data sets, but rather optimal forecasts are obtained by selecting models which are most suitable to the particular data series under consideration.

1 Introduction

Analyzing the forecastability of real estate prices in Canada is an important endeavor for many reasons. To begin with, housing represents a large portion of Canadian households' wealth and is thus directly tied to the greater macro economy through households' expenditures on housing, and housing related expenses. Over the past two decades, the value of real estate as a percentage of Canadians' personal disposable income has risen from 192% in 1990 to over 341% in 2012, for an overall increase of approximately 78%. [1] At such elevated multiples of disposable income, real estate values have the potential to significantly impact household consumption through the ability of households to service their mortgage related debts.

With the value of at least one major housing price index for Canada having increased by approximately 136% over roughly the last decade[2], it could be said that Canadian home owners have also experienced tremendous growth in the levels of their home equity. Thus, another important channel through which housing prices can affect the greater macro economy is via the ability for households to borrow against the equity in their homes. Furthermore, the fairly recent introduction of Home Equity Lines of Credit (HELOCs) by Canada's banks has made this type of borrowing even easier for Canadian households. This increased access to credit is somewhat of a

[1] Value is taken from Statistics Canada (2012), Table 378-0123 [StatsCan, 2012]
[2] Value is taken from Teranet – National Bank House Price Index, Composite 11, (2012). [Teranet-NB, 2012]

double edged sword however, since it allows households to increase consumption on the one hand, but on the other, it also exposes households to an increased level of vulnerability to negative economic shocks.

Understanding the factors which affect housing price dynamics also has important macroeconomic implications with respect to monetary and fiscal policy. Changes in housing prices can have a fairly significant impact on the value of the Consumer Price Index (CPI), as the weighting the CPI assigns to the value of owned accommodation is 16.81%[3], which is among the largest components of the index. Thus, dramatic swings in housing prices could affect the CPI fairly significantly, which could then in turn potentially have serious implications for monetary and fiscal policy in Canada. In this respect, it would be quite valuable to those at the reigns of monetary and fiscal policy in Canada to have the best tools available to forecast housing price dynamics.

While clearly not an exhaustive list, even the few aforementioned relationships between housing prices and the greater macro economy seem sufficient to justify rigorous study. Furthermore, with the recent commentary in the popular media speculating on the possibility that certain sectors of the Canadian Real Estate Market (CREM) may be in a 'bubble', it would seem that further research into the forecastability of housing price dynamics is warranted more so now than ever. With this in mind, this paper intends to contribute to this research by analyzing the forecastability of Canadian real estate prices by evaluating the relative forecasting performances of various time-series forecasting models.

Before delving into the analysis however, the paper begins by discussing some prescient issues relating to the real estate markets for which forecasts are generated in later sections of the paper, with the intention of providing some context to the analyses.

1.1 Vancouver Real Estate Market

Most recently, a great deal of media attention has been paid to the Vancouver Real Estate Market (VREM) as a result of the relatively high housing prices in the region. The general consensus among these commentators is that such high housing prices are of great cause for

[3] Value is taken from Statistics Canada (2012), Weighting Diagram of the Consumer Price Index - 2009 Basket at April 2011 Prices, Canada, Primary Classification. Retrieved from: http://www23.statcan.gc.ca/imdb-bmdi/document/2301_D48_T9_V1-eng.htm

concern, since the increasing housing values are clearly the leading force behind deteriorating measures of housing affordability in the region.

In order to get a rough sense of the level of housing affordability for the average family living in Vancouver, we can compare the average home price to average household income to derive an admittedly crude, but useful measure.[4] Thus, with the average single family home price in the Greater Vancouver region at $824,700 and the average family income value being $62,000 as at 2010, the value of housing as a multiple of family income stands at 13.3 for Vancouver.[5] By comparison, the same calculation using the average home and family income values for Canada of $339,058 and $64,100 yields a value of 5.3, for the national level.[6]

To provide some further context, as well as to get a sense of the relative scale of this metric, we can also compare the values of this metric with that of other cities elsewhere in the world. As a starting point, it is perhaps most instructive to report the price-to-income values for a few large American cities, due to the geographical proximity of Canada to the US. In this respect, as at 2010 the price-to-income ratios for Los Angeles, New York, and San Francisco are 7.5, 8.2, and 9.0 respectively.[7] In an effort to maintain comparability of this metric in a global context, we can look at the price-to-income ratios in a few large cities in other Commonwealth nations such as the UK and Australia. As at 2010, the price-to-income ratio for London[8] is 8.4, while for Sidney and Melbourne[9] the values are 4.3 and 4.6 respectively.

In comparing these figures, it can be seen that housing affordability in the Greater Vancouver region is considerably lower than at the national level, as well as internationally. While certainly far from being a perfect measure of housing affordability, it would appear that this metric lends some credibility to the argument being put forth that the Vancouver housing market exhibits signs of potentially being over-valued. Given that home prices in Vancouver appear to be at levels beyond the reach of the average domestic resident of British Columbia, or even Canada for that

[4] This measure is crude because there are many other determinants of housing affordability which are not captured by this metric. For example, one obvious determinant not included is the cost of borrowing in the particular region, which is clearly very important in determining the level of affordability.
[5] Values are taken from the Canadian Real Estate Association website, MLS Home Price Index [CREA, 2012], and Statistics Canada; Table 202-0408. [StatsCan, 2012]
[6] MLS Housing values are taken from the CMHC – Housing Market Outlook – Canada Highlights [CMHC, 2010], and Statistics Canada; Table 202-0408. [StatsCan, 2012]
[7] Values obtained from the National Association of Realtors [NAR, 2013] and Bureau of Economic Analysis [BEA, 2013] websites. See the References section for a more detailed description of these data sources.
[8] Value is obtained from the Greater London Authority website, Ratio of House Prices to Earnings by Borough, [GLA, 2013]. *NOTE:* This particular measure is calculated using the median income, not average income.
[9] Values obtained from the HIA Economics Group website, House Price to Income Ratio report, [HIA, 2010].

matter, those who analyze the real estate markets have been proposing many possible explanations for these high valuations.

In this regard, some analysts have put forth anecdotal evidence suggesting that at least some of the appreciation of home values in the region can be attributed to an influx of foreign demand for Vancouver real estate, specifically from China. [Stueck, 2012, para. 4] Given the relatively illiquid nature of real estate assets, concerns surrounding this type of foreign investment are not entirely without warrant, as macroeconomic shocks to the world economy could potentially cause a severe decline in the foreign demand for Vancouver real estate, if this were true. Such a sharp decline in foreign demand could in turn cause a significant drop in home values not only in Vancouver, but potentially across British Columbia and to a lesser extent, Canada.

A simple method of investigating whether this line of reasoning has any merit would be to look at the most recent numbers of foreign migration to British Columbia. If there exists considerable foreign demand for Vancouver real estate, it seems reasonable to assume that one might see a corresponding increase in the level of immigrants to the province, since it is unlikely that *all* of this foreign demand would wish to remain outside the country. It would appear however, that with the level of foreign immigrants moving to BC falling 12.75% from the most recent peak of 115,961 in 1995/1996 to its current level of 101,179 in 2011/2012, this type of reasoning is at odds with the evidence. [10]

While certainly an interesting topic to explore, the problem in analyzing the demand for housing in the Vancouver region from foreign buyers is largely informational in nature, as data pertaining to the level of foreign investment in the VREM is difficult to come by. To the best of the authors' knowledge, no such data exists or is readily accessible at the time of writing. Thus, without the availability of better data on the subject, the degree to which this foreign buyer effect is true remains difficult to substantiate empirically and thus, largely debatable.

Broadly speaking however, it might be said that much of the popular concern regarding the VREM is focused around the reduced levels of housing affordability for average BC residents, and the potentially deleterious effects of a demand-side shock resulting from a lack of foreign investment. The big question of course, is exactly how much of this concern is legitimately warranted. In this respect, there are always differing opinions and Cameron Muir, chief economist

[10] These values are taken from Statistics Canada; Table 051-0004 [StatsCan, 2012]

B.C. Real Estate Association, seems to believe the much of the worry surrounding the Vancouver market is unfounded. With reference to the VREM in a recent editorial, Mr. Muir remarks:

> "To see a substantial price decline, you need a macroeconomic shock or household financial disaster, writ large, which is what happened in the United States. You need a recession, high unemployment and extremely high interest rates, where people can't afford to make their mortgage payments and houses get flooded on the market and there's no one there to buy them because there are no jobs. But there's no evidence of that here." [as cited in Jang, 2012, para. 13]

Mr. Muir's remarks are certainly reassuring words for Vancouver home owners. Other commentators have been sounding alarm bells however, with some even suggesting a housing market crash is already in full swing, as is illustrated in the following excerpt from a recent editorial:

> "A housing correction—or, possibly, a crash—is no longer coming. It's here. And you don't have to own a tiny $500,000 condo in downtown Toronto or a $1.3-million bungalow in Vancouver to get hurt. With few exceptions, the impact will be indiscriminate as the euphoria of rising house prices is replaced by fear. The only question now is how bad things will get. If the decline picks up speed, as many believe it will, there could be a nasty snowball effect. Construction jobs will be lost. Homeowners will end up underwater. Consumers may stop spending." [Sorensen, 2013]

Given that this paper is not an editorial piece with a focus on presenting opinions but rather an empirical paper with a focus on presenting facts, it is statements such as these in which this paper seeks to assay. Of particular interest here, is whether such prognostications are at significant odds with the empirical evidence suggested by the various forecasting models employed in this paper. The question of whether or not it is possible to empirically measure the vulnerability of the VREM, or any other real estate market to significant short-term downside risk, is a question that is left to the latter sections of this paper.

1.2 Toronto Real Estate Market

The commentary surrounding the Toronto Real Estate Market (TREM), while similar in its' worrisome tone to that of the VREM, differs in that much of the concern revolves around the existence of a large supply of newly built condominiums. This "condo-boom" is of particular concern since it is commonly believed that much of the demand for these condos has been driven by speculation, rather than demand by those wanting to actually occupy the units. [Torobin, 2012] If the projected demographic-based demand turns out to be insufficient to absorb this over-supply, it could be the case that the TREM may face a considerable decline in home prices in the near future.

Adding further to the disequilibrium of the TREM, the scarcity of detached homes near the downtown core has also caused the values of condos as well as detached homes to rise significantly in recent years. In certain areas of the city, it has become commonplace to observe buyers entering into bidding wars for properties, sometimes paying well above the listed price. [11] Some analysts have also noted that an additional source of upward pressure on prices is due to growing demand for homes in desirable areas in and around the downtown core, mostly from high-income individuals who work in the area. [Mendleson, 2012]

Looking at the measure of housing affordability derived earlier, Toronto appears to offer home buyers considerably more value per dollar of income, as compared to Vancouver. With the average home price at $452,100 and the average family income value being $68,700 as at 2010, the value of housing as a multiple of family income is calculated to be 6.6 in Toronto. [12] Looking at this figure, it is apparent that the measure of housing affordability hasn't yet reached the levels found in Vancouver, at 13.3. As compared to the national level found earlier of 5.3, home prices in Toronto seem only mildly overvalued. Thus, while trepidation over valuations and future housing demand appear to be at the forefront of both the Vancouver and Toronto real estate markets, the downside risk facing the TREM seems comparatively more moderate relative to Vancouver, yet remains alarming nonetheless.

1.3 Canadian Real Estate Market

A common theme running among the Vancouver, Toronto, and Canadian real estate market in general, is the suggestion that the prolonged record-low interest rate environment of the post 2008 recession era has added upward pressure to home prices across the country. Some notable economists including the Governor of the Bank of Canada, Mark Carney, have pointed out that these

[11] A recent article in The Globe and Mail cites an instance where one buyer paid $421,800 over the asking price. For interested readers, the article is cited in the references section under [Ireland, 2012].
[12] Values are taken from the Canadian Real Estate Association website, MLS Home Price Index [CREA, 2012], and Statistics Canada; Table 202-0408. [StatsCan, 2012]

record-low interest rates are likely to persist for a few years into the future, [13] as the US has committed to near zero interest rates through 2014 and the global macroeconomic recovery remains sluggish.[14] On this point, economists are often quick to point out that interest rates are also likely to rise in the future, albeit gradually. This is worrisome since interest rate increases could have an adverse impact on housing affordability across Canada and in particular, the Vancouver and Toronto real estate markets.

Another metric widely viewed as being of cause for concern, is the record levels of household debt in Canada. Since 1990, the level of debt relative to the disposable income of Canadians has increased significantly. The most recent figure at the time of writing suggest that for every $100 in disposable income earned by Canadians, they hold $165.78 in debt, which is an increase of approximately 90% since 1990, when the figure stood at $87.04. [15] While this figure certainly appears to be sensational since Canadians now owe more than they earn in disposable income, the short and long-run effects of such elevated levels of household debt are not so easily determined. [16]

In this respect, there appears to be no shortage of popular commentary suggesting that these record high levels of debt in conjunction with relatively elevated home valuations are "unsustainable". [CBC, 2012, para. 7] Of course, statements such as these are perhaps overly simplistic in that exactly *what* constitutes 'sustainable' home values is less than clear cut. When addressing this issue, it seems that a common response is to suggest that home values are somehow way out of line with underlying fundamentals, which leads to the question of *what* exactly constitutes 'fundamentals'. To get some sense of the meaning, we can look to at least one analyst who describes these 'fundamentals' as being factors such as: "growth in disposable income, growth in GDP per capita, inflation, population growth, annual immigration growth or the rental indexes produced by CMHC" [Athanassakos, 2012, para. 4], though this is clearly far from being an exhaustive list.

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[13] See the Globe and Mail article by Jeremy Torobin, cited in the References section [Torobin, 2012].
[14] See the Globe and Mail article by Kevin Carmichael, cited in the References section [Carmichael, 2012].
[15] These values are taken from Statistics Canada; Table 378-0123 [StatsCan, 2012]
[16] See the article by Neil Macdonald for the CBC News which also quotes the famous US economist Robert Shiller and provides a typical cautionary perspective, cited in the References section [Macdonald, 2012].

1.4 *Scope of the Analysis*

With so many real estate related metrics being touted by market watchers as being 'the canary in the coal mine' so to speak, it is interesting to note that the potential predictive capability of many of these metrics are often only observable in hindsight. Thus, the problem facing researchers wishing to analyze the structural relationships between economic fundamentals and housing prices is one of choosing the correct metrics to analyze, as well as choosing the correct time frame which yields significant results. With this in mind, this study takes an alternative approach to forecasting real estate prices which to some extent avoids this problem, by making use of atheoretical time series models which are able to generate forecasts, based solely upon lagged values of the variable under consideration.

Using a number of atheoretical models, short-run forecasts are generated for a number of different data sets and the relative performances of the forecasts are evaluated by comparing Mean Squared Prediction Errors (MSPEs) and Mean Absolute Prediction Errors (MAPEs). It should be noted however, that the intent of this paper is not to prove whether or not the various real estate markets being analyzed are in a 'bubble' state, as there already exists considerable literature on the topic, with the general consensus being that the existence of bubbles is difficult if not impossible to determine empirically.[17] The goal of this study rather, is to examine the forecastability of real estate prices in a number of Canadian markets and to generate forecasts which might shed some light on whether or not concerns of dramatic near-term price declines can be substantiated by forecasts generated from atheoretical models.

In order to do so, the methodology employed will rely in part on methods originating from the existing literature on testing for the efficiency of the real estate market, as well as the literature on forecasting real estate prices. The following literature review will highlight the most relevant studies which pertain to the analysis undertaken in this paper in order to set up the models to be tested empirically, and will also provide some background on a few directly related issues.

[17] See the paper by Refet S. Gürkaynak called "Empirical Tests of Asset Price Bubbles: Taking Stock", [Gurkaynak, 2008]

2 Literature Review

There is a considerable amount of literature which attempts to forecasts real estate values, however there is very little which focuses on the Canadian real estate market; and none which focus on the Vancouver, Toronto and Canadian real estate markets simultaneously. [18] In what follows, a selection of previous empirical works which are most relevant to the topic at hand are reviewed, with a particular effort being made to separate literature relating to market efficiency from literature relating to forecasting real estate prices.

While the two topics may seem disjunct at first glance, the literature review makes clear that the two topics are in fact deeply related in that market efficiency or rather, the lack thereof, is a sufficient condition for the forecastability of real estate prices using atheoretical models. [19] Furthermore, it is within the literature on testing for market efficiency in which the theoretical framework underlying the forecastability of real estate market excess returns is originally presented. Since this paper attempts to forecast excess returns in various Canadian real estate markets using a multitude of time-series models, a discussion of the topic is certainly in order.

2.1 Market Efficiency

The notion of market efficiency which many papers in the real estate literature test, is of the form put forth by Eugene Fama [1970] most often referred to under the heading of the Efficient Market Hypothesis (EMH). While Fama was not the first to empirically test the notion of market efficiency, he was among the first authors to provide a comprehensive overview of the existing literature on the subject and expand the notion of market efficiency into three distinct forms: *weak* form, semi-strong form, and strong form efficiency. In all three forms, the basic premise of the theory is that a market can be considered 'efficient' if asset prices "at any point in time 'fully reflect' *all* available information." [Fama, 1970, p.388]

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[18] To the best of the authors' knowledge.

[19] In addition, and for a number of reasons, atheoretical models are sometimes able to produce superior forecasts than those obtained from economic models based on market efficiency, even if market efficiency does hold.

Given that the notion of market efficiency is integral to the forecastability of asset prices, it should prove useful to provide a slightly more detailed description of each form of efficiency. The methodology which Fama used to distinguish among the different forms was in reference to the information sets used in attempting to explain changes in asset prices. To begin with, weak form efficiency tests the degree to which the current price of an asset can be explained by using only historical prices, which is of most importance to the analyses carried out in the latter sections of this paper. The semi-strong form of efficiency tests whether asset prices "efficiently adjust to other information that is obviously publicly available." [Fama, 1970, p.383] Finally, the strong form of efficiency tests whether asset prices at any given point in time fully reflect all public and non-public information. [Fama, 1970]

Seeing as much of the commentary surrounding the Vancouver, Toronto, and Canadian real estate markets suggests that home values are somehow out of line with 'fundamentals', this line of reasoning harkens to the tests of market efficiency. The suggestion that housing prices at any given point in time either do, or do not, reflect fundamentals could be regarded as an implicit assumption that real estate markets are not efficient, in the sense put forth by Fama. Of course, this is not an entirely unreasonable assumption, since there are many aspects particular to real estate markets which are likely sources of market inefficiency. For example, real estate markets are considerably less liquid than financial markets and thus suffer from more market frictions than more common classes of asset markets.

It should be noted however that tests of market efficiency imply a rather extreme null hypothesis, in that it is perhaps unrealistic to assume that prices truly reflect *all* available information at any given time. As Fama himself points out, market efficiency "… is obviously an extreme null hypothesis. And, like any other extreme null hypothesis, we do not expect it to be literally true." [Fama, 1970, p.388] Thus, perhaps a more realistic assumption with regard to testing the efficiency of the real estate market would be to assume that prices *sufficiently* reflect all available information at any given point in time. In this case, the basic interpretation of 'sufficient' with respect to the EMH would be in the sense put forward by Jensen [1978], in which he states that a market "…is efficient with respect to information set θ_t if it is impossible to make economic profits by trading on the basis of information set θ_t." [Jensen, 1978, p. 3]

Given the rather limited information sets with which most participants in the real estate market have access to, it would seem unlikely to observe large numbers of market participants consistently extracting economic profits from the market, on the basis of such limited information.

Thus, in the context of the real estate market, as in other asset markets, the definition of market efficiency put forth by Jensen seems quite reasonable. More specifically, the hypothesis could be stated as saying that the real estate market can be considered efficient, if agents participating in the market are not able to systematically earn returns beyond what could be earned on alternative investments of comparable risk.

2.2 Sources of Inefficiency

With regards to sources of real estate market frictions, Gau [1987] suggests that most real estate market imperfections can be broken down into two broad categories: barriers to entry and informational inefficiencies. [Gau, 1987, p.4] The high capital cost of acquiring real estate, which excludes those without access to large amounts of capital from entering the market, is a rather obvious barrier to entry. Informational inefficiencies are more subtle, but can arise from location specific factors which can have significant effects on the value of real estate. Such factors can cause agents to incur high search costs in attempting to evaluate potential real estate investments, which then causes market participants to demand greater returns on investment in order to compensate for these increased costs. [Gau, 1987] These informational inefficiencies ultimately introduce further sources of market frictions.

Many other studies provide more detailed sources of real estate market inefficiencies, though it is not often they point out inefficiencies which lie outside of the categories proposed by Gau. A typical example can be seen in the paper by Case and Shiller [1989] who elaborate on these market frictions in their study of the efficiency of the real estate market for single family homes in the U.S. The authors suggest that due to "transactions costs, carrying costs, and tax considerations, professionals find it relatively difficult to take advantage of profit opportunities in this market. For these reasons, it is commonly casually asserted that the market for single-family homes is inefficient." [Case & Shiller, 1989, p.125] Thus, given that the real estate market suffers from such inefficiencies, a logical progression from this point would be to present a method by which one can quantify the degree to which the real estate market is (in)efficient.

2.3 A Word of Caution on Testing for Market Efficiency

In order to perform empirical tests of market efficiency, one needs a model by which to measure the level of efficiency. The dual nature of testing for market efficiency and thus, testing an empirical model of market efficiency raises an important issue however. As Jensen [1978] astutely points out, tests of market efficiency are necessarily tests of a joint hypothesis of market efficiency and the model of asset price determination. As a result of this, Jensen suggests that such tests "…can fail either because one of the two hypotheses is false or because both parts of the joint hypothesis are false." [Jensen, 1978, p. 2] This insight is important to keep in mind throughout the subsequent review of the literature so as to keep from misrepresenting the results with too strong a bias in favor of rejecting the rational expectations / EMH, when it is perhaps the model which is mis-specified.

While the nature of testing joint hypotheses certainly introduces a level of ambiguity to empirical results, it has been argued by some that the rational expectations / EMH framework is still useful in analyzing the real estate market. In his review of real estate market efficiency, Gau [1987] takes up this position and suggests that even though the theoretical framework may be less than perfect, it remains among the best method available to economists. Gau also points out that the application of the EMH framework to the analysis of real estate markets need not be "capable of describing perfectly all behavior observed in these markets" and that such a capability is "not required for a theory to be a useful paradigm." [Gau, 1987, p.2] Gau supports this position by presenting an interesting quote from Kuhn [1970], who states that for a theory to be accepted as a paradigm, "a theory must seem better than its competitors, but it need not, and in fact never does, explain all facts with which it can be confronted." [Kuhn 1970, p. 17, as cited in Gau, 1987, p. 2]

Thus, if one is to carry out empirical tests of market efficiency, one must believe that the efficient markets paradigm is in fact an appropriate model through which to analyze the real estate market. If this paradigm is deemed to be acceptable to the researcher, then a model must be presented which can link the informational and fundamental market conditions to the observed changes in asset prices. [Maier & Herath, 2009] Once a model has been established, it is important to remember that all tests of market efficiency using such a model are also jointly tests of the underlying model. Thus, as Maier & Herath [2009] note in their review of tests of real estate market efficiency, that any "…rejection of the EMH can therefore either result from the inefficiency of the market or the inadequate selection of the underlying model." [Maier & Herath, 2009, p. 5]

2.4 *Empirical Tests of Market Efficiency*

The vast majority of the literature which tests for real estate market efficiency relies heavily upon the definitions of market efficiency put forth by Fama [1970], and the theoretical framework largely derived from the literature on the efficiency of financial markets. A sizeable proportion of these studies test the *weak* and *semi-strong* forms of market efficiency using data sets at the local and national levels, mostly for U.S. real estate markets, though there are some studies which focus on markets in other parts of the world.

One of the earliest studies to test the weak form of market efficiency is a study by Hamilton & Schwab [1985]. Their study examined the efficiency of the real estate market and the extent to which households participating in this market conform to rational expectations. The authors showed that households formed systematically erroneous expectations about future home prices, which led the authors to conclude that the housing market is inefficient. Furthermore, they found that households "…interpreted past capital gains incorrectly, believing that rapid appreciation in the past implied slower capital gains in the future." [Hamilton & Shwab, 1985, p.104] They go on to show that this expectation was in fact not realized in the future periods, and thus they conclude such erroneous expectations as being "irrational". [Hamilton & Shwab, 1985]

The study by Hamilton and Schwab is interesting, in that it presents a number of findings which seem to be recurrent amongst the literature relating to tests of rational expectations / EMH. To begin with, the authors find that the results of the empirical tests do not support the rational expectations hypothesis. They also find that actual capital gains are positively associated with past income, population growth, as well as past capital gains. [Hamilton & Shwab, 1985, p.104] Furthermore, the authors find that markets "…in which capital gains had been unusually rapid expected a reversal in the future - at least a decline in the rate of appreciation, and possibly an actual decline in house values." [Hamilton & Shwab, 1985, p.117]

Another study published a few years later by Case & Shiller [1989], is also among the first to rigorously analyze the efficiency of the real estate market. Their study analyzes the market for single family homes in the U.S. and their findings are consistent with those of Hamilton & Schwab [1985], suggesting that the real estate market is indeed inefficient. More specifically, they find "substantial persistence through time in rates of change in indexes of real housing prices", and that a change in housing prices in a given year "tends to predict a change in the same direction, and one-quarter to one-half as large in magnitude, the following year." [Case & Shiller, 1989, p.135] Their findings suggest that the predictability of changes in housing price values is not efficiently incorporated in to current housing prices, and thus the real estate market is inefficient.

Case & Shiller [1990] revisit their earlier work and extend the analysis by constructing a more detailed model of excess returns to investment in the market for single family homes in the U.S. Their model tests for weak-form efficiency as did their earlier study, but this time it is augmented to incorporate sensitivities to the market value of housing services and marginal personal income tax rates. They also go a step further and test the *strong-form* of market efficiency by examining the forecastability of excess returns in the housing market. They do so by empirically testing a host of economic variables the authors believed to have forecasting capability.

With respect to their tests of weak-form efficiency, Case & Shiller [1990] find that as was the case in earlier studies, housing prices appear to exhibit serial dependence. Specifically, their results show that when home values increase in any given year, "they tend also to go up the next year, but by about a third as much. Moreover, this upward movement appears partly to be reversed in succeeding years", though the authors point out that that the evidence suggesting prices reverse is questionable since "the negative coefficients are not statistically significant." [Case & Shiller, 1990, p.268] Thus overall, their results appear to corroborate those found in earlier studies.

The results of their extended analysis examining the forecastability of excess returns in the housing market, also present findings consistent with market inefficiency. Case & Shiller evaluate the forecasting ability of number of economic variables and find that "the ratio of construction costs to prices, real per capita income growth, and increases in the adult population in one year are all positively related to price changes or excess returns over the subsequent year." [Case & Shiller, 1990, p.271] The results for other variables tested for their forecasting ability were less reliable or not statistically significant. In summary, Case and Shiller appear to have found evidence against the *strong-form* of market efficiency, though they acknowledge that due to the many imperfections of the real estate market, finding profitable trading strategies based on this knowledge could prove quite challenging, although theoretically possible.

Another study which follows in a similar vein to that of Case & Shiller [1990], is that of Capozza & Seguin [1996] who also examine household expectations of housing price appreciation. The authors use a considerably larger U.S. data set than that found in Case & Shiller [1990] and carry out empirical tests of households expectations and market efficiency. Using the data, the authors construct a quality-adjusted rent to price ratio, which they test for predictive capability in forecasting future housing price movements. The authors also test the rational expectations framework by examining whether lagged variables relating to population and income growth demonstrate any predictive power. Their findings present evidence consistent with earlier studies, which suggest lagged income growth enters negatively in household expectations of future home values. With respect to the testing for weak-form efficiency of the quality adjusted rent to price ratio, the authors also find statistically significant evidence of serial dependence.

While there are considerably more papers which focus on testing the rational expectations and efficient markets hypotheses, it would seem at this point that the literature reviewed thus far provides a telling sample of what is generally contained in other studies. For readers interested in a thoroughly comprehensive overview of the literature on real estate market efficiency however, it is suggested they refer to the aforementioned paper by Maier & Herath [2009], which provides an excellent review of the topic.

2.5 Forecasting Real Estate Prices

Given the considerable amount of empirical studies which test for real estate market efficiency and housing price forecastability, it is interesting that none of the aforementioned papers evaluated the out-of-sample predictive capability of their forecasting models. In this section, a brief review of some of the most current literature relating to out-of-sample forecastability of real estate prices is provided, with the intention of further setting up the framework by which the analyses to be carried out in this paper will follow.

In their 2003 paper, Crawford and Fratantoni compare both the in-sample and out-of-sample forecasting performance of three housing price forecasting models for the US. Specifically, the authors test an Autoregressive Integrated Moving Average (ARIMA) model, a Generalized Autoregressive Conditional Heteroskedastic (GARCH) model and finally, a regime-switching model. The authors suggest that the intuition behind using a regime switching model is "…that housing markets perform differently in different economic environments and this change in behavior results in discrete changes in the time series properties of home price indices." [Crawford & Fratantoni, 2003, p. 224] It is interesting to note however, that the authors' findings suggest that the simple ARIMA models perform better in tests of out-of-sample forecastability, while the regime switching model often performed better in-sample.

Partially motivated by the Crawford and Fratantoni [2003] study, Miles [2008] evaluates a few non-linear forecasting models including the threshold autoregression (TAR) model, the bilinear (BL) model, and the generalized autoregressive (GAR) model. After some consideration, Miles ultimately employs the GAR model in his paper since it can easily be estimated using OLS, and develops forecasting models for the same US states that were used in the Crawford and Fratantoni [2003] study. Miles then compares the forecasting results to the best ARMA and GARCH forecasting models and finds that the GAR model provides superior out-of-sample forecasts than the ARMA and GARCH models, especially in markets which displayed high levels of housing price volatility.

A later study by Rapach and Strauss [2009] comes to some similar conclusions as those found by Miles [2008]. In their study, the authors investigate forecasts of state-level real housing price growth in the US over the period of 1995-2006 and compare an autoregressive benchmark model to models which make use of additional economic variables. The authors findings suggest that autoregressive models, as well as models which make use of additional economic variables, tend provide reasonably accurate housing price forecasts, however the accuracy of these forecasts is largely dependent upon the strength of housing price growth over the sample period. More specifically, the authors find that housing price forecasts for states that exhibited relatively moderate housing price growth were often considerably more accurate than forecasts for states which exhibited strong price growth over the period. The authors also suggest that the fact housing price forecasts for states which exhibited the strongest price growth were inaccurate may potentially indicate that prices in these regions were possibly significantly out of line with economic fundamentals.

A contemporaneous study which addresses the issue of housing price forecast performance variability across different regional housing markets is by Gao et al. [2009]. In this study, the authors use two large panel datasets of the US housing market to analyze the price dynamics in markets which exhibit high and low housing price volatility. The authors make use of the empirical evidence suggesting housing prices exhibit mean reversion and serial correlation to employ an autoregressive mean reversion (ARMR) model to forecast housing prices. Not surprisingly, the authors' results show that forecasts of housing prices for markets which exhibit high levels of volatility in housing prices tend to result in AR coefficients which are generally, much larger than those found in forecasts of less volatile housing markets. It is interesting however, that the authors also found that housing price forecasts for prices in upward trends have significantly larger AR coefficients than those made in downtrend periods. The authors suggest this is evidence of downward price rigidity in the housing market.

An interesting critique of housing price forecasting methods is offered by Guirguis et al. (2005). The authors point out that many previous papers which attempt to forecast housing prices had relied on forecasts which employ the use of constant coefficients, and that these studies do not account for the sub-sample instability of housing prices. In order to take into account this instability, the authors employ six empirical models in which the estimated coefficients are allowed to vary over the sample period. More specifically, the authors use a rolling vector error correction model (VECM); a rolling autoregressive representation (AR); a rolling generalized autoregressive conditional heteroskedastic (GARCH) model; a Kalman filter with a random walk (KRW); a Kalman filter with an autoregressive presentation for the parameters' time variation (KAR) and finally; an Exponential smoothing with trend and seasonality (ES) model.

Upon estimating the extensive list of forecasting models using US data, the authors compared the out-of-sample forecasts generated by the models and found that the Kalman Filter with an autoregressive presentation for the parameters' time variation (KAR) model, along with the rolling GARCH model performed the best among all of the models tested. Furthermore, the authors point out that the forecasts of these models "exhibited a high degree of accuracy at the one to four quarter horizons." [Guirguis et al., 2005, p. 51] The findings of this study are certainly interesting in that they raise an air of suspicion around results found in many previous studies which rely upon constant coefficient approaches to forecasting.

In a another study, Gupta [2010] estimates univariate and multivariate Bayesian Vector Autoregressive (BVAR) models using data for the largest twenty US states and produces forecasts of real house price growth for periods one to four quarters ahead. The author then compare the results of the BVAR models to those of univariate and multivariate unrestricted classical Vector Autoregressive (VAR) models by way of average Root Mean Square Errors (RMSEs). The models which had the lowest average RMSEs were then used to predict downturns in the real house price growth over the period of 2007: Q1–2008:Q1. Gupta finds that the BVAR models performed best and that they also did a reasonably good job of predicting the downturn in the real house price growth in 18 of the 19 largest US states.

2.6 *Real Estate Market Efficiency, Forecastability, and the Canadian Context*

While relevant to the topic at hand, the studies outlined in the previous section tended to focus on the U.S. real estate market for the most part, thus it would be interesting to review the results of studies carried out using Canadian data. Fortunately, there exists a small number of studies which have analyzed the efficiency of the real estate market in Canada; even more fortunate is that within this small sample there are studies pertaining to the Vancouver and Toronto real estate markets. This section is then devoted to presenting these studies.

The earliest study to use Canadian data that will be reviewed here was carried out by Gau (1984), who tested for weak-form efficiency using a large data set of commercial and apartment real estate transactions for the Vancouver market, over the period of 1971-1980. Gau used the data to construct monthly price and returns series for each type of property and then tests these series for weak-form efficiency. His findings suggest there are some statistically significant relationships among the monthly series, though he finds that the relationships are not strong enough to yield accurate price forecasts. Gau attributes the finding of weak-form efficiency largely to measurement problems within the data set, and indicates that the results should be interpreted with caution. It is interesting however, that Gau's paper is among the minority which found any evidence of market efficiency.

Gau [1985] revisits the data used in his 1984 study and conducts empirical tests of the semi-strong form of efficiency in the Vancouver real estate market. The study tests the speed at which a number of publicly available informational factors were capitalized into real estate values. These factors include changes in government tax shelter, changes in rent control policies, and unanticipated changes in interest rates. The results suggest that there is no significant presence of abnormal returns related to changes in these informational variables. Gau elaborates on this finding by saying there is "…no evidence to suggest that real estate investors can utilize information concerning government policy changes or interest rate movements to earn higher returns on a risk-adjusted basis" and that "the findings of this study conform to the semi-strong form version of the efficient markets hypothesis." [Gau, 1985, p. 26]

A later study by Hosios & Pesando [1991] focusing on the Toronto real estate market, comes to rather different conclusions than that of Gau [1985]. Their study uses data from the Multiple Listing Service (MLS) for the period of 1974 to 1989 to estimate a quarterly price index for home values in the City of Toronto. In order to circumvent the problem of using a data set which varies in composition continually over time, the authors use data on the average prices of units sold through MLS over this time period to obtain an index measure based on repeat sales. The authors then use this index to test for market efficiency in the TREM and their findings suggest that the housing market in Toronto is inefficient. The authors note that "real house price movements appear to exhibit 'too much' persistence, as past price changes contain important information for forecasting future price changes." [Hosios & Pesando, 1991, p. 316] The authors also point out that they observe a "pronounced seasonal pattern in real house prices." [Hosios & Pesando, 1991, p. 316]

Roughly a decade after Gau's [1985] study, Clayton [1996] picks up the analysis of the Vancouver real estate market again and also comes to different conclusions than what Gau had found originally. Clayton's study develops a forward-looking rational expectations model of housing prices and uses it to empirically test whether the model can predict short-run fluctuations in real house prices. He also develops a method of creating a proxy variable for the values of imputed rents of owner-occupied housing, which is derived from information on observable housing market fundamentals. Clayton then uses this new variable in conjunction with a present value model of housing prices similar to that outlined by Hamilton & Schwab [1985], to test the rational expectations / asset-based housing price model for single detached home prices in the VREM.

The findings of Clayton's paper are interesting, in that the model developed in his paper is considerably more extensive than those used in earlier studies however the paper largely comes to similar conclusions as other studies. Specifically, Clayton finds that the empirical results reject the rational expectations model as well as the semi-strong form of market efficiency, and that "…there is little forward looking behavior of market fundamentals on the part of housing market participants." [Clayton, 1996, p. 467] Clayton also finds that while his model is not able to full capture the housing price dynamics of the VREM, particularly in periods of large swings in the values of home prices, his model generally does a good job of tracking the values of real home prices. As a result, Clayton suggests that it may be the case that housing prices in the VREM can deviate largely from fundamental values in times of large price swings.

In a later paper, Clayton [1997] revisits the analysis of the VREM but this time focuses in particular on the condominium market. He extends his previous analyses of the VREM by introducing a variation on the standard model of excess returns, which relies on the market efficiency condition to "generate a measure of expected house price appreciation under the assumptions of a frictionless asset market and risk neutrality." [Clayton, 1997, p. 341] Even with this augmented model and different data set, Clayton still finds statistically significant evidence against the rational expectations / market efficiency hypotheses. Clayton also notes a finding similar to that found in earlier studies and in particular those of Case & Shiller mentioned previously, which finds that "house price appreciation, on average, moves in the direction opposite to that predicted by the rational expectations model." [Clayton, 1997, p. 343]

Clayton [1998] again extends the analysis of his 1997 paper further by testing for *weak form* and semi-strong form efficiency in the Vancouver market for condominiums and examines whether investors exhibit irrational expectations. Clayton uses variables such as lagged annual housing returns as well as a measure of the deviation of price from fundamental value to predict future returns, and attributes some of the large deviations from fundamental values as a being a result of market participants who tend to overreact to new information about the housing market. [Clayton, 1998] In this way, Clayton describes a housing market model which can be subject to bubbles and notes that since his findings suggest housing prices are mean-reverting over the long-run, a "…sharp run-up in house prices is due in part to irrational expectations, and thus signals a future correction as prices ultimately reflect market fundamentals." [Clayton, 1998, p. 41]

Clayton's [1998] findings are consistent with much of the pre-existing literature in that they show that the housing market is likely inefficient and that investors often do not conform to rational expectations. Furthermore, Clayton finds that using a measure of excess returns derived from the deviation of price from fundamental values, excess returns appear to be predictable with respect to currently available information. As a result, Clayton suggests that when housing values are largely out of line with fundamental values, there may be a correction to prices in the near future to bring them in line with their long run trends due to the mean reversion of housing values over longer time horizons. Clayton argues that this type of speculative behavior on the part of investors can to some extent explain the boom and bust cycles of the housing market in Vancouver.

The last paper which will be reviewed here is a study conducted by Brox, Carvalho and Duckett [2007], which uses data on prices, rents and property taxes for single detached homes in seven sub-markets in the Greater Toronto Area and tests the degree to which the TREM conforms to the efficient market hypothesis paradigm. The study also analyzes the short-term forecastability of returns in the TREM by fitting various ARIMA models to data of a constructed measure of excess returns using the Box-Jenkins methodology. The authors' findings suggest that the ARIMA models provide superior forecasts to that of a naïve model and present comparisons of the forecast accuracy of various models using Theil's U-Statistic.

At this point, it would seem that the literature has been sufficiently reviewed such that we may now turn the focus of this paper toward presenting the data used in estimating the empirical models evaluated in this paper.

3 Data

This paper is unique among the Canadian real estate market forecasting literature, in that it uses a number of Canadian housing price data series to carry out estimations and generate forecasts. In particular, three time-series data sets are considered: the Royal Lepage House Price Survey (RLHPS), the Teranet National Bank House Price Index (TNBHPI), and the Statistics Canada New Housing Price Index (NHPI). Detailed descriptions of the data are available in the Appendix where indicated, and a comprehensive guide to the nomenclature used in this paper is provided in Section Z, should the reader have any difficulties. What follows is a more detailed description of each data set.

3.1 Royal LePage – Housing Price Survey

The Royal LePage Housing Price Survey[20] (RLHPS) data set is comprised of appraisal-based estimates of home prices for selected regions across Canada, and is released quarterly with the earliest data points dating back to April, 1974. The data set also includes estimates of property taxes as well as rent prices, which will be useful in constructing the measure of excess returns analyzed in the latter sections of this paper. Unlike previous studies which generally focused on a single housing type, this study evaluates the forecastability of real estate prices for *both* the markets for single detached homes, as well as for Standard Condominiums. Also, given that a considerable amount of time has elapsed since earlier studies which made use of the RLHPS, this paper is afforded the added benefit of including considerably more data points – an often cited limitation of earlier studies.

[20] Available at the Royal LePage website at the following URL: http://www.royallepage.ca/HPS/en/HousePricingSearch.aspx

It should also be noted that the RLHPS in fact reports data on the various sub-markets which fall under the geographic regions of Vancouver and Toronto, but does not offer more general aggregate values for the Greater Vancouver and Greater Toronto metropolitan areas; these aggregate level measure will be addressed by the data sets discussed in the latter sub-sections. In selecting the various Vancouver and Toronto sub-markets to be analyzed in this paper, two basic data set selection criteria were followed:

1. Whether the region is considered part of the greater Vancouver or Toronto region, and;
2. The overall length and consistency of the data points available for each sub-market.

In the Appendix, Sections A.1, A.2, and A.3 provide a more complete summary of the RLHPS data series for the Vancouver and Toronto sub-markets under consideration in this paper. Section A.1 lists the specific sub-markets and time frames for which each data series are available. Section A.2 provides plots of each data series, and Section A.3 provides detailed descriptive statistics for each data series. It should be noted that while nearly all the RLHPS price series have data points ending at 2012:Q4[21], certain property tax and rental prices series do not extend as far as that of the price series.

Given the appraisal based methodology used in producing the RLHPS, it has been noted in some earlier studies[22] that such an approach may introduce a level of appraiser-induced bias into the data set. This bias occurs because real estate appraisers rely on both current and historical real estate values when making their estimates of a home's current market value, and iterating the process forward results in a type of smoothing process of the estimated housing price series over time. As a result, appraisal-based estimates of housing prices are said to lag current market conditions and systematically underestimate the true variance of real estate prices. [Clayton 1998, p. 46].

Fortunately, this issue with respect to the RLHPS has been addressed to some degree in Clayton's [1998] paper, in which he compares a transactions-based housing price series for one particular Vancouver sub-market, with the RLHPS data for the same sub-market. As Clayton notes in his study, the comparison of the transactions-based constant quality housing price index and the RLHPI shows that the two series exhibit a high degree of correlation over the sample period, with a

[21] With the exception of the Toronto Detached Bungalow Price series for Etobicoke – Islington/Kinsway which terminates 2010:Q4.
[22] See Clayton (1998), pp. 45-46 for a more detailed discussion.

correlation coefficient of 0.98. [Clayton 1998, p. 46] As a result, Clayton suggests that "while this analysis by itself certainly does not prove the absence of smoothing, it does suggest that there does not appear to be any strong evidence of appraisal-based smoothing in the Royal LePage single-detached house price data." [Clayton 1998, p. 48] This study will take Clayton's result as given and will make the assumption that there is no such appraisal-based error in any of the RLHPS data series used in this paper.

3.2 Teranet – National Bank Housing Price Index

The first aggregate level data set considered in this paper is The Teranet National Bank House Price Index [23] (TNBHPI). This data set is relatively new, with the first data point dating back to July of 1990, however there are a few interesting features about this particular time series which should be highlighted. To begin with, the data set offers a much more fine grained level of housing price information, with data point for various large geographical areas in Canada being reported at monthly intervals, versus the quarterly intervals which are most common among real estate data, such as the RLHPS. Thus, hypothetically speaking, a well specified forecasting model which employs the TNBHPI data set should be able to produce more accurate near term forecasts than might be otherwise obtained using more coarse data sets.

Another interesting characteristic by which the TNBHPI differs from other real estate data sets, is that it is a constant quality index estimated using the repeat-sales methodology. While the details of how this index is precisely calculated is rather detailed, the basic premise is that the index is calculated using a matched "sales pair" which tracks the sale prices of registered homes in a linear fashion over time.[24] This methodology is particularly beneficial since the prices are transaction based which produces a (perhaps) more accurate market based estimate of home values, and thereby avoids the potential problems of appraisal based methods alluded to earlier.

This paper will make use of the TNBHPI data pertaining to the Vancouver and Toronto metropolitan areas, as well as the Teranet Composite 6 and Teranet Composite 11 Indices which measures aggregate housing price fluctuations for Canada as a whole. The exact geographical areas

[23] Available at the following URL: http://www.housepriceindex.ca/default.aspx?langue=EN
[24] Refer to the Teranet website for a complete discussion of the Index calculation methodology at the following URL: http://www.housepriceindex.ca/Default.aspx under the heading, "Methodology".

each data set covers is as defined on the Teranet website.[25] In the Appendix, Sections A.4, A.5, and A.6 provide a more complete summary of the TNBHPI data series. Section A.4 lists the specific time frames for which each data series are available, Section A.5 provides plots of each data series, and Section A.6 provides detailed descriptive statistics for each data series.

3.3 Statistics Canada – New Housing Price Index

The last housing price index which is considered in this study is the Statistics Canada New Housing Price Index (NHPI), which tracks the contractors' price changes of newly constructed residential homes in various regions across Canada. The NHPI is an aggregate level index which is published regularly at monthly intervals and spans the time frame from January 1981 to December 2012.

The index is constructed through a survey method which requests information on selected house models and their respective total market based property values, which is an estimate of the land and house values combined. Estimates of the land-only value are also obtained and as a result, a residual measure of the housing structure is provided by subtracting the land value from the total estimated market value of the property. This data set is particularly unique in that it is the only data set which provides estimates of the value of raw land, which is arguably the most fundamental driver of housing values, since it is a function of spatial supply and demand conditions in any given geographical area. However, for the purposes of this study only the 'house and land' data set is considered since it is most comparable to the other data sets.

In the Appendix, Sections A.7, A.8, and A.9 provide a more complete summary of the NHPI data series. Section A.7 lists the specific time frames for which each data series are available, Section A.8 provides plots of each data series, and Section A.9 provides detailed descriptive statistics for each data series.

[25] Available at the following URL: http://www.housepriceindex.ca/Default.aspx. See the section labeled "Description and Geographical Composition"

3.4 *Economic Variables*

This paper also makes use of the risk-free interest rate in calculating the measure of excess returns for which forecasts are then generated in a later section.[26] Since the forecasts are short-run, the quarterly risk-free interest rate is proxied here by using the average yield on 3 month Government of Canada Bonds.

4 Market Efficiency and Excess Returns

Since the result that the real estate market is generally weak-form inefficient has been well documented in other papers, this paper does not test for weak-form market efficiency before generating forecasts, but rather assumes that the real estate market is not weak-form efficient. The notion of weak-form efficiency is useful however in constructing a measure of excess returns for which earlier papers have cited as being forecastable. Previous studies which analyze the efficiency of financial markets as well as markets for many other asset classes often make use of this measure, which is purported to indicate the extent to which an asset is under or over-valued in the short-run. To gain some further understanding of this measure, the theoretical framework which is used to construct the data series to be estimated is explained in greater detail.

4.1 *Excess Returns – Theoretical Framework*

In order to test for weak-form efficiency in asset markets, many previous studies have relied on a market efficiency condition which if true, would indicate that housing prices are not forecastable and follow a random walk. More specifically, the theory postulates that for the real estate market to be considered an efficient asset market, the expected rate of return to housing

[26] These rates are obtained from Statistics Canada, Table 176-0043, available at the following URL: http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&p2=33&id=1760043

investment should be equal to the rate of return on alternative investments.[27] Following the theoretical framework outlined in Clayton [1998], such a relationship within the context of the housing market could then be represented by the following equation, which under the EMH paradigm should hold with equality:

$$\frac{E_t[P_{t+1}|I_t] - P_t + R_t - T_t}{P_t} - \delta_t = i_t \tag{1}$$

Where P_t denotes housing prices at time t; I_t denotes the information set available at time t; R_t denotes rent prices at time t; T_t are property taxes at time t; δ_t is a measure of maintenance and depreciation costs expressed as a percentage of house value; and i_t is the risk-free interest rate at time t.

Using this formulation, it can be seen that if the real estate market is weak-form efficient, then knowledge of previous prices should not be useful in predicting future prices. More formally, it should be the case that expected excess returns conditional on the information set I_t should then theoretically, be equal to zero. Mathematically this is represented by the following equation:

$$E_t[r_{t+1}|I_t] = 0 \tag{2}$$

Where r_{t+1} are excess returns at time $t + 1$; and excess returns are represented by the following equation:

$$r_{t+1} = \frac{P_{t+1} - P_t + R_t - T_t}{P_t} - \delta_t - i_t \tag{3}$$

Having now described the theoretical framework which will be used in generating various excess return series, we now turn to discussing the construction of the various data sets used throughout out this paper.

[27] This paper uses the average yield on Canadian 3 month Treasury Bills as a proxy to the risk-free rate of return on alternative investments.

5 Data Transformations Prior to Estimation

This section provides greater detail with respect to the construction of the various data series used in the estimations and forecasts generated in this paper. In all cases, the various data series are detrended and unless otherwise specified, hereafter in the paper any discussion relating to these constructed data series should assume it is the detrended series being discussed. Linear detrending was carried out to ensure that only the stochastic part of the returns series are examined.[28] Plots, summary statistics, and unit root tests are presented for each of the newly constructed data series in the specified sections of the Appendix.

5.1 RLHPS – Excess Return Series

This paper uses equation (3) to generate excess return series for all of the various Vancouver and Toronto sub-markets considered in this paper. It should be noted however, that the RLHPS does not report a measure of depreciation costs, nor is any such data series known to exist for the particular sub-markets selected for this study, thus the δ_t term from the theoretical framework will unfortunately have to be omitted. It could be argued however, that such costs would be fairly negligible in most cases and that the lack of including such costs in the calculations of excess returns is therefore unlikely to greatly bias the results. It is also plausible that such depreciation costs can be assumed constant and would therefore be picked up by the constant term of the various time-series models.

Upon generating the excess return series as per equation (3), initial inspection of the data revealed a significant time trend, thus as noted earlier, the data set was detrended to render it stationary. Plots and Summary Statistics of the quarterly excess return series for the various Vancouver and Toronto sub-markets considered in this paper are shown in the Appendix, Sections C.1 and D.1, respectively. From looking at the plots, it seems clear that the various excess return

[28] Linear detrending was performed by first regressing the return series on a time trend and then the resulting trend is subtracted from the return series.

series are stationary, however to be sure Augmented Dickey-Fuller (ADF) Unit Root Tests are carried out for each of the data series with the results presented in Section E.1 of the Appendix. The results of the ADF tests unanimously reject the null hypothesis of a unit root in all the data series at the 5% significance level. Given these results, we can be fairly certain that the forecasting results derived from the estimated models in the latter sections of the paper are not spurious.

5.2 RLHPS – Annualized Quarterly Price Growth Rates

To some extent, this paper follows the procedure carried out in Crawford and Fratantoni [2003], thus their treatment of the price and index value data sets used to generate their estimations and forecasts is reproduced here. More specifically, Crawford and Fratantoni [2003] render the data sets under consideration in their paper stationary by transforming the data into annualized quarterly growth rates. Thus, in order to render the various RLHPS sub-market price series stationary, the data series are transformed into annualized quarterly growth rates using the following formula:

$$P_g = \left[\left(\frac{P_t}{P_{t-1}}\right)^4 - 1\right] \times 100 \tag{4}$$

Upon transforming the data into annualized quarterly growth rates, the data series are then detrended. Plots and Summary Statistics of the quarterly annualized price growth rate series for the various Vancouver and Toronto sub-markets considered in this paper are shown in the Appendix, Sections C.2 and D.2, respectively. A visual examination of the generated data series suggest the data are stationary however to be certain, Augmented Dickey-Fuller (ADF) Unit Root Tests are once again carried out for each of the data series with the results presented in Section E.2 of the Appendix. Again, the results of the ADF tests reject the null hypothesis of a unit root in all the annualized quarterly price growth data series at the 5% significance level.

5.3 TNBHPI – Annualized Monthly Index Growth Rates

In a similar fashion to the annualized quarterly price growth rates of the RLHPS data series, the TNBHPI index values are also transformed to be stationary in the same manner; however since the data set is reported at a monthly frequency, the transformation is now as follows:

$$P_g = \left[\left(\frac{P_t}{P_{t-1}}\right)^{12} - 1\right] \times 100 \tag{5}$$

Once again, upon transforming the data into annualized quarterly growth rates the data series are detrended. Plots and Summary Statistics of the monthly annualized index growth rate series for the Canadian Composite 6, Composite 11, Vancouver and Toronto indices are shown in the Appendix, Sections C.3 and D.3, respectively. A visual examination of the generated data series suggest the data are stationary however to be certain, Augmented Dickey-Fuller (ADF) Unit Root Tests are once again carried out for each of the data series with the results presented in Section E.3 of the Appendix. Again, the results of the ADF tests reject the null hypothesis of a unit root in all the annualized monthly index growth data series at the 5% significance level.

5.4 NHPI – Annualized Monthly Index Growth Rates

Since the NHPI index values are also reported at a monthly frequency, the index values are also transformed to be stationary using equation (5) and are then detrended. Plots and Summary Statistics of the monthly annualized index growth rate series for Canada, British Columbia, Ontario, Vancouver and Toronto are shown in the Appendix, Sections C.4 and D.4, respectively. Again, visual inspection of the generated data series suggest the data are stationary, however once again Augmented Dickey-Fuller (ADF) Unit Root Tests are carried out for each of the transformed data series, with the results presented in Section E.4 of the Appendix. As was the case for all of the other data series, the results of the ADF tests reject the null hypothesis of a unit root in all the annualized monthly index growth data series at the 5% significance level.

6 Model Specifications

This section describes in greater detail the various forecasting models which are used to generate the single-step and multi-step-ahead forecasts carried out in this paper. The general model specifications are similar to those outlined by Crawford and Fratantoni [2003], who derive their specifications upon those found in Hamilton [1994]. As has been mentioned previously, these models are atheoretical in the sense that they are non-structural in nature. The models simply make use of lagged valued of the dependent variable, lagged values of the error terms, and in some cases, lagged variances as well. All of the models considered here are ubiquitous among the forecasting literature and have been employed with high degrees of success in a variety of fields.

6.1 ARIMA Models

The most basic model estimated in this paper is the Autoregressive model of order *p*, or AR(*p*) where *p* is choice number of lags. In its simplest form, the model can be expressed by the following specification:

$$y_t = \mu + \sum_{i=1}^{p} \phi_i \left(y_{t-i}\right) + \varepsilon_t$$

$$\varepsilon_t \sim N(0,1)$$

Where y_t are the detrended excess returns, index, or price growth rate data; μ is the trend growth rate, which as was motioned earlier has been removed from each data series estimated, thus the models are estimated without an intercept; the ϕ_i are the autoregressive coefficients; i is the lag length; and ε_t is a white-noise error term. This paper estimates three autoregressive models of orders, AR(1), AR(2), and AR(4).

Partly due to its simplicity, the AR model can be augmented in a number of ways to provide greater flexibility with respect to forecasting applications. The simplest augmented AR models estimated in this paper are of the Autoregressive Moving Average form, or ARMA(*p,q*) where *p* and

q are the respective choice number of lags of each component. The ARMA(p,q) model is similar in structure to the basic AR(p) model, and can be described in the following form:

$$y_t = \mu + \sum_{i=1}^{p} \phi_i \, (y_{t-i}) + \sum_{i=1}^{q} \theta_i \, (\varepsilon_{t-i}) + \varepsilon_t$$

$$\varepsilon_t \sim N(0,1)$$

Where the specification is as for the AR(p) model, save for the addition of the moving average component and its' associated coefficients, θ_i.

In this paper, a number of AR and ARMA models are estimated instead of simply choosing a single AR and ARMA with optimally estimated lags, as doing so follows the forecasting literature.[29] Following such a methodology is also supported by the well documented fact in the literature that in some cases, ad-hoc forecasting models can sometimes produce superior forecasts to best-fitted models. [See Makridakis et al., 1979] Thus, four ARMA(p,q) models in total are estimated in this study, with chosen specifications: ARMA(1,1), ARMA(1,2), ARMA(2,2) and ARMA(4,4).

6.2 ARCH, GARCH, and EGARCH Models

Since it is common to observe periods of relatively small and large price swings at various times in the real estate market, this paper employs a number of models which account for changes in the volatility of the price metric under consideration. These models fall under the heading of Generalized Autoregressive Conditionally Heteroscedastic models, or GARCH(p,q) models.

The GARCH(p,q) model contains p GARCH coefficients for lagged variances and q ARCH coefficients for lagged squared innovations. Clearly, in the case where $p = 0$, the model reduces to the ARCH(q) model. Again, these models can be combined with the simple AR model to form AR(p)-GARCH(p,q) models. The general specification of the AR(p)-GARCH(p,q) models can be described by the following form:

[29] To demonstrate that such a method is commonplace among the forecasting literature, see for example any of the following papers already cited in the literature review by Guirguis et al. (2005), Gupta (2008), or Crawford and Fratantoni (2003).

$$y_t = \mu + \sum_{i=1}^{p} \phi_i \, (y_{t-i}) + \varepsilon_t$$

$$\varepsilon_t = \sqrt{h_t} e_t$$

$$h_t = \lambda_0 + \lambda_1 \varepsilon_{t-1}^2 (\theta) + \gamma_1 h_{t-1}$$

$$e_t \sim N(0, 1)$$

Where the AR component is as was specified earlier; the λs are the ARCH coefficients; and the γs are the GARCH coefficients. In the above specification, it should be noted that a non-negativity constraint is imposed since variances, by definition, cannot be negative.

In order to do away with this constraint, an Exponential GARCH model (EGARCH) is also estimated, which models the logarithm of the conditional variance process thus removing the need for the non-negativity constraint. Another interesting property of the EGARCH model is that it also contains additional leverage terms which capture asymmetry in volatility clustering. Thus, the EGARCH(*p*,*q*) model contains *p* GARCH coefficients for lagged log variance terms, *q* ARCH coefficients which measure the magnitude of lagged squared innovations, and *q* leverage coefficients which reflect the lagged standardized innovations.

As was the case earlier, the EGARCH model can be combined with the AR models to form AR(*p*)-EGARCH(*p*,*q*) models. The general specification of these models can be represented by the following:

$$y_t = \mu + \sum_{i=1}^{p} \phi_i \, (y_{t-i}) + \varepsilon_t$$

$$\ln{(h_t)} = \lambda_0 + \lambda_1 g(z_{t-i}) + (\theta) + \gamma_1 \ln{(h_{t-1})}$$

$$g(z_t) = \theta_{zt} + |z_t| - E\,|z_t|$$

$$z_t = \frac{\varepsilon_t}{\sqrt{h_t}}$$

Where the AR component is as was specified earlier; the λs are the ARCH coefficients; and the γs are the GARCH coefficients. Under this formulation, the sign and magnitude of z_t can have asymmetric effects on the volatility. In this paper, the following AR-GARCH and AR-EGARCH models are estimated: AR(1)-ARCH(1), AR(2)-ARCH(1), AR(1)-ARCH(2), AR(2)-ARCH(2), AR(1)-GARCH(1,1), AR(2)-GARCH(1,1), AR(1)-EGARCH(1,1), and AR(2)-EGARCH(1,1).

7 Empirical Results

In generating the forecasts in this paper, all of the models outlined in the previous section are estimated for each of the data sets using a rolling sample period for the estimation process. Wherever possible, estimations on quarterly data use an estimation sample size of 20 years, while for monthly data the sample size is set to 10 years, since these data sets are generally smaller. The holdout periods for both quarterly and monthly data series are set to 10 years. Due to data limitations however, there are some cases where the estimation sample periods and holdout periods had to be reduced accordingly. A more detailed description of the exact sample estimation and holdout periods for each of the RLHPS, TNBHPI, and NHPI can be found in the Appendix, Section B.

After generating all of the single-step and multi-step-ahead forecasts, the Mean Squared Prediction Errors (MSPEs) and Mean Absolute Prediction Errors (MAPEs) are calculated and used to compare the relative performance of the forecasts. It should be noted however, that the comparisons of the MSPEs and MAPEs are only qualitative, and are not compared statistically across models in this paper. Readers might also note that the MSPEs and MAPEs for the excess return series forecasts are considerably smaller than those found for the other series; this is a direct result of the fact the excess returns are by definition, the difference between the rate of return on real estate investment and the risk free rate of return, which of course yields a smaller value by definition. The MSPEs and MAPEs from these forecasts are presented in the Appendix, Sections F, G, and H, for the RLHPS, TNBHPI, and NHPI data series respectively.

7.1 RLHPS – Forecasts of Excess Returns

1-Step-Ahead Forecasts

Section F.1 of the Appendix displays the resulting MSPEs and MAPEs from the 1-step-ahead forecasts of the quarterly excess returns series, for each of the Vancouver and Toronto sub-markets.

In examining the MSPEs and MAPEs of these 1-step-ahead forecasts for the various Vancouver Detached Bungalow series shown in table F1.01, it can be seen that the models which appear to provide the most accurate forecasts across all of these series are of the ARMA variety. In the case of the Vancouver Standard Condominium series shown in table F1.02, the MSPEs and MAPEs suggest that for the Vancouver West and North Vancouver series, the simple AR(4) model provides the most accurate forecasts; while for the Vancouver East series the MSPEs and MAPEs suggest the AR(1)-EGARCH(1,1) model is the most accurate.

Turning to the MSPEs and MAPEs of the Toronto Detached Bungalow series 1-step-ahead forecasts shown in table F1.03, it is evident that the models which provide the most accurate forecasts are again, consistently of the ARMA variety, which is similar to the findings for Vancouver. Interestingly, the models suggested by the MSPEs and MAPEs for the Toronto Standard Condominium series forecasts shown in table F1.04 are slightly less consistent than for the Detached Bungalow series. For all of the Standard Condominium series, the MSPEs suggest that models of the ARMA variety provide the most accurate forecasts; while for The Annex and North Toronto series, the MAPEs suggest the AR-ARCH and AR-GARCH models are the most accurate.

4-Step-Ahead Forecasts

Section F.2 of the Appendix shows the resulting MSPEs and MAPEs from the 4-step-ahead forecasts of the excess returns series, for each of the Vancouver and Toronto sub-markets.

Similarly to the 1-step-ahead forecasts, the MSPEs and MAPEs of these 4-step-ahead forecasts for the various Vancouver Detached Bungalow series shown in table F2.01, suggest models of the ARMA variety provide the most accurate forecasts, with the exception of the West Vancouver series. In the case of West Vancouver, both the MSPE and MAPE suggest the AR(1)-EGARCH(1,1) model provides the most accurate forecasts.

Looking at the Vancouver Standard Condominium series shown in table F2.02, the MSPEs and MAPEs suggest that for the Vancouver West and North Vancouver series, the simple AR(4) model provides the most accurate forecasts, as was the case for the 1-step-ahead forecasts. For the Vancouver East series, the MSPEs and MAPEs suggest the ARMA(2,2) model is the most accurate.

With respect to the Toronto Detached Bungalow series forecasts shown in table F2.03, the MSPEs and MAPEs report similar findings to those for the 1-step-ahead forecasts. With the exception of the Burlington series, the models which provide the most accurate forecasts are again all of the ARMA variety. In the particular case of the Burlington series, the MSPEs and MAPEs suggest three different models provide the best forecasts; the MSPE suggest the ARMA(1,1), while the MAPE suggest both the AR(1)-ARCH(2) and AR(1)-GARCH(1,1) provide equivalently accurate forecasts.

Looking at the MSPEs and MAPEs from the forecasts of the various Toronto Standard Condominium series in table F2.04, it can be seen that for the Annex and North Toronto series, models of the AR-ARCH and AR-GARCH variety appear to provide the most accurate forecasts. In the case of the Oakville Standard Condominium series, the MSPEs and MAPEs suggest that models of the ARMA specification provide the most accurate 4-step-ahead forecasts.

7.2 RLHPS – Forecasts of Annualized Quarterly Growth Rates

1-Step-Ahead Forecasts

Section F.3 of the Appendix displays the resulting MSPEs and MAPEs from the 1-step-ahead forecasts of the annualized quarterly price growth rate series, for each of the Vancouver and Toronto sub-markets.

Beginning by examining the MSPEs and MAPEs for the various Vancouver Detached Bungalow series shown in table F3.01, it can be seen that the model which provide the best forecasts for the Vancouver East and Surrey series is the AR(1)-EGARCH(1,1) model. For the Vancouver West and West Vancouver series, the AR(4) model appears to provide the best forecasts; while for the North Vancouver series the MSPE suggests an AR(4) model whereas the MAPE indicates the ARMA(1,2) specification provide the best forecasts. Looking at the Vancouver Standard Condominium series shown in table F3.02, the MSPEs and MAPEs reveal that for the Vancouver West and North Vancouver series, the AR(4) and ARMA(1,1) models provide the most accurate forecasts; while for the Vancouver East series, the MSPEs and MAPEs suggest the AR(1)-ARCH(2) and AR(1)-GARCH(1,1) models are the most accurate.

Upon examination of the MSPEs and MAPEs for the Toronto Detached Bungalow series 1-step-ahead forecasts shown in table F3.03, it can be seen that the model which provides the most accurate forecasts for the Burlington and North Toronto series is the ARMA(1,1) model; while for the Etobicoke series, the simple AR(4) model provides the best results. In the case of the Scarborough series, the MSPEs suggest the best forecasts are obtained using the ARMA(1,1) model, while the MAPEs suggest either of the AR(1)-ARCH(2) or AR(1)-GARCH(1,1) models provide equivalently accurate forecasts. With respect to the Oakville series, the MSPEs and MAPEs suggest the ARMA(2,2) and AR(1)-ARCH(1) provide the most accurate forecasts, respectively.

Looking at the MSPEs and MAPEs for the Toronto Standard Condominium series forecasts shown in table F3.04 reveals that only in the case of the Oakville series does a single model produce the most accurate forecast, which the Oakville series is the ARMA(1,1) model. For the North Toronto series, the MSPEs indicate the most accurate forecasts are produced using the ARMA(1,1) model, while the MAPEs suggest the AR(1)-EGARCH(1,1) model is best. Lastly, for the Annex series the MSPEs suggest the AR(4) model yields the best forecasts while the MAPEs indicate that both the AR(1)-ARCH(2) and AR(1)-GARCH(1,1) provide equivalently accurate forecasts.

4-Step-Ahead Forecasts

Section F.4 of the Appendix displays the resulting MSPEs and MAPEs from the 4-step-ahead forecasts of the annualized quarterly price growth rate series, for each of the Vancouver and Toronto sub-markets.

With respect to the MSPEs and MAPEs of the 4-step-ahead forecasts for the various Vancouver Detached Bungalow series shown in table F4.01, it can be seen that for the West Vancouver and North Vancouver series the AR(4) appears to provide the best forecasts; while for the Vancouver East series the MSPEs and MAPEs suggest the AR(1)-EGARCH(1,1) model is best. As for the Vancouver West series, the MSPEs suggests an ARMA(1,2) specification produces optimal forecast results, whereas the MAPEs suggests the ARMA(2,2) provides the most accurate forecasts. Lastly, the MSPEs for the Surrey series indicates an ARMA(1,1) model produces the best forecasts while the MAPEs report that the AR(1)-ARCH(1) is best.

Looking at the 4-step-ahead forecasts for the Vancouver Standard Condominium series shown in table F4.02, the MSPEs and MAPEs suggest that in the case of the North Vancouver series, the AR(4) model provides the most accurate forecasts while in the case of the Vancouver East series the AR(1)-EGARCH(1,1) model appear to provide the best results. For the Vancouver West series, the MSPEs indicate that the AR(2)-ARCH(2) and AR(2)-GARCH(1,1) provide equivalently accurate forecasts, while the MAPEs suggest the AR(2)-ARCH(1) model specification produces the best results.

Upon examination of the Toronto Detached Bungalow series 4-step-ahead forecasts in table F4.03, it is apparent that the MSPEs and MAPEs do not agree with one another for the most part, save for the Burlington series in which the MSPEs and MAPEs suggest the ARMA(1,1) model specification provides the best forecasts. For the Etobicoke, Scarborough, Oakville and North Toronto series, the MSPEs suggest the best forecasts are produced using the AR(4), ARMA(4,4), AR(1)-EGARCH(1,1) and ARMA(1,2) models, respectively; whereas for these same series, the MAPEs suggest that the best forecasts are produces using the ARMA(1,1), AR(4), AR(1) and AR(4) model specifications, again, respectively.

Turning to table F4.04, the MSPEs and MAPEs from the forecasts of the various Toronto Standard Condominium series show that for the Oakville series, the AR(2)-EGARCH(1,1) model specification provides the optimal forecasts. In the case of the Annex and North Toronto series, the MSPEs and MAPEs report more mixed results. With respect to the Annex series, the MSPEs suggest the ARMA(4,4) model specification provides the best results, whereas the MAPEs suggest the simple AR(1) model specification is the most accurate. Finally, the MSPEs for the North Toronto series indicate that the AR(4) model generates the best forecasts, whereas the MAPEs suggest the optimal specification is the ARMA(2,2) model.

7.3 TNBHPI – Forecasts of Annualized Monthly Growth Rates

1-Step-Ahead Forecasts

Section G of the Appendix displays the resulting MSPEs and MAPEs from the 1-step-ahead, 3-step-ahead, and 12-step-ahead forecasts of the annualized monthly growth rate series for the Composite 6, Composite 11, Vancouver and Toronto series respectively.

Beginning by examining the MSPEs and MAPEs of these 1-step-ahead forecasts in table G1.01, it can be seen that in for the Vancouver series, both the AR(2)-ARCH(2) and AR(2)-GARCH(1,1) provide equivalently accurate 1-step-ahead forecasts. As for the other series, the results are considerably more mixed. In the case of the Toronto series, the MSPEs suggest the ARMA(1,2) specification produces the best forecasts whereas the MAPEs indicate the AR(4) model is best. Interestingly, the MSPEs for the Composite 6 and Composite 11 also suggest that indicate the AR(4) model specification produces optimal forecasts, while the MAPEs suggest the ARMA(2,2) and ARMA(1,2) models yield the best results for each of these series, respectively.

3-Step-Ahead Forecasts

Looking at the MSPEs and MAPEs from the 3-step-ahead forecasts in table G2.01 it is again observed that for the Vancouver series, both the AR(2)-ARCH(2) and AR(2)-GARCH(1,1) provide equivalently accurate 3-step-ahead forecasts. With respect to the Toronto series, the MSPEs suggest the ARMA(1,2) specification is best, as was the case for the 1-step-ahead forecasts, however the MAPEs indicate the ARMA(1,1) model provides the most accurate forecasts. As for the Composite 6 series, the MSPEs and MAPEs suggest the AR(4) specification is best while for the Composite 11 series, the MSPEs and MAPEs indicate the ARMA(4,4) model yields the optimal results.

12-Step-Ahead Forecasts

In examining the MSPEs and MAPEs from the 12-step-ahead forecasts in table G3.01, it is evident that the results are fairly mixed. Particularly noteworthy however, is that the MSPEs and MAPEs for the Vancouver series once again indicate that both the AR(2)-ARCH(2) and AR(2)-GARCH(1,1) provide equivalently accurate forecasts, as was the case for the 1-step-ahead forecasts. In the case of the Toronto series, the MSPEs and MAPEs both suggest the ARMA(1,1) specification yields the best forecasts. As for the Composite 6 and Composite 11 series, the MSPEs indicate the ARMA(1,2) and ARMA(4,4) models produce the best forecasts respectively, while the MAPEs suggest the AR(4) and AR(2) model specification provide the best respective results.

7.4 NHPI – Forecasts of Annualized Monthly Growth Rates

1-Step-Ahead Forecasts

Section H of the Appendix displays the resulting MSPEs and MAPEs from the multi-step-ahead forecasts of the annualized quarterly growth rate series derived from the NHPI data, for the Canada, British Columbia, Ontario, Vancouver and Toronto series, respectively.

Among the 1-step-ahead forecasts in table H1.01, it is apparent that there is a great deal of consistency in model specifications which yield the best forecasting results for the NHPI data set. With the exception of the Ontario series, the MSPEs and MAPEs for all of the other data series suggest the ARMA(1,1) model produces the best forecasting results. As for the Ontario series, the MSPEs suggest the optimal forecasting model specification is also the ARMA(1,1) model, however the MAPEs suggest this model to be of the AR(4) specification.

3-Step-Ahead Forecasts

In examining the MSPEs and MAPEs from the 3-step-ahead forecasts in table H2.01, both measures show that for the British Columbia and Toronto series the AR(2)-ARCH(1) and ARMA(1,1) models produce the most accurate forecasts for each series respectively. In the case of the Ontario and Vancouver series, the MSPEs indicate the ARMA(1,2) yield the best forecasts while the MAPEs suggest the AR(4) and ARMA(1,1) specifications provide the most accurate forecasts for each series respectively. Finally, examination of the MSPEs for the Canada series suggest that AR(2)-EGARCH(1,1) models specification is best, while the MAPEs indicate the simpler AR(4) model is yields the most accurate results.

12-Step-Ahead Forecasts

In examining the 12-step-ahead forecasts in table H3.01, it is immediately apparent that the models which yield the best forecasts are considerably less consistent across the various data series as was the case for the 1-step-ahead forecasts. Looking at the British Columbia series, it can be seen that both the MSPEs and MAPEs both suggest the AR(4) specification yields the most accurate forecasts, while for the Vancouver and Canada series, the MSPEs and MAPEs suggest the optimal model specification is the ARMA(1,1) model. For the Ontario series, the MSPEs indicate the

ARMA(1,2) model produces the best forecasts, while the MAPEs indicate the ARMA(4,4) model yields the best results. As the Toronto series, the MSPEs and MAPEs suggest the ARMA(2,2) and ARMA(1,1) specifications produce the best forecasts respectively.

7.5 Discussion

It is interesting to note that the MSPEs and MAPEs recorded for the numerous forecasts generated in this study do not suggest that any single model performs best across all data sets; though this was to be expected to some extent, given the large number of models estimated. Also interesting is that in some cases, the MSPEs and MAPEs suggest more than one model may yield equivalently accurate forecasts for the same data series, which leaves the forecaster with the conundrum of deciding which model is in fact best. Furthermore, given that the models estimated here are atheoretical in nature, the problem of model selection then becomes one of running numerous diagnostic checks, rather than one rooted in economic theory; which may or may not be desirable, depending on the forecasting application at hand.

Another interesting finding is that the AR-ARCH and AR-GARCH model specification appear to function as they were intended, in that the MSPEs and MAPEs suggest variants of these models provide the most accurate forecasts in series which exhibit greater degrees of price volatility. By contrast, for many of the data series which exhibit lower levels of price volatility, the simple ARMA and AR specifications appear to provide sufficiently accurate forecasts, as indicated by the MSPEs and MAPEs.

8 Prognostications

Seeing as the results of the previous section have provided some indication of the models which yield the most accurate forecasts for each of the data series, it would seem wasteful not to attempt some prognostications of future real estate prices, at least informally. For this purpose, the models which yielded the optimal forecasting results were used to generate single-step and multi-step ahead forecasts for all of the data series, except those of the excess returns, given that the goal here is an attempt to divine future growth rates of prices, and not excess returns.

Since the RLHPS data series are recorded at quarterly intervals while those of the TNBHPI and NHPI are recorded monthly, 1-step and 4-step ahead forecasts are generated for the RLHPS data series; while 1-step, 3-step, and 12-step-ahead forecasts are generated for the TNBHPI and NHPI series, in order to maintain some degree of comparability across the forecasts. It should be noted however that in all cases the forecast standard errors are fairly large, such that the point estimates should be interpreted with a high degree of caution. The results of these forecasts are presented in the Appendix, Sections I.1, I.2, and I.3 for the RLHPS, TNBHPI and NHPI series, respectively.

In cases where multiple models are indicated as providing the best forecasting results for any given series, each model is estimated and used to generate the aforementioned forecasts with the headings of M1, M2, and M3 used to differentiate forecasts generated from different models in the tables. Furthermore, a tabulation column is also included in the tables, which calculates the average of the various forecasts for each series when multiple forecasts are recorded.

8.1 RLHPS Annualized Growth Rate Prognostications

Vancouver Detached Bungalows and Standard Condominiums

Tables I1.01 and I1.02 of the Appendix report the projected annualized price growth rates for the various Vancouver Detached Bungalow and Standard Condominium sub-markets, respectively. Looking at the 1-step-ahead forecasts for the various Detached Bungalow series, the point forecasts of the Vancouver West, West Vancouver and North Vancouver regions suggest the possibility of fairly substantial price growth over the near-term, with projected growth rates of over 20% in the cases of West Vancouver and North Vancouver. As for the Vancouver East and Surrey regions, projected price appreciation is suggested to be near 0%, and even slightly negative in the case of Surrey.

Upon examination of the 4-step-ahead forecasts for the various Detached Bungalow series, it would appear that the dramatic projected price appreciations of the Vancouver West and North Vancouver regions may see a reversal of fortune over the longer term, as price growth is projected to fall to less than 4% in each of these regions over the next four quarters. By contrast, price growth projections for the Vancouver West and Surrey regions are expected to increase over 6% in each region over the same period, while price growth in the Vancouver East region is projected to remain near 0%.

Turning to the Standard Condominium series, the pattern of price appreciation is almost opposite that of the Detached Bungalows in the region, with the exception of the North Vancouver Standard Condominium series. More specifically, the 1-step-ahead projection for the regions of Vancouver West and Vancouver East suggest price growth depreciation in the range of approximately -3%, while in the region of North Vancouver, price appreciation is expected to grow at a rate of over 10%. With respect to the 4-step-ahead projections, the pattern is to remain the same except that the growth rate in prices for the North Vancouver region is expected to moderate to around 2% over the longer term.

Toronto Detached Bungalows and Standard Condominiums

Tables I1.03 and I1.04 of the Appendix report the projected annualized price growth rates for the various Toronto Detached Bungalow and Standard Condominium sub-markets, respectively. Upon examination of the 1-step-ahead forecasts for the various Detached Bungalow series, it can be seen that the general trend across all of the series is that of price growth rate appreciation in nearly every region, with the exception of one forecast for the Oakville region which suggest the possibility of a slight depreciation of prices of approximately -0.6%. Looking at the 4-step-ahead projections, this trend might be expected to remain intact, with the exceptions of the Oakville region, which might see price growth stagnating at near the 0% mark.

More interesting however, is the projections for the various Toronto regions Standard Condominium series for which the 1-step-ahead forecasts suggest the possibility of fairly substantial price growth appreciation, though in the case of the Annex, multiple models suggest the possibility of negative price growth, or stagnation near 0%. Also interesting is that the 4-step-ahead projections appear to suggest a fairly large moderation in the appreciation of the price growth rate for the North Toronto and Oakville regions, while for the Annex, prices growth is projected to turn substantially negative over the next 4 quarters.

8.2 TNBHPI Annualized Growth Rate Prognostications

Composite 6, Composite 11, Vancouver and Toronto

Table I2.01 of the Appendix reports the projected annualized growth rates for the Composite 6, Composite 11, Vancouver, and Toronto index series, respectively. Looking at the 1-step, 3-step, and 12-step-ahead projections for the Composite 6 and Composite 11 series, it can be seen that price appreciation might be expected to moderate from levels around 1% - 1.5% in the short term, to levels near 0% over the longer term. As for the projections of the Vancouver region, price growth appreciation is suggested to remain at levels in the range of 5.5% - 7% over the shorter and longer term. With respect to the projections for the Toronto region, price appreciation rates are suggested to remain negative in the range of -4% to -1% over the shorter and longer term.

8.3 NHPI Annualized Growth Rate Prognostications

Canada, British Columbia, Ontario, Vancouver and Toronto

Table I3.01 of the Appendix shows the projected annualized growth rates of the NHPI for Canada, British Columbia, Ontario, Vancouver and respectively. Similar to the projections made for the TNBHPI, the 1-step, 3-step, and 12-step-ahead projections for Canada suggest price appreciation may remain around the 1.5% mark over the shorter and longer terms. In the case of price appreciation at the provincial levels, projection for British Columbia suggest a slowing of price appreciation from around 1% to 0% over the next 12 months, while for Ontario, price appreciation is suggested to remain fairly strong at around 6.5% over the same period. Interestingly, all the projection for the Vancouver region suggest negative price growth is expected over the shorter and longer terms, while in the case of the Toronto region, price appreciation is expected to fall from around 7% in the near term to around 2% over the next 12 months.

8.4 Discussion

In considering all of the projections just discussed, a common element among them is the noticeable damping in the magnitude of the projections as they extend further into the future. Of course, this phenomenon occurs by design, as can be seen from the specifications of these models illustrated in earlier sections of this paper. It is interesting nonetheless to observe that for the most part, the projections suggest similar trends across the regions examined and across data sets, with the notable exception of projections based on the NHPI series. For this series, projected price growth in the Vancouver region is generally expected to be negative over the shorter and longer term, which stands out as being contrary to many of the other projections for the Vancouver region.

Thus, the question of whether these atheoretical forecasting models lend any credibility to the prognostications of the popular media which suggest a severe real estate market downturn may be in store for the near future, it could be said that the point estimate forecasts generally do not support this theory. It should be noted however, that with respect to the price appreciation rates in the Vancouver and Toronto regions, the forecasts overall seem to suggest a possible moderation of price appreciation in the near future, with the potential of even observing negative growth rates. It is evidently clear however, that models of the autoregressive form are not capable of predicting severe market corrections until such an event is already underway, since by construction they forecast the future, based on the past.

9 Conclusion

This paper has analyzed the forecastability of Canadian real estate prices with a particular focus on the regional markets of Vancouver, and Toronto, and also considers the more aggregate data for British Columbia, Ontario, and Canada as a whole. Using the data from the RLHPS, TNBHPI and NHPI, a number of time-series forecasting models are estimated to generate single-step-ahead and multi-step-ahead forecasts. The Mean Squared Prediction Errors (MSPEs) and Mean Absolute Prediction Errors (MAPEs) are calculated from these forecasts and are then used to qualitatively compare the relative forecasting performances of the various models for each particular data set.

Unlike many earlier studies which forecast real estate prices relying on forecasting models which employ the use of constant coefficients, this study allows the estimated coefficients of the forecasting models to vary over a rolling sample period. In particular, estimations are derived from quarterly data use a rolling sample period of 20 years while estimations derived from monthly data use a rolling sample period of 10 years. The resulting MSPEs and MAPEs from the numerous forecasting models estimated in this study indicate that no single model performs best across all data sets, but rather optimal forecasts are obtained by selecting models which are most suitable to the particular data series under consideration.

As an added exercise, the paper also examines a number of point forecasts for the various data sets analyzed in this study in an attempt to assay the suggestion in the popular media that the Vancouver and Toronto real estate markets may be due for a sizeable correction in the near-term. While the resulting point estimate forecasts should be interpreted with considerable caution, overall the point estimate forecasts generally do not support the notion that the real estate markets in these region are due for a correction which is large in magnitude, however in some instances the forecasts do point to a slight moderation of price appreciation in these regions over the near-term.

Future studies which attempt to forecasts real estate prices using the methodology outlined in this paper could certainly be improved upon in a number of ways. One possible improvement would be to augment the autoregressive models by including structural component related to fundamental drivers of real estate prices, in attempt to improve the forecasting accuracy. Another possible avenue of further research would be to examine whether condominium prices tend to lead prices for single family homes in a particular market, whether the opposite is true, or if prices in various sub-markets tend to lead or lag prices in other near-by regions.

The intuition behind the last possible line of future investigation is that certain housing markets, whether a particular housing type, region, or both, may be more likely to attract speculative investment than others for various reasons. Since speculative investors seek returns on investment over relatively shorter time horizons, it is plausible that speculative investors might be the first movers in response to changes in fundamental markets conditions. If this were the case, housing markets in which the composition of housing stock ownership is more heavily saturated with speculative investors might act as 'bell-weathers' of the overall housing market. In such cases, useful predictive information could be gleaned as to the direction of housing prices in markets which are slower to react to changes in market conditions.

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Appendix

Section A – Raw Data

A.1 – RLHPS – Data Point Availability

A1.01 – Vancouver – Detached Bungalows

Region	Price	Property Tax	Rent
Vancouver West	1975:Q2 – 2012:Q4	1975:Q2 – 2012:Q4	1982:Q2 – 2012:Q4
Vancouver East[30]	1980:Q4 – 2012:Q4	1980:Q4 – 2005:Q3	1982:Q2 – 2005:Q3
West Vancouver	1975:Q2 – 2012:Q4	1975:Q2 – 2008:Q3	1982:Q2 – 2008:Q3
North Vancouver	1974:Q2 – 2012:Q4	1974:Q2 – 2008:Q3	1982:Q2 – 2008:Q3
Surrey[31]	1974:Q2 – 2012:Q4	1974:Q2 – 2012:Q4	1982:Q2 – 2012:Q4

A1.02 – Vancouver – Standard Condominiums

Region	Price	Property Tax	Rent
Vancouver West	1982:Q2 – 2012:Q4	1982:Q2 – 2012:Q3	1982:Q2 – 2012:Q3
Vancouver East[32]	1982:Q2 – 2012:Q4	1982:Q2 – 2005:Q3	1982:Q2 – 2005:Q3
North Vancouver	1982:Q2 – 2012:Q4	1982:Q2 – 2008:Q3	1982:Q2 – 2008:Q3

A1.03 – Toronto – Detached Bungalows

Region	Price	Property Tax	Rent
Burlington	1974:Q2 – 2012:Q4	1974:Q2 – 2012:Q4	1982:Q2 – 2012:Q4
Etobicoke – Islington/Kingsway	1977:Q3 – 2010:Q4	1977:Q3 – 2009:Q1	1980:Q3 – 2008:Q3
Scarborough – Central	1974:Q2 – 2012:Q4	1974:Q2 – 2012:Q4	1982:Q2 – 2012:Q4
Oakville	1974:Q2 – 2012:Q4	1974:Q2 – 2012:Q4	1982:Q2 – 2012:Q4
North Toronto	1981:Q1 – 2012:Q4	1981:Q1 – 2004:Q3	1982:Q1 – 2004:Q3

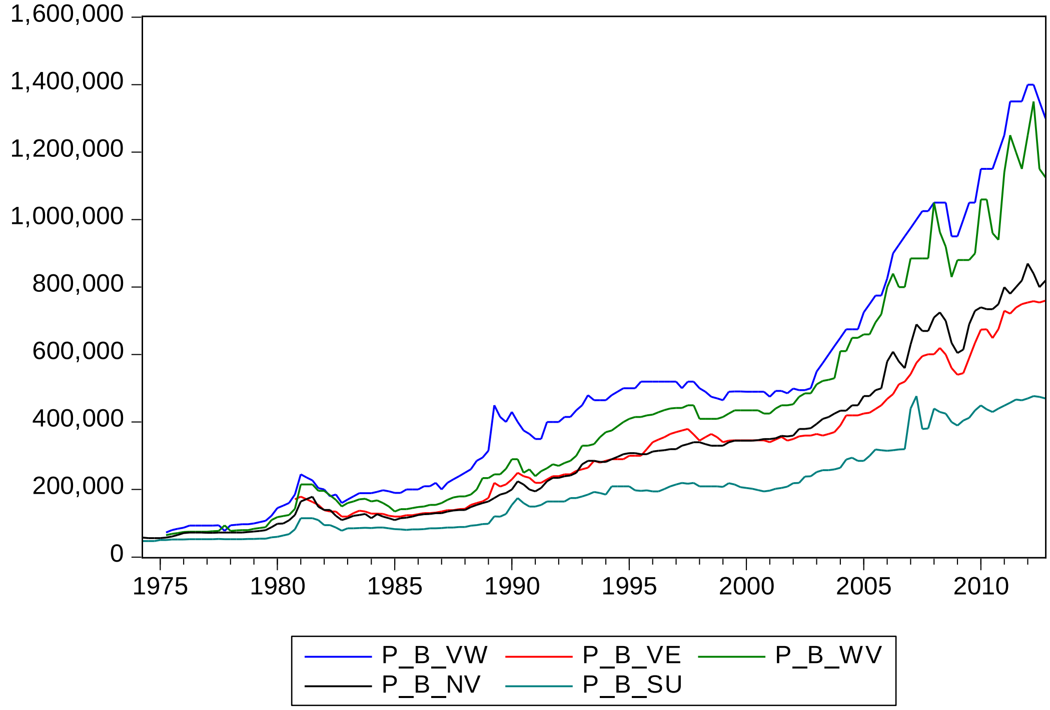
A1.04 – Toronto – Standard Condominiums

Region	Price	Property Tax	Rent
North Toronto	1982:Q2 – 2012:Q4	1982:Q2 – 2004:Q3	1982:Q2 – 2004:Q3
The Annex	1985:Q3 – 2012:Q4	1985:Q3 – 2003:Q4	1985:Q3 – 2003:Q4
Oakville	1982:Q2 – 2012:Q4	1982:Q2 – 2012:Q4	1982:Q2 – 2012:Q4

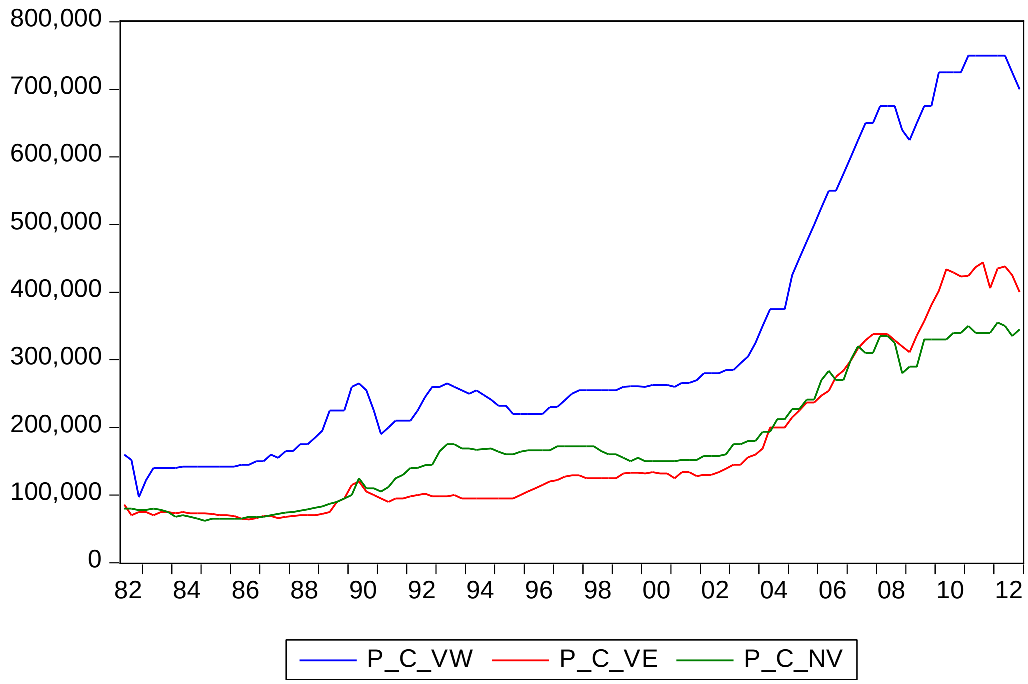
[30] Some missing Income Tax & Rent data from 1995:Q4 – 1997:Q2 were imputed.
[31] Some missing Income Tax & Rent data from 2002:Q4 – 2007:Q4 were imputed.
[32] Some missing Income Tax & Rent data from 1995:Q4 – 1997:Q2 were imputed.

<u>A.2 – RLHPS – Plots</u>

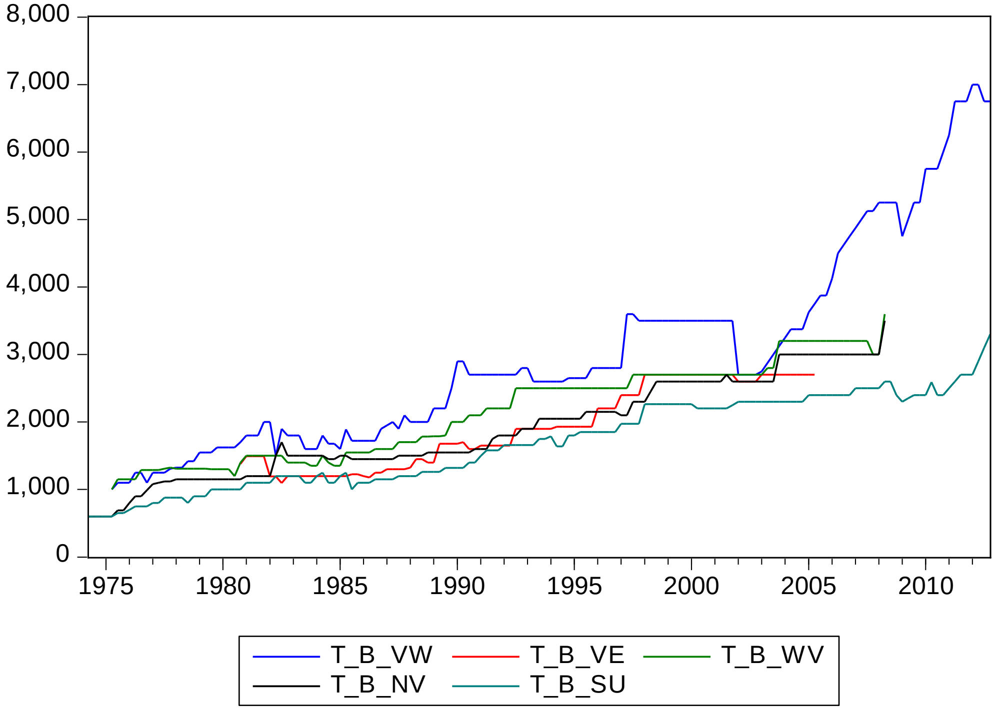
A2.01 – Vancouver Detached Bungalow – Prices, from 1974:Q2 – 2012:Q4



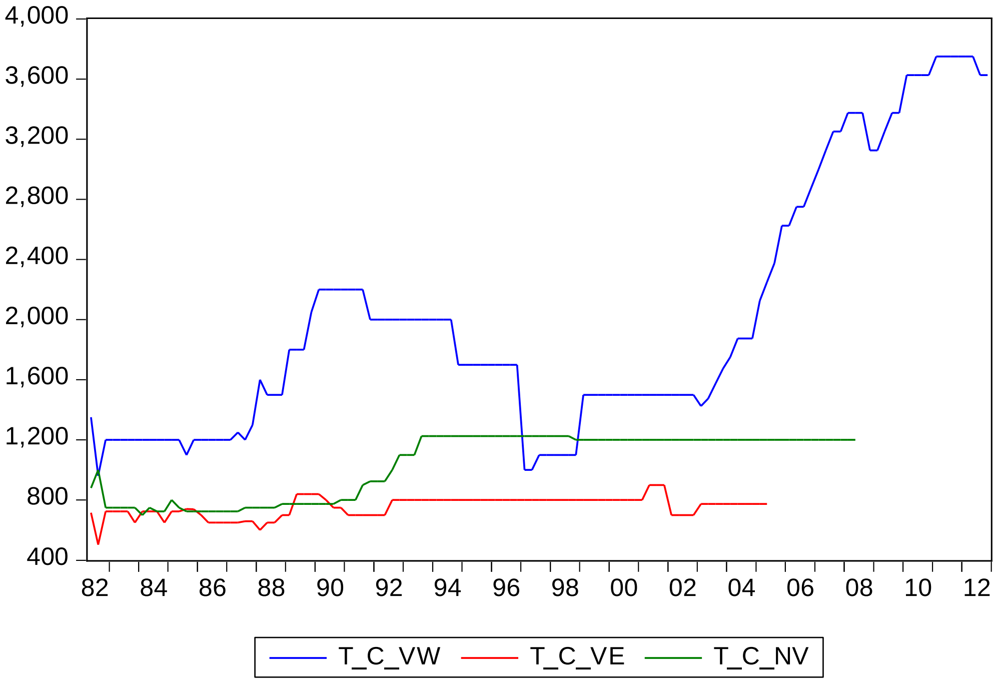
A2.02 – Vancouver Standard Condominium – Prices, from 1982:Q2 – 2012:Q4



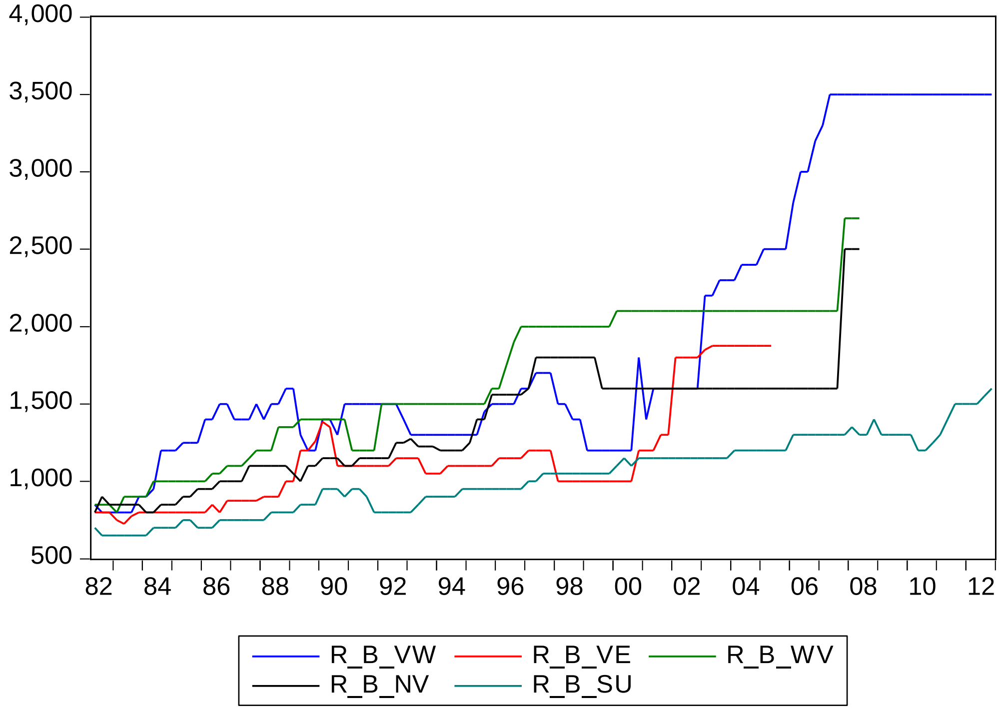
A2.03 – Vancouver Detached Bungalow – Taxes, from 1974:Q2 – 2012:Q4



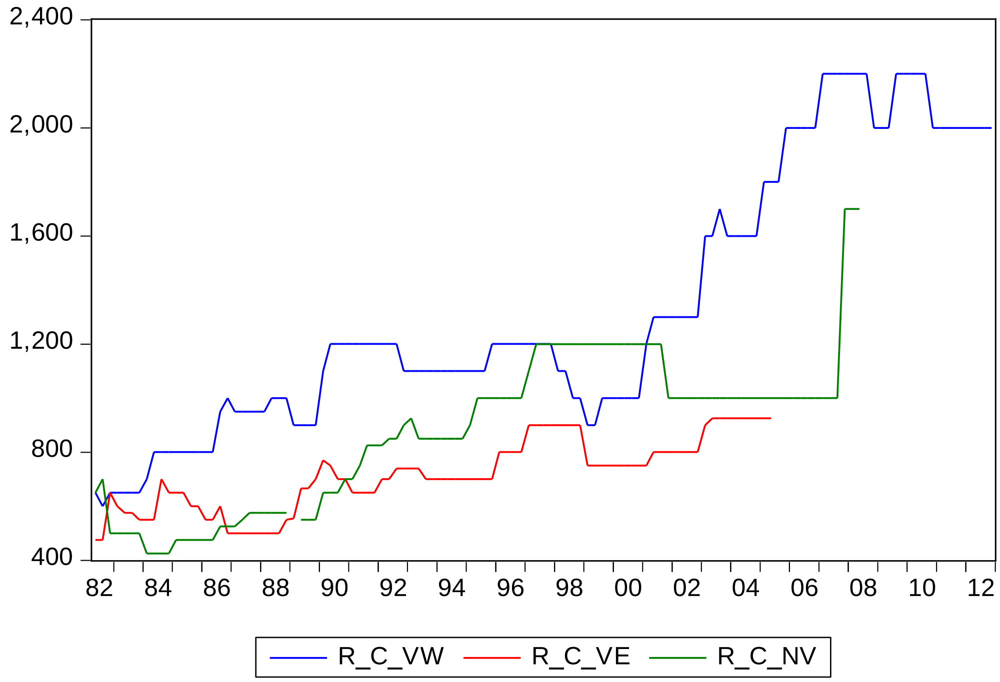
A2.04 – Vancouver Standard Condominium – Taxes, from 1982:Q2 – 2012:Q4



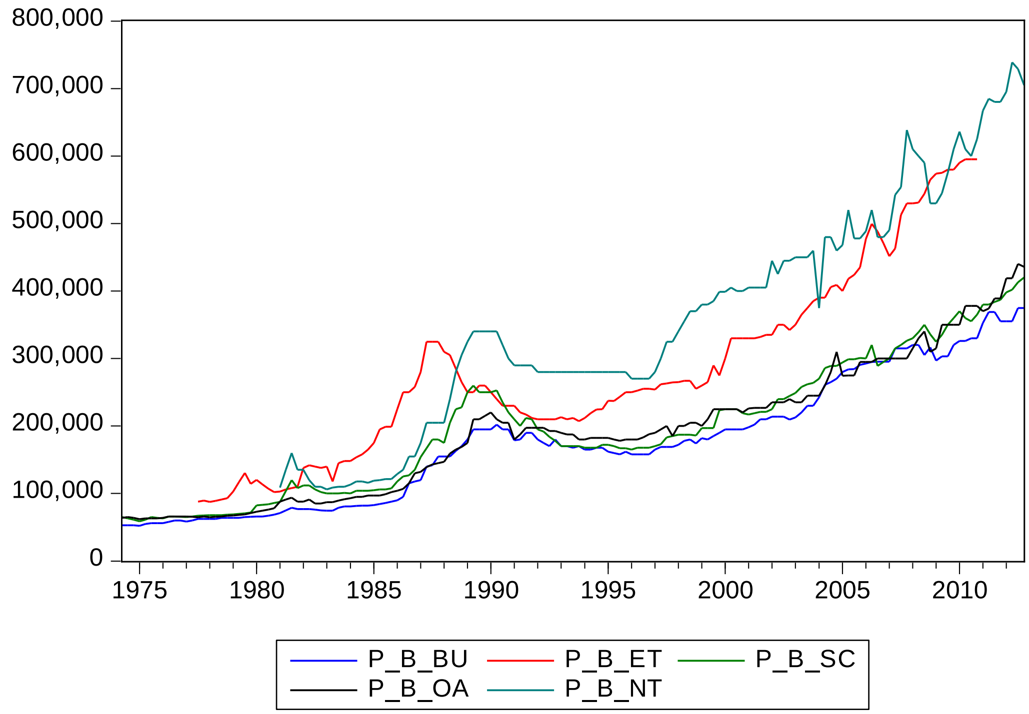
A2.05 – Vancouver Detached Bungalow – Rents, from 1982:Q2 – 2012:Q4



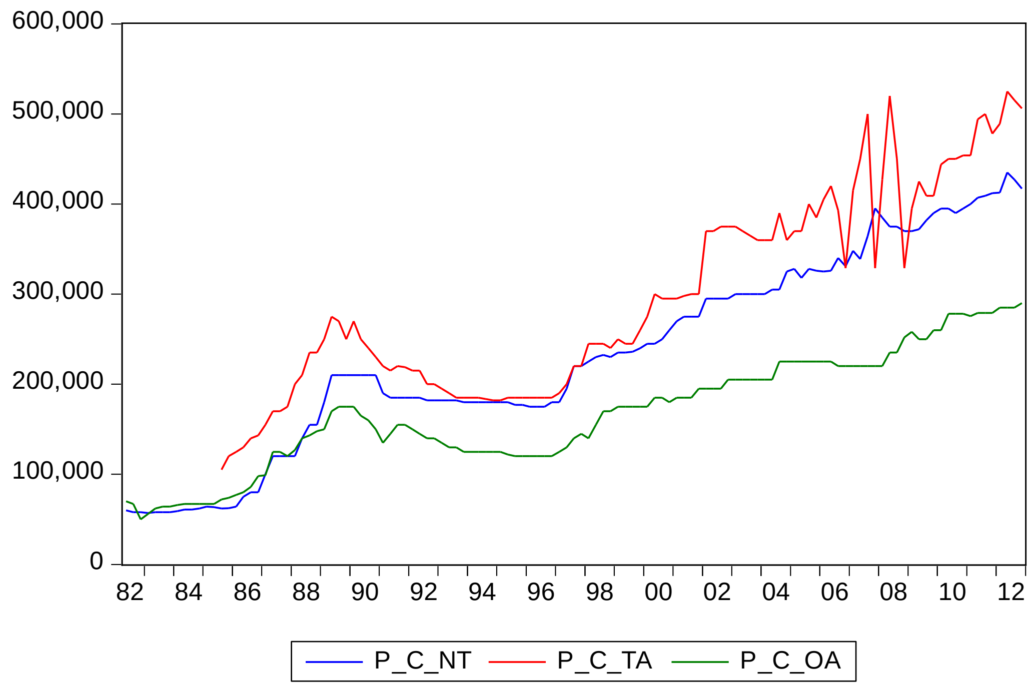
A2.06 – Vancouver Standard Condominium – Rents, from 1982:Q2 – 2012:Q4



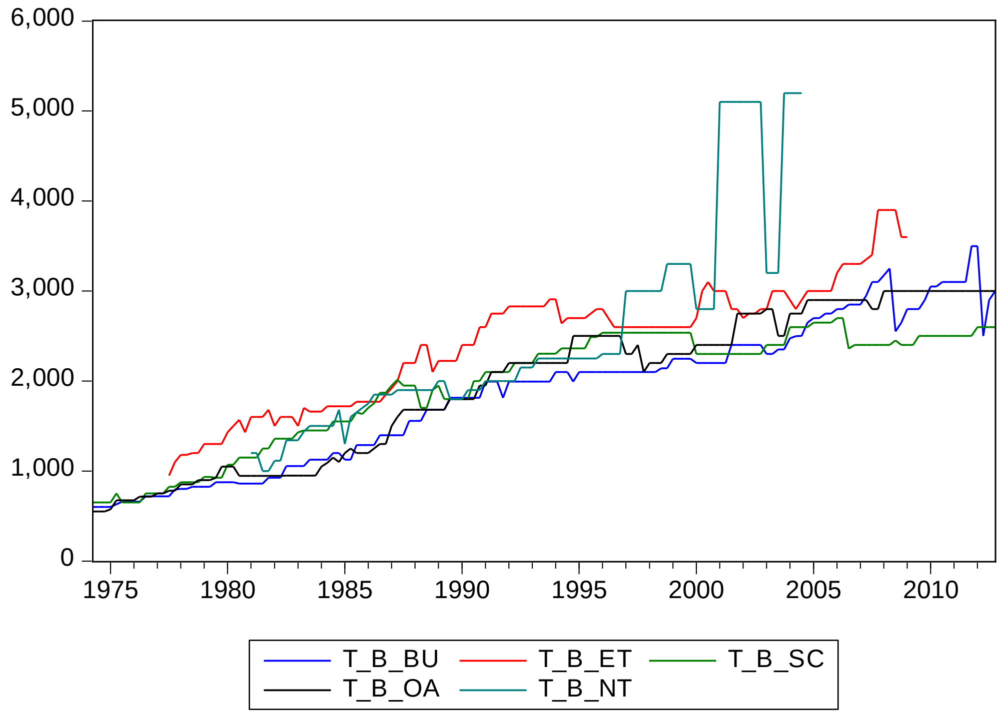
A2.07 – Toronto Detached Bungalow – Prices, from 1974:Q2 – 2012:Q4



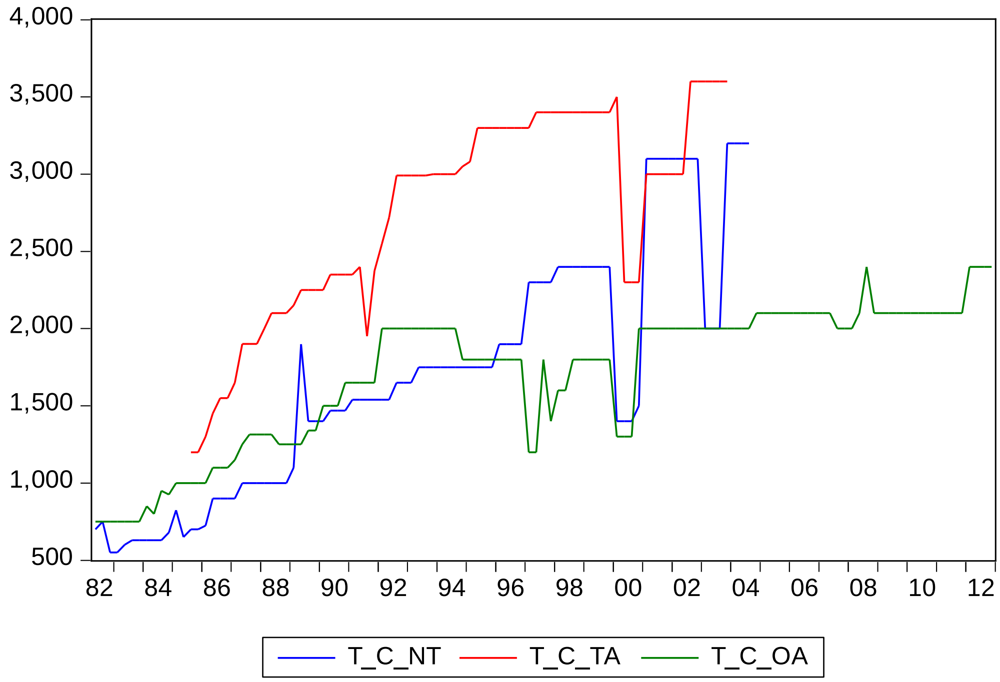
A2.08 – Toronto Standard Condominium – Prices, from 1982:Q2 – 2012:Q4



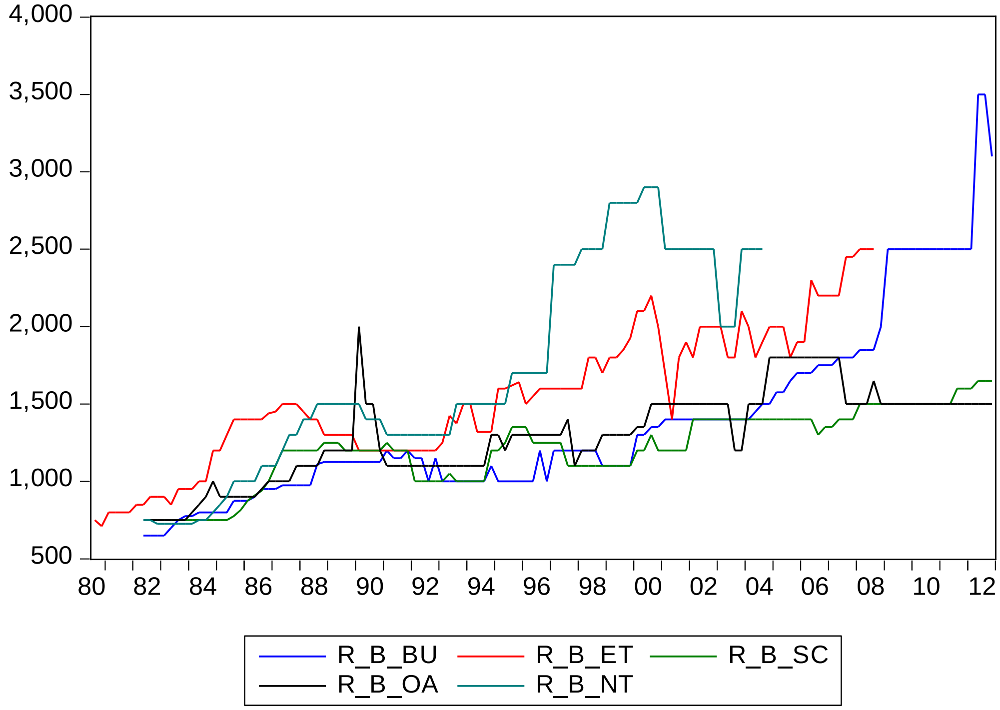
A2.09 – Toronto Detached Bungalow – Taxes, from 1974:Q2 – 2012:Q4



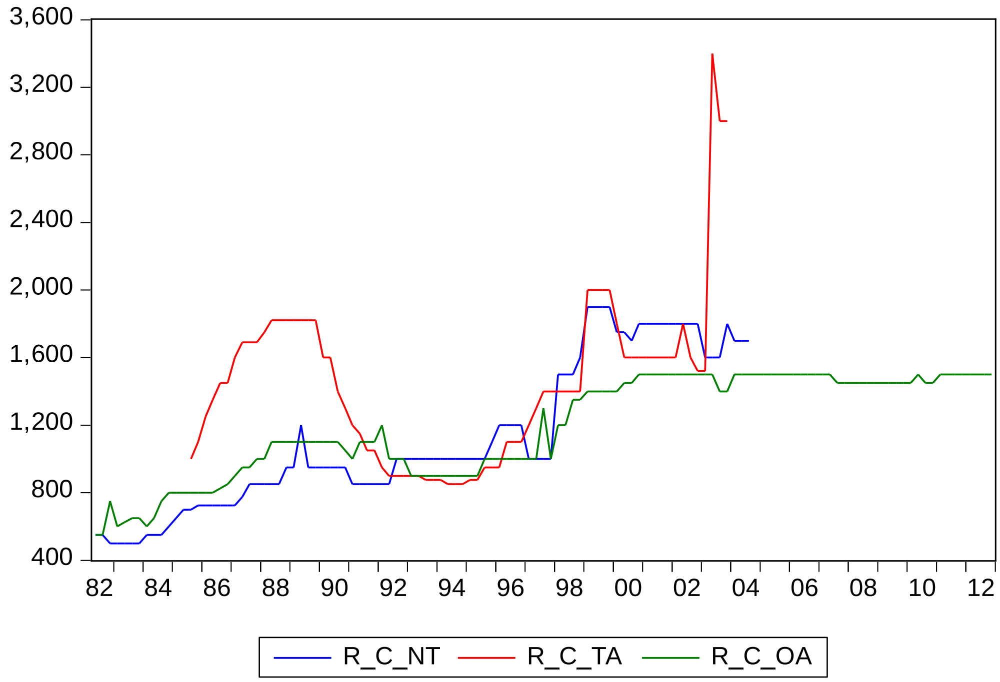
A2.10 – Toronto Standard Condominium – Taxes, from 1982:Q2 – 2012:Q4



A2.11– Toronto Detached Bungalow – Rents, from 1980:Q3 – 2012:Q4



A2.12 – Toronto Standard Condominium – Rents, from 1982:Q2 – 2012:Q4



A.3 – RLHPS – Descriptive Statistics

A3.01 – Vancouver Detached Bungalow – Prices

	P_B_VW	P_B_VE	P_B_WV	P_B_NV	P_B_SU
Mean	$ 492,970.20	$ 341,807.60	$ 421,397.40	$ 310,019.40	$ 194,966.80
Median	$ 465,000.00	$ 345,000.00	$ 370,000.00	$ 282,000.00	$ 185,000.00
Maximum	$ 1,400,000.00	$ 760,000.00	$ 1,350,000.00	$ 870,000.00	$ 477,000.00
Minimum	$ 73,000.00	$ 120,000.00	$ 65,000.00	$ 56,000.00	$ 48,000.00
Std. Dev.	$ 348,746.60	$ 181,638.70	$ 318,731.10	$ 222,730.40	$ 128,062.00
Skewness	0.970752	0.732508	1.039319	0.89829	0.809434
Kurtosis	3.124005	2.673778	3.168514	2.765078	2.603354
Jarque-Bera	23.8128	12.10821	27.36332	21.20198	17.94167
Probability	0.000007	0.002348	0.000001	0.000025	0.000127
Sum	74438500	44093180	63631000	48053000	30219850
Sum Sq. Dev.	1.82E+13	4.22E+12	1.52E+13	7.64E+12	2.53E+12
Observations	151	129	151	155	155

A3.02 – Vancouver Standard Condominium – Prices

	P_C_VW	P_C_VE	P_C_NV
Mean	$ 334,089.40	$ 167,674.80	$ 176,146.30
Median	$ 255,000.00	$ 125,000.00	$ 160,000.00
Maximum	$ 750,000.00	$ 444,000.00	$ 355,000.00
Minimum	$ 97,000.00	$ 64,000.00	$ 62,000.00
Std. Dev.	$ 199,016.40	$ 115,570.10	$ 89,751.04
Skewness	1.037486	1.227144	0.628968
Kurtosis	2.577061	3.097448	2.257947
Jarque-Bera	22.98246	30.91924	10.93187
Probability	0.00001	0	0.004228
Sum	41093000	20624000	21666000
Sum Sq. Dev.	4.83E+12	1.63E+12	9.83E+11
Observations	123	123	123

A3.03 – Vancouver Detached Bungalow – Taxes

	T_B_VW	T_B_VE	T_B_WV	T_B_NV	T_B_SU
Mean	$ 2,990.56	$ 1,928.60	$ 2,144.01	$ 1,881.68	$ 1,697.90
Median	$ 2,700.00	$ 1,900.00	$ 2,200.00	$ 1,700.00	$ 1,660.00
Maximum	$ 7,000.00	$ 2,700.00	$ 3,600.00	$ 3,500.00	$ 3,300.00
Minimum	$ 1,000.00	$ 1,097.00	$ 1,000.00	$ 600.00	$ 600.00
Std. Dev.	$ 1,481.69	$ 589.63	$ 690.85	$ 712.67	$ 654.12
Skewness	1.017592	0.170228	0.090985	0.203991	0.050233
Kurtosis	3.356292	1.469892	1.634317	1.986105	1.784656
Jarque-Bera	26.85859	10.1357	10.51921	6.818217	9.604534
Probability	0.000001	0.006296	0.005197	0.033071	0.008211
Sum	451575	190931	285153	257790	263174
Sum Sq. Dev.	3.29E+08	34070930	63000541	69074514	65892282
Observations	151	99	133	137	155

A3.04 – Vancouver Standard Condominium – Taxes

	T_C_VW	T_C_VE	T_C_NV
Mean	$ 1,996.44	$ 754.87	$ 1,035.52
Median	$ 1,700.00	$ 775.00	$ 1,200.00
Maximum	$ 3,750.00	$ 900.00	$ 1,225.00
Minimum	$ 962.00	$ 503.00	$ 700.00
Std. Dev.	$ 834.27	$ 67.82	$ 213.11
Skewness	0.898877	-0.67289	-0.502572
Kurtosis	2.541091	3.983496	1.372507
Jarque-Bera	17.64288	10.76616	16.00834
Probability	0.000148	0.004594	0.000334
Sum	245562	70203	108730
Sum Sq. Dev.	84912134	423154.5	4723146
Observations	123	93	105

A3.05 – Vancouver Detached Bungalow – Rents

	R_B_VW	R_B_VE	R_B_WV	R_B_NV	R_B_SU
Mean	$ 1,883.98	$ 1,130.05	$ 1,605.00	$ 1,338.18	$ 1,012.11
Median	$ 1,500.00	$ 1,100.00	$ 1,500.00	$ 1,250.00	$ 975.00
Maximum	$ 3,500.00	$ 1,875.00	$ 2,700.00	$ 2,500.00	$ 1,600.00
Minimum	$ 800.00	$ 725.00	$ 800.00	$ 800.00	$ 650.00
Std. Dev.	$ 900.46	$ 332.76	$ 496.27	$ 376.52	$ 243.56
Skewness	0.886236	1.230011	-0.001814	0.557317	0.253573
Kurtosis	2.301613	3.534457	1.865414	3.440362	2.096009
Jarque-Bera	19.3568	25.87754	5.900115	6.58316	5.730123
Probability	0.000063	0.000002	0.052337	0.037195	0.05698
Sum	241150	110745	176550	147200	129550
Sum Sq. Dev.	1.03E+08	10740825	26844750	15452636	7533730
Observations	128	98	110	110	128

A3.06 – Vancouver Standard Condominium – Rents

	R_C_VW	R_C_VE	R_C_NV
Mean	$ 1,331.71	$ 715.51	$ 875.48
Median	$ 1,200.00	$ 700.00	$ 1,000.00
Maximum	$ 2,200.00	$ 925.00	$ 1,700.00
Minimum	$ 600.00	$ 475.00	$ 425.00
Std. Dev.	$ 484.82	$ 132.30	$ 289.46
Skewness	0.580541	-0.03283	0.32808
Kurtosis	2.004624	2.119777	3.012395
Jarque-Bera	11.98678	3.019022	1.88431
Probability	0.002495	0.221018	0.389787
Sum	163800	66542	91925
Sum Sq. Dev.	28676341	1610403	8713726
Observations	123	93	105

A3.07 – Toronto Detached Bungalow – Prices

	P_B_BU	P_B_ET	P_B_SC	P_B_OA	P_B_NT
Mean	$ 175,528.90	$ 282,431.40	$ 195,929.70	$ 190,645.60	$ 357,275.80
Median	$ 170,000.00	$ 255,000.00	$ 185,000.00	$ 188,000.00	$ 340,000.00
Maximum	$ 375,000.00	$ 595,000.00	$ 420,000.00	$ 440,000.00	$ 739,000.00
Minimum	$ 52,000.00	$ 87,700.00	$ 59,000.00	$ 62,000.00	$ 106,000.00
Std. Dev.	$ 92,798.08	$ 136,778.50	$ 97,755.54	$ 98,809.90	$ 169,496.50
Skewness	0.420038	0.714002	0.388418	0.494389	0.32906
Kurtosis	2.166978	2.773156	2.203816	2.481239	2.30387
Jarque-Bera	9.039421	11.6728	7.991439	8.052219	4.894507
Probability	0.010892	0.002919	0.018394	0.017844	0.086531
Sum	27206972	37845808	30369100	29550068	45731300
Sum Sq. Dev.	1.33E+12	2.49E+12	1.47E+12	1.50E+12	3.65E+12
Observations	155	134	155	155	128

A3.08 – Toronto Standard Condominium – Prices

	P_C_NT	P_C_TA	P_C_OA
Mean	$ 232,484.60	$ 295,470.50	$ 167,660.60
Median	$ 220,000.00	$ 265,000.00	$ 170,000.00
Maximum	$ 435,000.00	$ 524,900.00	$ 290,000.00
Minimum	$ 57,000.00	$ 105,000.00	$ 50,000.00
Std. Dev.	$ 109,231.40	$ 111,435.20	$ 63,827.08
Skewness	0.031596	0.396814	0.090862
Kurtosis	2.011968	1.974306	2.175271
Jarque-Bera	5.023527	7.708674	3.655159
Probability	0.081125	0.021188	0.160802
Sum	28595600	32501750	20622250
Sum Sq. Dev.	1.46E+12	1.35E+12	4.97E+11
Observations	123	110	123

A3.09 – Toronto Detached Bungalow – Taxes

	T_B_BU	T_B_ET	T_B_SC	T_B_OA	T_B_NT
Mean	$ 1,865.79	$ 2,420.79	$ 1,945.99	$ 1,958.36	$ 2,498.63
Median	$ 1,995.00	$ 2,600.00	$ 2,300.00	$ 2,200.00	$ 2,150.00
Maximum	$ 3,500.00	$ 3,900.00	$ 2,700.00	$ 3,000.00	$ 5,200.00
Minimum	$ 600.00	$ 950.00	$ 650.00	$ 550.00	$ 1,000.00
Std. Dev.	$ 785.53	$ 685.55	$ 640.85	$ 820.67	$ 1,161.07
Skewness	-0.025389	-0.170413	-0.776507	-0.263744	1.277219
Kurtosis	1.921063	2.323206	2.20801	1.599171	3.697967
Jarque-Bera	7.534831	3.038544	19.62755	14.47032	27.75707
Probability	0.023112	0.218871	0.000055	0.000721	0.000001
Sum	289198	307440	301628	303545	237370
Sum Sq. Dev.	95026053	59217821	63245986	1.04E+08	1.27E+08
Observations	155	127	155	155	95

A3.10 – Toronto Standard Condominium – Taxes

	T_C_NT	T_C_TA	T_C_OA
Mean	$ 1,683.67	$ 2,747.74	$ 1,702.14
Median	$ 1,650.00	$ 3,000.00	$ 1,800.00
Maximum	$ 3,200.00	$ 3,600.00	$ 2,400.00
Minimum	$ 550.00	$ 1,200.00	$ 750.00
Std. Dev.	$ 786.86	$ 675.60	$ 454.89
Skewness	0.436372	-0.601858	-0.704577
Kurtosis	2.288905	2.266234	2.303471
Jarque-Bera	4.752516	6.127647	12.66319
Probability	0.092898	0.046709	0.001779
Sum	151530	203333	209363
Sum Sq. Dev.	55104440	33319372	25244965
Observations	90	74	123

A3.11 – Toronto Detached Bungalow – Rents

	R_B_BU	R_B_ET	R_B_SC	R_B_OA	R_B_NT
Mean	$ 1,382.81	$ 1,538.89	$ 1,211.50	$ 1,297.56	$ 1,688.89
Median	$ 1,200.00	$ 1,500.00	$ 1,200.00	$ 1,300.00	$ 1,500.00
Maximum	$ 3,500.00	$ 2,500.00	$ 1,650.00	$ 2,000.00	$ 2,900.00
Minimum	$ 650.00	$ 710.00	$ 750.00	$ 750.00	$ 725.00
Std. Dev.	$ 589.58	$ 440.93	$ 241.58	$ 287.43	$ 675.20
Skewness	1.496382	0.195086	-0.415374	-0.013429	0.323847
Kurtosis	4.986756	2.397411	2.441858	2.439302	1.830946
Jarque-Bera	66.13218	2.426431	5.133523	1.614908	6.698229
Probability	0	0.29724	0.076784	0.445992	0.035115
Sum	170085	173895	149015	159600	152000
Sum Sq. Dev.	42408357	21774837	7119897	10079268	40575139
Observations	123	113	123	123	90

A3.12 – Toronto Standard Condominium – Rents

	R_C_NT	R_C_TA	R_C_OA
Mean	$ 1,120.83	$ 1,445.61	$ 1,186.59
Median	$ 1,000.00	$ 1,400.00	$ 1,200.00
Maximum	$ 1,900.00	$ 3,400.00	$ 1,500.00
Minimum	$ 500.00	$ 850.00	$ 550.00
Std. Dev.	$ 440.99	$ 498.60	$ 297.11
Skewness	0.485255	1.437783	-0.380086
Kurtosis	1.901446	6.42473	1.790735
Jarque-Bera	8.057669	61.65943	10.45594
Probability	0.017795	0	0.005364
Sum	100875	106975	145950
Sum Sq. Dev.	17307812	18147598	10769116
Observations	90	74	123

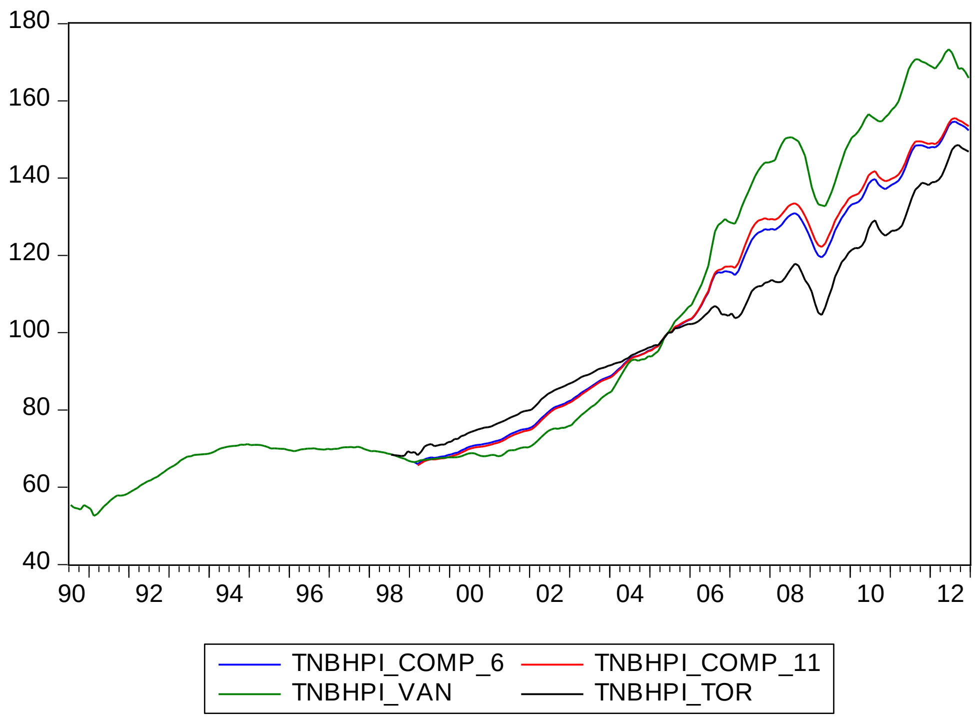
A.4 – TNBHPI – Data Point Availability

A4.01 – Vancouver, Toronto, Composite 6, and Composite 11 Data Availability

Region	Start Date	End Date
Vancouver	July, 1990	December, 2012
Toronto	July, 1998	December, 2012
Composite 6	February, 1999	December, 2012
Composite 1	March ,1999	December, 2012

A.5 – TNBHPI – Plots

A5.01 – Plot of Vancouver, Toronto, Composite 6, and Composite 11 Indices



A.6 – TNBHPI – Descriptive Statistics

A6.01 – Vancouver, Toronto, Composite 6, and Composite 11 – Index Values

	TNBHPI_COMP_6	TNBHPI_COMP_11	TNBHPI_VAN	TNBHPI_TOR
Mean	106.4742	107.4257	95.28659	101.033
Median	103.51	104.12	70.935	101.365
Maximum	154.64	155.52	173.33	148.55
Minimum	66.03	65.63	52.6	68.09
Std. Dev.	27.96649	28.85123	37.55824	22.32439
Skewness	0.099073	0.065608	0.836147	0.318874
Kurtosis	1.636541	1.57263	2.111348	2.165233
Jarque-Bera	13.20887	14.211	40.34553	8.0008
Probability	0.001354	0.000821	0	0.018308
Sum	17781.19	17832.66	25727.38	17579.74
Sum Sq. Dev.	129832.6	137344.9	379457.1	86219.44
Observations	167	166	270	174

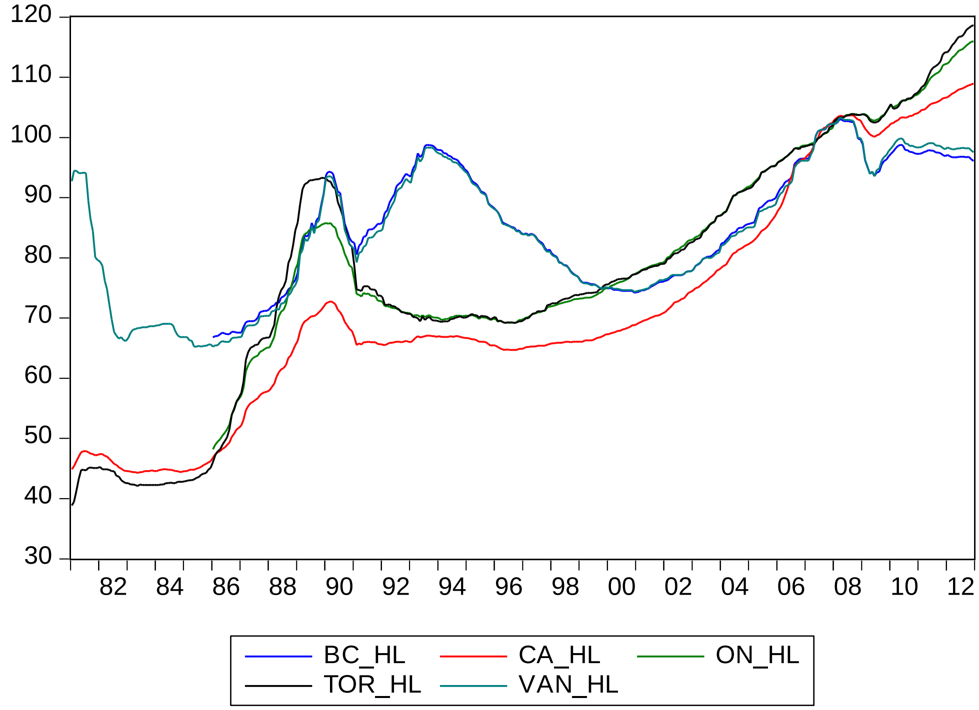
A.7 – NHPI – Data Point Availability

A7.01 – Canada, ON, BC, Vancouver and Toronto Data Availability

Region	House and Land	House Only	Land Only
Canada	Jan. 1981 – Dec. 2012	Jan. 1981 – Dec. 2012	Jan. 1981 – Dec. 2012
British Columbia	Jan. 1986 – Dec. 2012	Jan. 1986 – Dec. 2012	Jan. 1986 – Dec. 2012
Ontario	Jan. 1986 – Dec. 2012	Jan. 1986 – Dec. 2012	Jan. 1986 – Dec. 2012
Vancouver	Jan. 1981 – Dec. 2012	Jan. 1981 – Dec. 2012	Jan. 1981 – Dec. 2012
Toronto	Jan. 1981 – Dec. 2012	Jan. 1981 – Dec. 2012	Jan. 1981 – Dec. 2012

A.8 – NHPI – Plots

A8.01 – NHPI – House and Land Index Values for Canada, BC, ON, Vancouver and Toronto



A.9 – NHPI – Descriptive Statistics

A9.01 – Canada, BC, ON, Vancouver and Toronto – House and Land

	CA_HL	BC_HL	ON_HL	VAN_HL	TOR_HL
Mean	71.7276	86.30278	82.78549	84.01667	77.32187
Median	66.9	85.7	78.5	83.9	75.05
Maximum	109	103	116	103.3	118.7
Minimum	44.3	66.8	48.2	65.3	38.9
Std. Dev.	18.96576	9.974663	15.68145	11.24777	20.73113
Skewness	0.463528	-0.1558	0.363062	-0.04181	-0.10749
Kurtosis	2.291617	1.839719	2.284151	1.765063	2.270959
Jarque-Bera	21.77982	19.48511	14.03589	24.51302	9.243525
Probability	0.000019	0.000059	0.000896	0.000005	0.009835
Sum	27543.4	27962.1	26822.5	32262.4	29691.6
Sum Sq. Dev.	137765.1	32136.53	79428.24	48454.23	164605.6
Observations	384	324	324	384	384

Section B – First Estimation Samples and Holdout Periods

B.1 – RLHPS – Annualized Quarterly Excess Returns

B1.01 – Vancouver – Detached Bungalows

Region	First Estimation Sample	Holdout Period
Vancouver West	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Vancouver East*	1982:Q3 – 2002:Q3	2002:Q4 – 2005:Q3
West Vancouver*	1982:Q3 – 2002:Q3	2002:Q4 – 2008:Q3
North Vancouver*	1982:Q3 – 2002:Q3	2002:Q4 – 2008:Q3
Surrey	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4

** Indicates Series with holdout periods of less than 10 years.*

B1.02 – Vancouver – Standard Condominiums

Region	First Estimation Sample	Holdout Period
Vancouver West	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Vancouver East*	1982:Q3 – 2002:Q3	2002:Q4 – 2005:Q3
North Vancouver*	1982:Q3 – 2002:Q3	2002:Q4 – 2008:Q3

** Indicates Series with holdout periods of less than 10 years.*

B1.03 – Toronto – Detached Bungalows

Region	First Estimation Sample	Holdout Period
Burlington	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Etobicoke – Islington/Kingsway*	1980:Q4 – 2000:Q4	2001:Q1 – 2008:Q4
Scarborough – Central	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Oakville	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
North Toronto*	1982:Q3 – 2002:Q3	2002:Q4 – 2004:Q4

** Indicates Series with holdout periods of less than 10 years.*

B1.04 – Toronto – Standard Condominiums

Region	First Estimation Sample	Holdout Period
North Toronto*	1982:Q3 – 2002:Q3	2002:Q4 – 2004:Q4
The Annex**	1985:Q4 – 1999:Q4	2000:Q1 – 2004:Q1
Oakville	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4

** Indicates Series with holdout periods of less than 10 years.*
*** This series is particularly shorter than all others, thus the sample period is adjusted to 15 years and the holdout period is also less than 10 years.*

B.2 – RLHPS – Annualized Quarterly Growth Rates

B2.01 – Vancouver – Detached Bungalows

Region	First Estimation Sample	Holdout Period
Vancouver West	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Vancouver East	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
West Vancouver	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
North Vancouver	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Surrey	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4

B2.02 – Vancouver – Standard Condominiums

Region	First Estimation Sample	Holdout Period
Vancouver West	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Vancouver East	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
North Vancouver	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4

B2.03 – Toronto – Detached Bungalows

Region	First Estimation Sample	Holdout Period
Burlington	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Etobicoke – Islington/Kingsway*	1979:Q4 – 1999:Q4	2001:Q1 – 2011:Q1
Scarborough – Central	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
Oakville	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
North Toronto	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4

** Series ends in 2011.*

B2.04 – Toronto – Standard Condominiums

Region	First Estimation Sample	Holdout Period
North Toronto	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4
The Annex*	1985:Q4 – 2002:Q3	2002:Q4 – 2012:Q4
Oakville	1982:Q3 – 2002:Q3	2002:Q4 – 2012:Q4

** Due to data limitations, the sample period is adjusted to ~17 years.*

B.3 – TNBHPI – Annualized Monthly Growth Rates

B3.01 – Vancouver, Toronto, Composite 6, and Composite 11

Region	First Estimation Sample	Holdout Period
Vancouver	1992:M11 – 2002:M11	2002:M12 – 2012:M12
Toronto*	1998:M08 – 2008:M08	2008:M12 – 2012:M12
Composite 6*	1999:M03 – 2009:M03	2009:M04 – 2012:M12
Composite 11*	1999:M04 – 2009:M04	2009:M05 – 2012:M12

** Indicates Series with holdout periods of less than 10 years.*

B.4 – NHPI – Annualized Monthly Growth Rates

B4.01 – Canada, ON, BC, Vancouver and Toronto

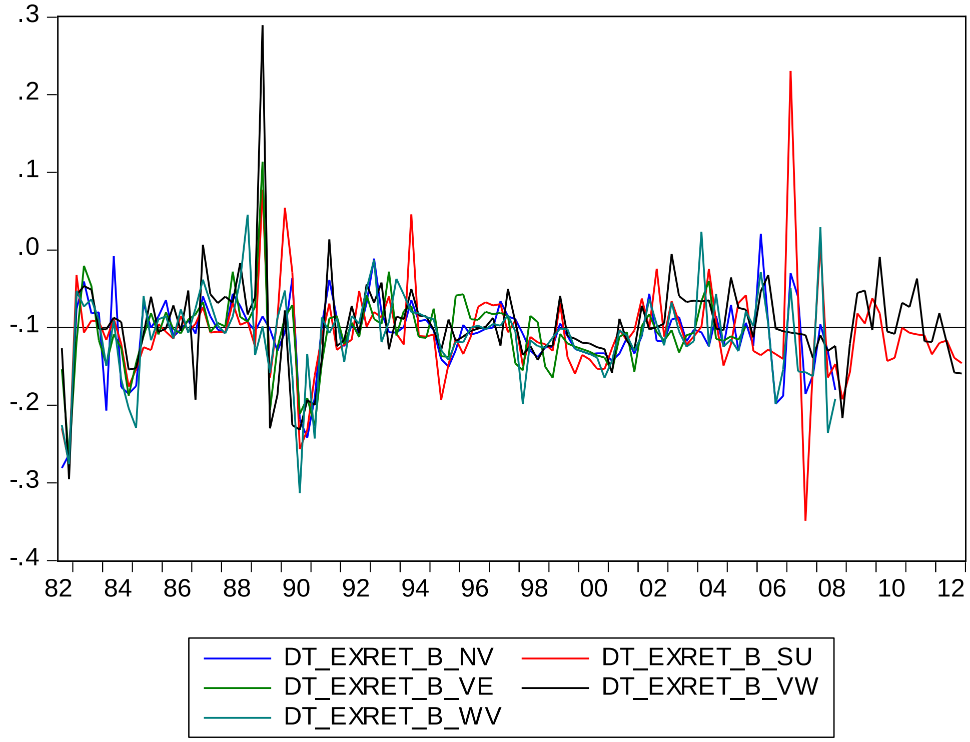
Region	First Estimation Sample	Holdout Period
Canada	1982:M11 – 2002:M11	2002:M12 – 2012:M12
British Columbia*	1986:M02 – 2006:M02	2006:M03 – 2012:M12
Ontario*	1986:M02 – 2006:M02	2006:M03 – 2012:M12
Vancouver	1982:M11 – 2002:M11	2002:M12 – 2012:M12
Toronto	1982:M11 – 2002:M11	2002:M12 – 2012:M12

** Indicates Series with holdout periods of less than 10 years.*

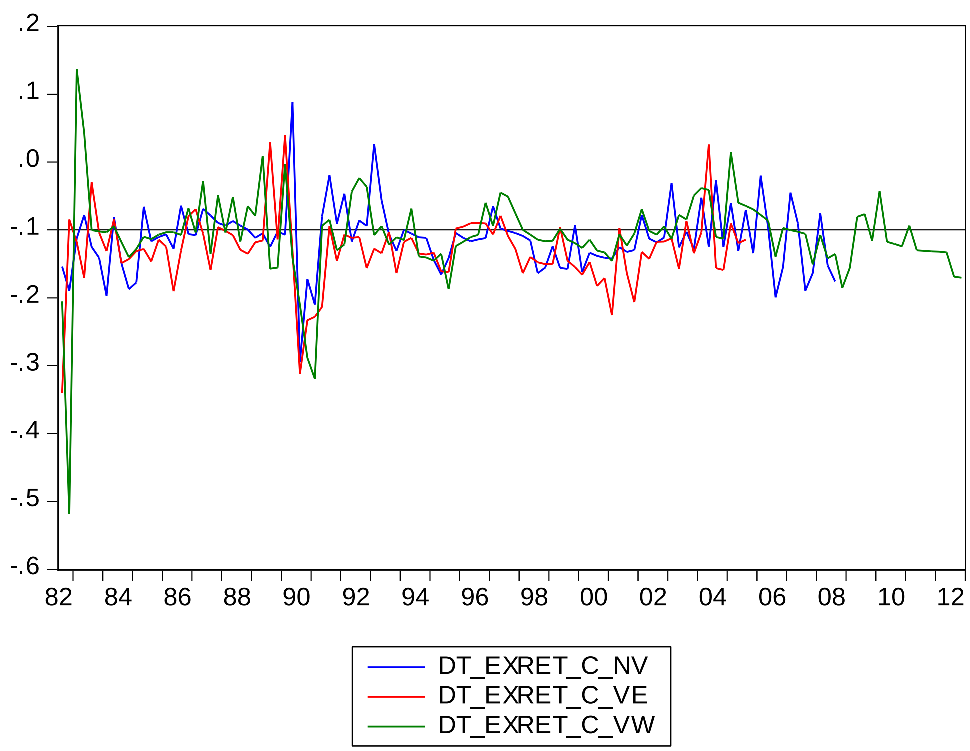
Section C – Plots of Data Used in Estimations and Forecasts

C.1 – RLHPS – Plots of Quarterly Excess Returns (Next Page)

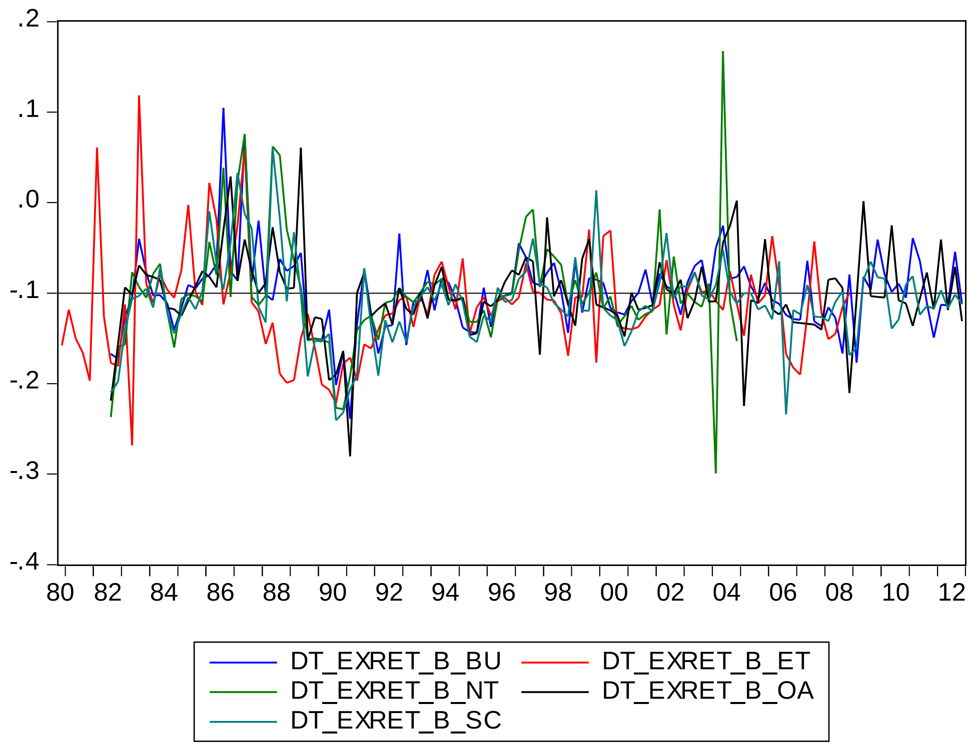
C1.01 – Vancouver – Detached Bungalows – Quarterly Excess Returns



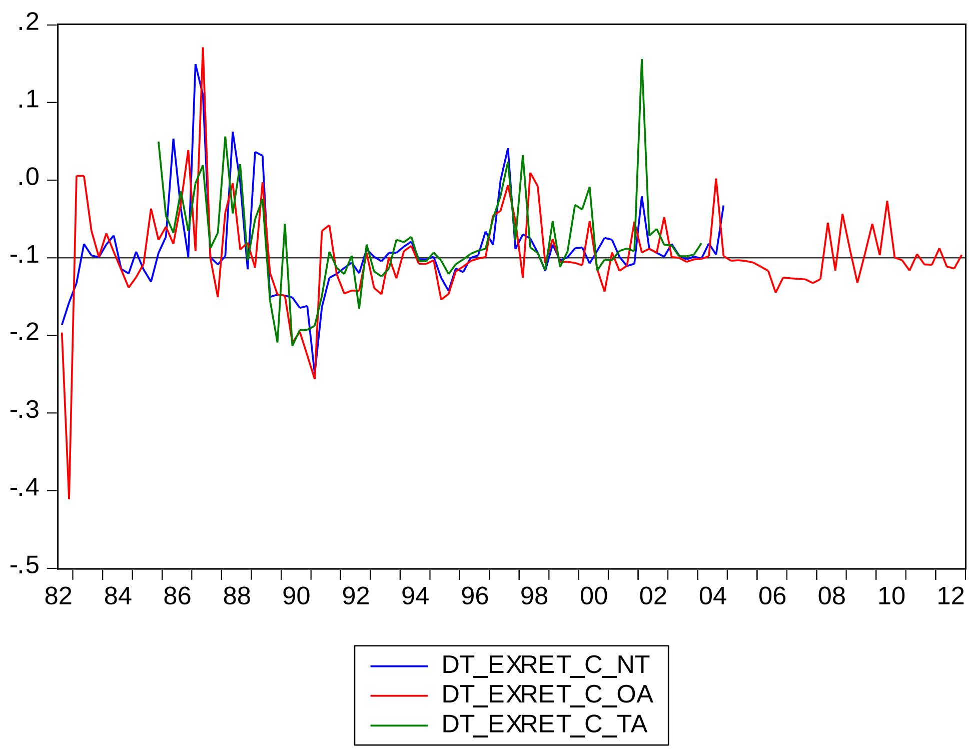
C1.02 – Vancouver – Standard Condominiums – Quarterly Excess Returns



C1.03 – Toronto – Detached Bungalows – Quarterly Excess Returns

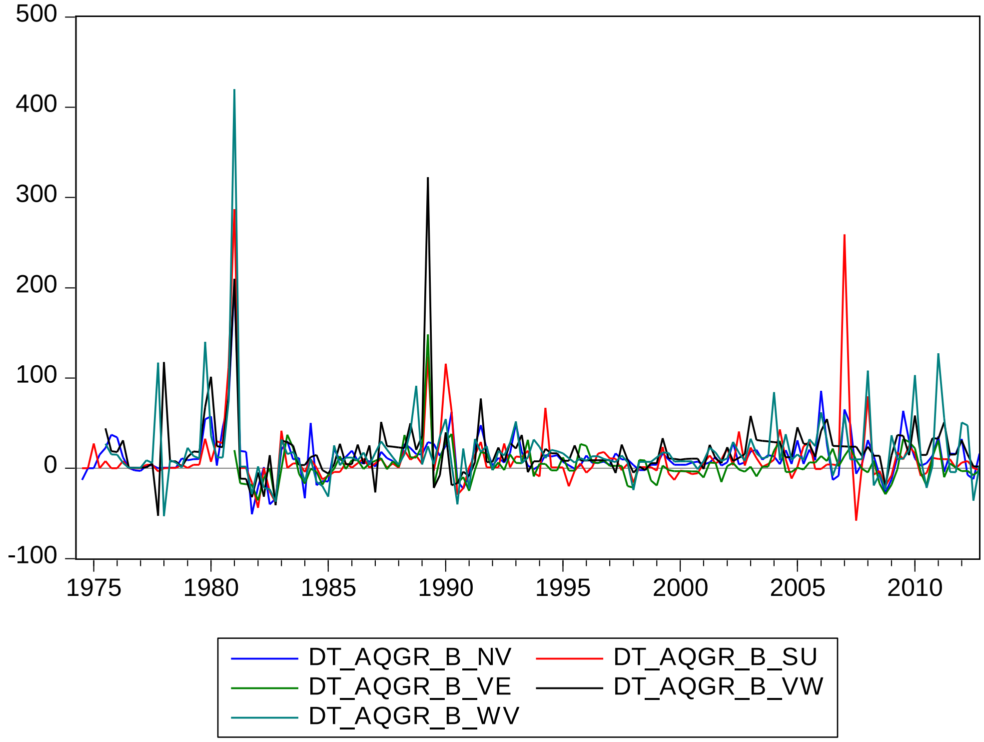


C1.04 – Toronto – Standard Condominiums – Quarterly Excess Returns

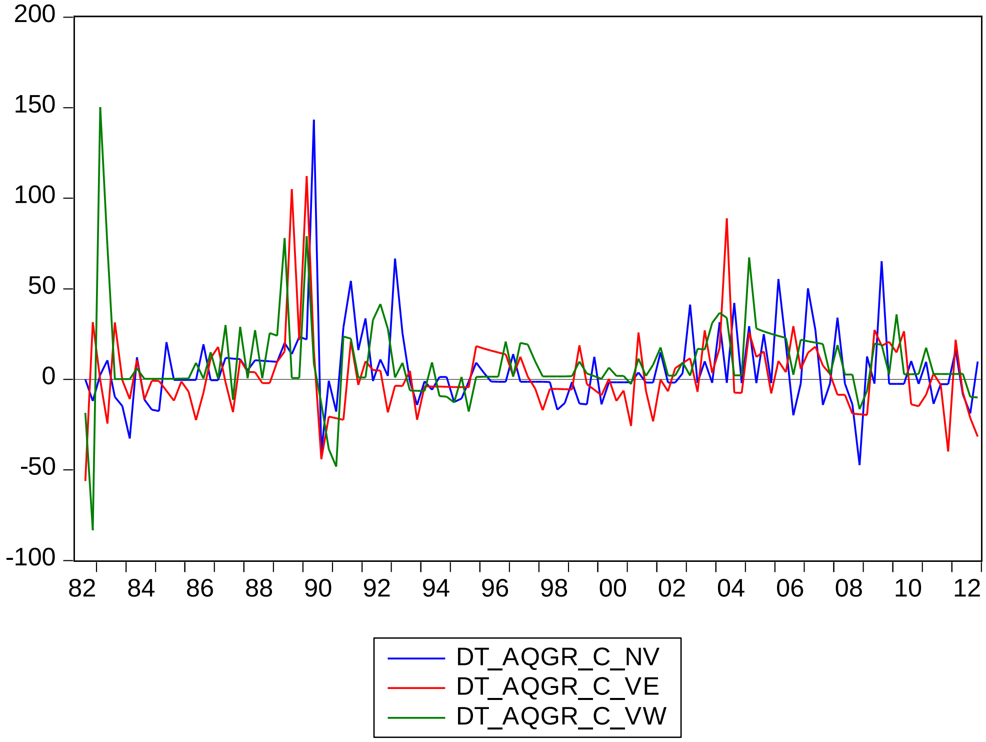


C.2 – RLHPS – Plots of Annualized Growth Rates

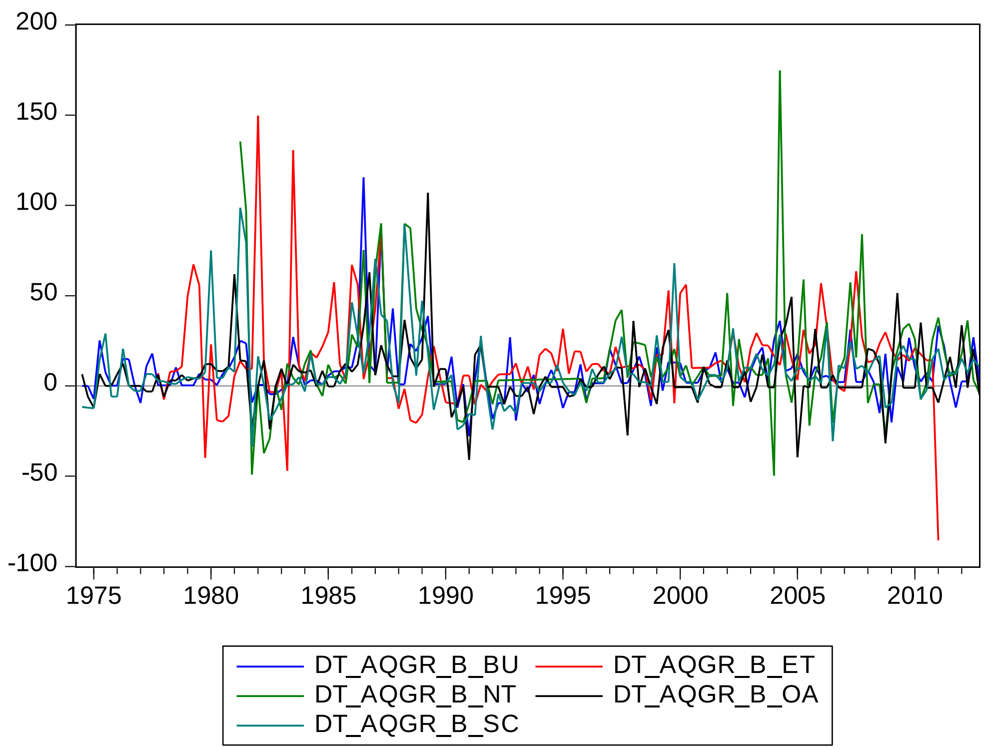
C2.01 – Vancouver – Detached Bungalows – Annualized Quarterly Growth Rates



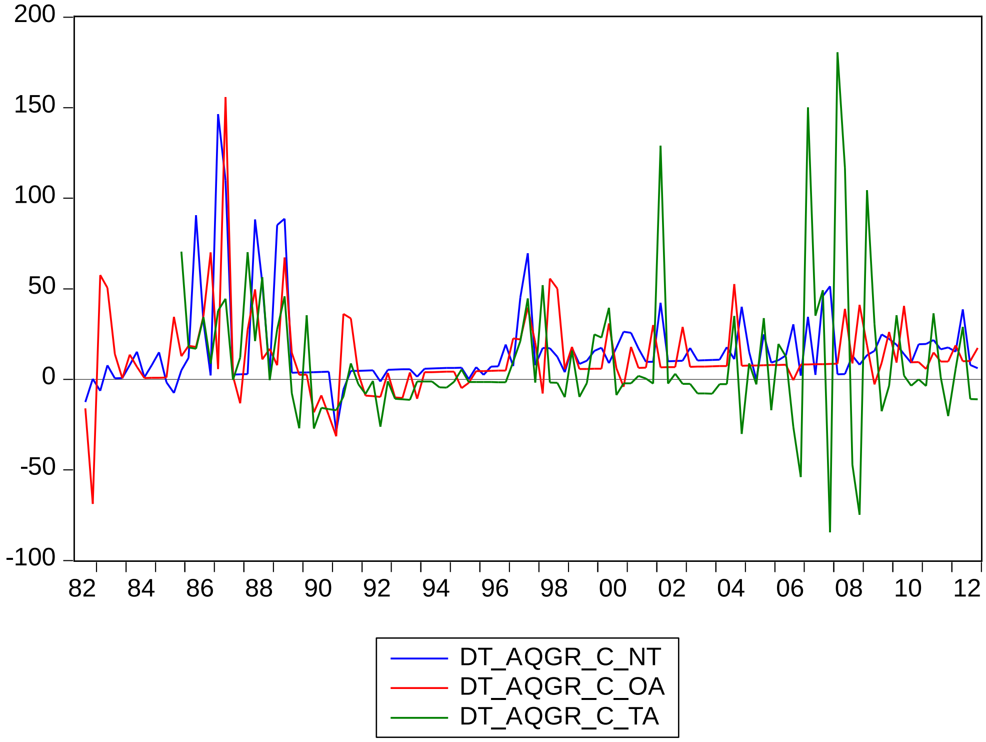
C2.02 – Vancouver – Standard Condominiums – Annualized Quarterly Growth Rates



C2.03 – Toronto – Detached Bungalows – Annualized Quarterly Growth Rates

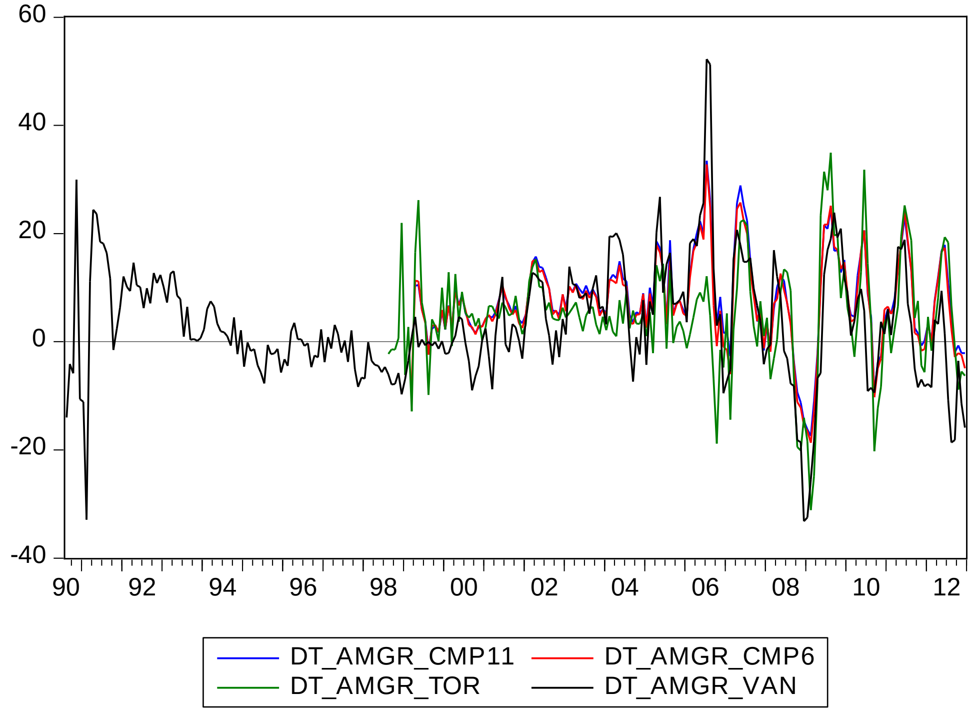


C2.04 – Toronto – Standard Condominiums – Annualized Quarterly Growth Rates



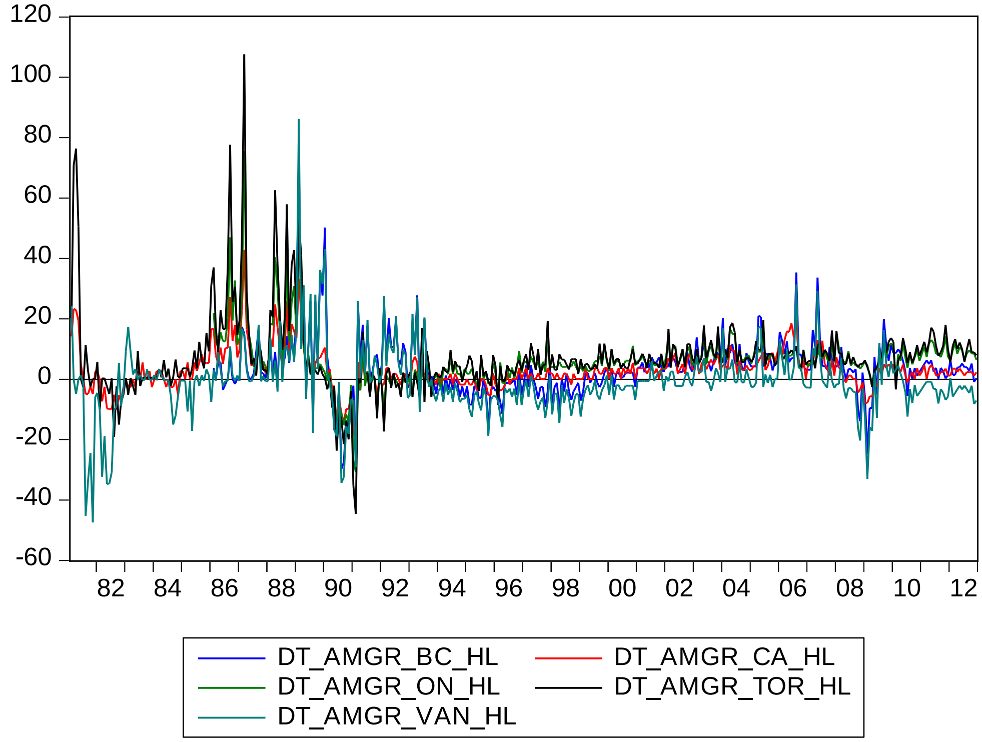
C.3 – TNBHPI – Plots of Annualized Monthly Growth Rates

C3.01 – Annualized Monthly Growth Rates



C.4 – NHPI – Plots of Annualized Monthly Growth Rates

C4.01 – Annualized Monthly Growth Rates



Section D – Descriptive Statistics of Data Used in Estimations and Forecasts

D.1 – RLHPS – Quarterly Excess Returns – Descriptive Statistics

D1.01 – Vancouver Detached Bungalow – Quarterly Excess Returns

	DT_EXRET_B_NV	DT_EXRET_B_SU	DT_EXRET_B_VE	DT_EXRET_B_VW	DT_EXRET_B_WV
Mean	-11.06%	-10.81%	-10.70%	-9.75%	-11.04%
Median	-10.59%	-11.09%	-10.67%	-10.21%	-10.51%
Maximum	2.07%	23.06%	11.37%	28.96%	4.54%
Minimum	-28.09%	-34.89%	-26.79%	-29.54%	-31.30%
Std. Dev.	4.86%	6.27%	4.72%	6.01%	5.63%
Skewness	-0.780351	0.993947	0.372158	1.669434	-0.582337
Kurtosis	5.007456	11.47282	8.420403	16.69783	5.087807
Jarque-Bera	28.28731	385.0134	115.9972	1010.457	25.00491
Probability	0.000001	0	0	0	0.000004
Sum	-11.61543	-13.19121	-9.954196	-11.89754	-11.59223
Sum Sq. Dev.	0.245239	0.47583	0.205077	0.43653	0.330176
Observations	105	122	93	122	105

D1.02 – Vancouver Standard Condominium – Quarterly Excess Returns

	DT_EXRET_C_NV	DT_EXRET_C_VE	DT_EXRET_C_VW
Mean	-11.27%	-12.93%	-10.77%
Median	-11.16%	-12.83%	-10.75%
Maximum	8.86%	3.95%	13.69%
Minimum	-29.44%	-34.02%	-51.88%
Std. Dev.	4.91%	5.40%	6.51%
Skewness	0.337543	-0.388549	-1.871233
Kurtosis	6.437271	7.339495	17.11244
Jarque-Bera	53.68376	75.31099	1083.599
Probability	0	0	0
Sum	-11.83277	-12.02335	-13.13328
Sum Sq. Dev.	0.250954	0.268479	0.512806
Observations	105	93	122

D1.03 – Toronto Detached Bungalow – Quarterly Excess Returns

	DT_EXRET_B_BU	DT_EXRET_B_ET	DT_EXRET_B_NT	DT_EXRET_B_OA	DT_EXRET_B_SC
Mean	-9.98%	-11.42%	-9.94%	-10.20%	-10.95%
Median	-10.08%	-11.32%	-10.56%	-10.58%	-11.13%
Maximum	10.48%	11.86%	16.73%	6.06%	6.04%
Minimum	-23.90%	-26.81%	-29.91%	-28.02%	-24.07%
Std. Dev.	4.35%	5.70%	6.49%	4.62%	4.74%
Skewness	0.942854	0.962256	0.910385	-0.061703	0.289855
Kurtosis	8.200506	5.893973	6.850245	5.943321	5.144882
Jarque-Bera	155.5559	56.87112	68.02347	44.11503	25.0943
Probability	0	0	0	0	0.000004
Sum	-12.17558	-12.909	-8.949394	-12.44509	-13.35619
Sum Sq. Dev.	0.228756	0.364088	0.375293	0.258744	0.27231
Observations	122	113	90	122	122

D1.04 – Toronto Standard Condominium – Quarterly Excess Returns

	DT_EXRET_C_NT	DT_EXRET_C_OA	DT_EXRET_C_TA
Mean	-8.90%	-9.81%	-7.96%
Median	-9.86%	-10.32%	-8.96%
Maximum	14.95%	17.11%	15.58%
Minimum	-24.95%	-41.09%	-21.35%
Std. Dev.	5.88%	5.96%	6.15%
Skewness	1.529849	-0.370981	0.781531
Kurtosis	7.209559	11.47131	5.311969
Jarque-Bera	101.558	367.5938	24.01413
Probability	0	0	0.000006
Sum	-8.009252	-11.97148	-5.889108
Sum Sq. Dev.	0.307688	0.429938	0.275947
Observations	90	122	74

D.2 – RLHPS – Quarterly Annualized Growth Rates – Descriptive Statistics

D2.01 – Vancouver Detached Bungalow – Annualized Quarterly Price Growth Rates

	DT_AQGR_B_NV	DT_AQGR_B_SU	DT_AQGR_B_VE	DT_AQGR_B_VW	DT_AQGR_B_WV
Mean	12.43%	10.91%	3.53%	19.75%	18.54%
Median	8.97%	3.01%	1.65%	14.28%	11.05%
Maximum	204.63%	287.18%	148.32%	322.35%	419.96%
Minimum	-50.85%	-58.05%	-37.91%	-52.75%	-52.95%
Std. Dev.	25.28%	37.94%	19.55%	37.15%	43.69%
Skewness	3.106875	4.776555	3.166157	4.648601	5.59934
Kurtosis	23.99332	32.07263	24.95518	35.29951	49.49358
Jarque-Bera	3075.701	6009.078	2784.683	7060.601	14294.15
Probability	0	0	0	0	0
Sum	1913.831	1680.49	451.5296	2961.967	2780.507
Sum Sq. Dev.	97784.82	220221.7	48519.77	205618.2	284466.2
Observations	154	154	128	150	150

D2.02 – Vancouver Standard Condominium – Annualized Quarterly Price Growth Rates

	DT_AQGR_C_NV	DT_AQGR_C_VE	DT_AQGR_C_VW
Mean	5.47%	2.22%	9.29%
Median	-0.95%	-1.41%	2.61%
Maximum	143.42%	112.17%	150.31%
Minimum	-47.29%	-56.19%	-83.37%
Std. Dev.	22.25%	22.48%	24.02%
Skewness	2.375274	1.92825	1.711986
Kurtosis	14.60858	11.24253	14.18829
Jarque-Bera	799.7446	420.9605	695.9152
Probability	0	0	0
Sum	666.8386	270.4076	1133.239
Sum Sq. Dev.	59908.25	61165.18	69839.52
Observations	122	122	122

D2.03 – Toronto Detached Bungalow – Annualized Quarterly Price Growth Rates

	DT_AQGR_B_BU	DT_AQGR_B_ET	DT_AQGR_B_NT	DT_AQGR_B_OA	DT_AQGR_B_SC
Mean	7.46%	14.73%	13.80%	5.80%	8.20%
Median	2.96%	11.33%	5.11%	0.51%	4.81%
Maximum	115.53%	149.64%	174.69%	106.94%	98.64%
Minimum	-27.91%	-85.67%	-49.65%	-41.03%	-33.75%
Std. Dev.	15.88%	26.63%	30.55%	17.08%	19.88%
Skewness	3.106875	4.776555	3.166157	4.648601	5.59934
Kurtosis	23.99332	32.07263	24.95518	35.29951	49.49358
Jarque-Bera	3075.701	6009.078	2784.683	7060.601	14294.15
Probability	0	0	0	0	0
Sum	1913.831	1680.49	451.5296	2961.967	2780.507
Sum Sq. Dev.	97784.82	220221.7	48519.77	205618.2	284466.2
Observations	154	154	128	150	150

D2.04 – Toronto Standard Condominium – Annualized Quarterly Price Growth Rates

	DT_AQGR_C_NT	DT_AQGR_C_OA	DT_AQGR_C_TA
Mean	16.21%	12.09%	9.73%
Median	9.45%	7.54%	-1.36%
Maximum	146.51%	155.82%	180.51%
Minimum	-28.63%	-68.82%	-84.45%
Std. Dev.	23.97%	22.91%	37.67%
Skewness	2.375274	1.92825	1.711986
Kurtosis	14.60858	11.24253	14.18829
Jarque-Bera	799.7446	420.9605	695.9152
Probability	0	0	0
Sum	666.8386	270.4076	1133.239
Sum Sq. Dev.	59908.25	61165.18	69839.52
Observations	122	122	122

D.3 – TNBHPI – Annualized Monthly Growth Rates – Descriptive Statistics

D3.01 – Vancouver, Toronto, Composite 6, and Composite 11 – Annualized Quarterly Index Value Growth Rates

	DT_AMGR_CMP11	DT_AMGR_CMP6	DT_AMGR_TOR	DT_AMGR_VAN
Mean	7.82%	7.17%	4.74%	3.14%
Median	6.82%	6.54%	4.48%	1.92%
Maximum	33.45%	32.78%	34.96%	52.27%
Minimum	-17.41%	-18.68%	-31.12%	-33.17%
Std. Dev.	8.16%	8.29%	10.13%	10.87%
Skewness	3.106875	4.776555	3.166157	4.648601
Kurtosis	23.99332	32.07263	24.95518	35.29951
Jarque-Bera	3075.701	6009.078	2784.683	7060.601
Probability	0	0	0	0
Sum	1913.831	1680.49	451.5296	2961.967
Sum Sq. Dev.	97784.82	220221.7	48519.77	205618.2
Observations	154	154	128	150

D.4 – NHPI – Annualized Monthly Growth Rates – Descriptive Statistics

D4.01 – Canada, BC, ON, Vancouver and Toronto – House and Land Annualized Monthly Index Value Growth Rates

	DT_AQGR_B_BU	DT_AQGR_B_ET	DT_AQGR_B_NT	DT_AQGR_B_OA	DT_AQGR_B_SC
Mean	7.46%	14.73%	13.80%	5.80%	8.20%
Median	2.96%	11.33%	5.11%	0.51%	4.81%
Maximum	115.53%	149.64%	174.69%	106.94%	98.64%
Minimum	-27.91%	-85.67%	-49.65%	-41.03%	-33.75%
Std. Dev.	15.88%	26.63%	30.55%	17.08%	19.88%
Skewness	3.106875	4.776555	3.166157	4.648601	5.59934
Kurtosis	23.99332	32.07263	24.95518	35.29951	49.49358
Jarque-Bera	3075.701	6009.078	2784.683	7060.601	14294.15
Probability	0	0	0	0	0
Sum	1913.831	1680.49	451.5296	2961.967	2780.507
Sum Sq. Dev.	97784.82	220221.7	48519.77	205618.2	284466.2
Observations	154	154	128	150	150

Section E – Unit Root Tests

E.1 – RLHPS – Excess Returns – Augmented Dickey-Fuller Unit Root Tests

E1.01 – Vancouver Excess Returns – ADF Unit Root Tests

Augmented Dickey-Fuller Unit Root Tests
Exogenous: Constant

Null Hypothesis:	t-Statistic	Prob.*
DT_EXRET_B_ST_NV has a unit root	-9.106	0.000
DT_EXRET_B_ST_SU has a unit root	-10.772	0.000
DT_EXRET_B_ST_VE has a unit root	-7.641	0.000
DT_EXRET_B_ST_VW has a unit root	-9.920	0.000
DT_EXRET_B_ST_WV has a unit root	-8.628	0.000
DT_EXRET_C_ST_NV has a unit root	-9.689	0.000
DT_EXRET_C_ST_VE has a unit root	-8.734	0.000
DT_EXRET_C_ST_VW has a unit root	-9.312	0.000

**MacKinnon (1996) one-sided p-values.*

E1.02 – Toronto Excess Returns – ADF Unit Root Tests

Augmented Dickey-Fuller Unit Root Tests
Exogenous: Constant

Null Hypothesis:	t-Statistic	Prob.*
DT_EXRET_B_ST_BU has a unit root	-5.385	0.000
DT_EXRET_B_ST_ET has a unit root	-8.445	0.000
DT_EXRET_B_ST_NT has a unit root	-7.710	0.000
DT_EXRET_B_ST_OA has a unit root	-9.351	0.000
DT_EXRET_B_ST_SC has a unit root	-6.901	0.000
DT_EXRET_C_ST_NT has a unit root	-3.207	0.023
DT_EXRET_C_ST_OA has a unit root	-8.525	0.000
DT_EXRET_C_ST_TA has a unit root	-6.151	0.000

**MacKinnon (1996) one-sided p-values.*

E.2 – RLHPS – Annualized Quarterly Price Growth Rates – Augmented Dickey-Fuller Unit Root Tests

E2.01 – Vancouver – Annualized Quarterly Growth Rates – ADF Unit Root Tests

Augmented Dickey-Fuller Unit Root Tests

Exogenous: Constant

Null Hypothesis:	t-Statistic	Prob.*
DT_AQGR_B_NV has a unit root	-9.152	0.000
DT_AQGR_B_SU has a unit root	-10.146	0.000
DT_AQGR_B_VE has a unit root	-9.338	0.000
DT_AQGR_B_VW has a unit root	-11.648	0.000
DT_AQGR_B_WV has a unit root	-11.300	0.000
DT_AQGR_C_NV has a unit root	-10.811	0.000
DT_AQGR_C_VE has a unit root	-9.375	0.000
DT_AQGR_C_VW has a unit root	-9.830	0.000

**MacKinnon (1996) one-sided p-values.*

E2.02 –Toronto – Annualized Quarterly Growth Rates – ADF Unit Root Tests

Augmented Dickey-Fuller Unit Root Tests

Exogenous: Constant

Null Hypothesis:	t-Statistic	Prob.*
DT_AQGR_B_BU has a unit root	-10.945	0.000
DT_AQGR_B_ET has a unit root	-9.788	0.000
DT_AQGR_B_NT has a unit root	-10.703	0.000
DT_AQGR_B_OA has a unit root	-11.644	0.000
DT_AQGR_B_SC has a unit root	-9.650	0.000
DT_AQGR_C_NT has a unit root	-4.294	0.001
DT_AQGR_C_OA has a unit root	-10.073	0.000
DT_AQGR_C_TA has a unit root	-3.518	0.009

**MacKinnon (1996) one-sided p-values.*

E.3 – TNBHPI – Augmented Dickey-Fuller Unit Root Tests

E3.01 – Annualized Monthly Growth Rates – ADF Unit Root Tests

Augmented Dickey-Fuller Unit Root Tests

Exogenous: Constant

Null Hypothesis:	t-Statistic	Prob.*
DT_AMGR_COMP_11 has a unit root	-6.800	0.000
DT_AMGR_COMP_6 has a unit root	-6.685	0.000
DT_AMGR_TOR has a unit root	-7.650	0.000
DT_AMGR_VAN has a unit root	-6.264	0.000

**MacKinnon (1996) one-sided p-values.*

E.4 – NHPI – Augmented Dickey-Fuller Unit Root Tests

E4.01 – Annualized Monthly Growth Rates – ADF Unit Root Tests

Augmented Dickey-Fuller Unit Root Tests

Exogenous: Constant

Null Hypothesis:	t-Statistic	Prob.*
DT_AMGR_CA_HL has a unit root	-6.124	0.000
DT_AMGR_BC_HL has a unit root	-6.747	0.000
DT_AMGR_ON_HL has a unit root	-4.926	0.000
DT_AMGR_VAN_HL has a unit root	-7.291	0.000
DT_AMGR_TOR_HL has a unit root	-3.837	0.003

**MacKinnon (1996) one-sided p-values.*

Section F – RLHPS – Forecast Mean Squared Prediction Errors (MSPE) & Mean Absolute Prediction Errors (MAPE)

F.1 – RLHPS – Quarterly Excess Returns – 1-Step-Ahead Forecasts

F1.01 – Vancouver – Detached Bungalow – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT_EXRET_B_VW_F1		DT_EXRET_B_VE_F1		DT_EXRET_B_WV_F1		DT_EXRET_B_NV_F1		DT_EXRET_B_SU_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.002209	0.039437	0.000927	0.022988	0.007894	0.066313	0.004448	0.051165	0.009498	0.062139
AR(2)	0.001919	0.037577	0.000925	0.023625	0.006522	0.061352	0.004425	0.049320	0.010436	0.061133
AR(4)	0.001817	0.033886	0.000900	0.023436	0.004615	0.052654	0.002518	0.039489	0.007009	0.051789
ARMA(1,1)	0.001842	0.033294	0.000667	0.019225	0.004249	0.051833	0.002786	0.039102	0.006118	0.045972
ARMA(1,2)	0.001726	0.032608	0.000576	0.016511	0.004738	0.052070	0.002990	0.041671	0.006362	0.045323
ARMA(2,2)	0.001817	0.031990	0.000610	0.017122	0.004929	0.054829	0.002914	0.041100	0.006294	0.043906
ARMA(4,4)	0.001633	0.031855	0.000874	0.021319	0.004907	0.055240	0.003084	0.042472	0.006548	0.045288
AR(1)-ARCH(1)	0.002039	0.034666	0.000828	0.021179	0.008194	0.066276	0.004488	0.051176	0.009422	0.059679
AR(2)-ARCH(1)	0.001919	0.036326	0.000857	0.022582	0.006475	0.060822	0.004494	0.050643	0.010821	0.061758
AR(1)-ARCH(2)	0.002063	0.034331	0.001141	0.027484	0.008160	0.066168	0.004501	0.051573	0.009457	0.059679
AR(2)-ARCH(2)	0.002069	0.038383	0.000933	0.023907	0.006130	0.058880	0.004388	0.049837	0.010889	0.060638
AR(1)-GARCH(1,1)	0.002063	0.034331	0.001141	0.027484	0.008160	0.066168	0.004501	0.051573	0.009457	0.059679
AR(2)-GARCH(1,1)	0.002069	0.038383	0.000933	0.023907	0.006130	0.058880	0.004388	0.049837	0.010889	0.060638
AR(1)-EGARCH(1,1)	0.002045	0.036087	0.000899	0.022420	0.008321	0.068214	0.004446	0.051527	0.009409	0.061083
AR(2)-EGARCH(1,1)	0.002047	0.038375	0.000860	0.022196	0.006373	0.061176	0.004558	0.052562	0.011955	0.060889

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F1.02 – Vancouver – Standard Condominium – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT_EXRET_C_VW_F1		DT_EXRET_C_VE_F1		DT_EXRET_C_NV_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.001607	0.030712	0.004722	0.048293	0.005023	0.062560
AR(2)	0.001453	0.029391	0.004081	0.044711	0.004133	0.051328
AR(4)	0.001253	0.026184	0.003385	0.040501	0.002293	0.036157
ARMA(1,1)	0.001369	0.028592	0.003866	0.046802	0.002821	0.043617
ARMA(1,2)	0.001441	0.028494	0.002860	0.039362	0.002873	0.044497
ARMA(2,2)	0.001328	0.028236	0.002998	0.037769	0.002596	0.041336
ARMA(4,4)	0.001346	0.029242	0.003555	0.045619	0.002868	0.042091
AR(1)-ARCH(1)	0.001544	0.029604	0.004806	0.048323	0.005042	0.063231
AR(2)-ARCH(1)	0.001404	0.028394	0.003997	0.044677	0.004189	0.052143
AR(1)-ARCH(2)	0.001520	0.028631	0.004823	0.048124	0.005045	0.063267
AR(2)-ARCH(2)	0.001427	0.028413	0.004046	0.044918	0.004141	0.053409
AR(1)-GARCH(1,1)	0.001520	0.028631	0.004823	0.048124	0.005045	0.063267
AR(2)-GARCH(1,1)	0.001427	0.028413	0.004046	0.044918	0.004141	0.053409
AR(1)-EGARCH(1,1)	0.001549	0.029921	0.002457	0.037115	0.005141	0.064194
AR(2)-EGARCH(1,1)	0.001450	0.029182	0.003580	0.043582	0.004382	0.055233

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F1.03 – Toronto – Detached Bungalow – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT EXRET B BU F1		DT EXRET B ET F1		DT EXRET B SC F1		DT EXRET B OA F1		DT EXRET B NT F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.001541	0.031547	0.001612	0.033647	0.001690	0.026849	0.003410	0.043055	0.020205	0.085337
AR(2)	0.001134	0.027930	0.001850	0.034639	0.001454	0.027301	0.002923	0.038806	0.015450	0.072404
AR(4)	0.001047	0.027601	0.001750	0.034004	0.001383	0.026847	0.002447	0.034364	0.013821	0.068806
ARMA(1,1)	0.000960	0.025711	0.001351	0.029502	0.001107	0.024415	0.002126	0.032037	0.012187	0.064146
ARMA(1,2)	0.001172	0.027868	0.001384	0.030642	0.001246	0.024295	0.002109	0.032180	0.012688	0.064096
ARMA(2,2)	0.001021	0.026895	0.001397	0.031219	0.001410	0.027342	0.002217	0.032982	0.012663	0.064468
ARMA(4,4)	0.001220	0.028911	0.001688	0.033136	0.001475	0.026739	0.002231	0.032818	0.014199	0.070210
AR(1)-ARCH(1)	0.001524	0.030742	0.001531	0.031014	0.001689	0.026953	0.003509	0.042060	0.021363	0.085642
AR(2)-ARCH(1)	0.001149	0.027857	0.001732	0.033029	0.001476	0.027111	0.002877	0.037864	0.014439	0.071885
AR(1)-ARCH(2)	0.001530	0.030563	0.001504	0.030495	0.001735	0.027231	0.003395	0.041722	0.021514	0.085169
AR(2)-ARCH(2)	0.001158	0.028095	0.001764	0.033749	0.001457	0.027536	0.003048	0.039376	0.013629	0.066866
AR(1)-GARCH(1,1)	0.001530	0.030563	0.001504	0.030495	0.001735	0.027231	0.003395	0.041722	0.021514	0.085169
AR(2)-GARCH(1,1)	0.001158	0.028095	0.001764	0.033749	0.001457	0.027536	0.003048	0.039376	0.013629	0.066866
AR(1)-EGARCH(1,1)	0.001522	0.031303	0.001519	0.031412	0.001692	0.026894	0.003390	0.042469	0.020613	0.084221
AR(2)-EGARCH(1,1)	0.001146	0.027872	0.001819	0.034550	0.001526	0.027264	0.003092	0.041105	0.014577	0.069095

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F1.04 – Toronto – Standard Condominium – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT EXRET C NT F1		DT EXRET C TA F1		DT EXRET C OA F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.001073	0.026058	0.006913	0.046225	0.001538	0.032276
AR(2)	0.001008	0.025436	0.006076	0.044507	0.001232	0.028492
AR(4)	0.000983	0.023631	0.006018	0.048874	0.001075	0.024499
ARMA(1,1)	0.000772	0.021439	0.005200	0.042066	0.000947	0.023242
ARMA(1,2)	0.001169	0.023802	0.006245	0.049678	0.000925	0.023803
ARMA(2,2)	0.001033	0.024038	0.007287	0.055307	0.001216	0.025465
ARMA(4,4)	0.001051	0.023410	0.008789	0.065928	0.001188	0.024619
AR(1)-ARCH(1)	0.001120	0.028491	0.007055	0.042395	0.001396	0.029267
AR(2)-ARCH(1)	0.001109	0.027170	0.005938	0.044132	0.001126	0.026833
AR(1)-ARCH(2)	0.001009	0.023165	0.007162	0.041906	0.001441	0.030442
AR(2)-ARCH(2)	0.000932	0.021176	0.006052	0.044008	0.001148	0.027427
AR(1)-GARCH(1,1)	0.001009	0.023165	0.007162	0.041906	0.001441	0.030442
AR(2)-GARCH(1,1)	0.000932	0.021176	0.006052	0.044008	0.001148	0.027427
AR(1)-EGARCH(1,1)	0.001004	0.023625	0.007015	0.043279	0.001420	0.029372
AR(2)-EGARCH(1,1)	0.001042	0.022521	0.006060	0.044177	0.001156	0.027093

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F.2 – RLHPS – Quarterly Excess Returns – 4-Step-Ahead Forecasts

F2.01 – Vancouver – Detached Bungalow – 4-Step-Ahead Forecasts – MSPE & MAPE

	DT_EXRET_B_VW_F4		DT_EXRET_B_VE_F4		DT_EXRET_B_WV_F4		DT_EXRET_B_NV_F4		DT_EXRET_B_SU_F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.003835	0.052751	0.003583	0.050150	0.004633	0.056211	0.004622	0.057249	0.008942	0.070588
AR(2)	0.002620	0.044490	0.002889	0.046142	0.005227	0.060094	0.004701	0.054852	0.010651	0.068584
AR(4)	0.001980	0.035790	0.001353	0.028575	0.003883	0.049626	0.002120	0.032886	0.007527	0.057196
ARMA(1,1)	0.001937	0.034610	0.001042	0.025086	0.004075	0.051011	0.002660	0.036311	0.006534	0.049358
ARMA(1,2)	0.002075	0.035545	0.000824	0.019343	0.003943	0.047224	0.002523	0.037804	0.005913	0.043609
ARMA(2,2)	0.001773	0.032673	0.000850	0.020756	0.004416	0.054444	0.002667	0.038496	0.005859	0.045045
ARMA(4,4)	0.001724	0.033757	0.001267	0.027232	0.004207	0.050404	0.002050	0.032310	0.005612	0.039821
AR(1)-ARCH(1)	0.002468	0.040326	0.003257	0.050013	0.004209	0.051924	0.004508	0.055866	0.008205	0.063455
AR(2)-ARCH(1)	0.002253	0.040692	0.002805	0.046062	0.005026	0.058279	0.004275	0.052999	0.009824	0.065668
AR(1)-ARCH(2)	0.002454	0.039823	0.004734	0.060693	0.004189	0.051989	0.004661	0.057367	0.008226	0.063643
AR(2)-ARCH(2)	0.002456	0.042402	0.002580	0.043978	0.004808	0.056559	0.004138	0.052696	0.010387	0.064069
AR(1)-GARCH(1,1)	0.002454	0.039823	0.004734	0.060693	0.004189	0.051989	0.004661	0.057367	0.008226	0.063643
AR(2)-GARCH(1,1)	0.002456	0.042402	0.002580	0.043978	0.004808	0.056559	0.004138	0.052696	0.010387	0.064069
AR(1)-EGARCH(1,1)	0.003124	0.045255	0.003413	0.048769	0.003063	0.046168	0.004566	0.057189	0.008480	0.066705
AR(2)-EGARCH(1,1)	0.003571	0.050897	0.003029	0.047714	0.005497	0.056689	0.004134	0.054246	0.012273	0.066771

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F2.02 – Vancouver – Standard Condominium – 4-Step-Ahead Forecasts – MSPE & MAPE

	DT_EXRET_C_VW_F4		DT_EXRET_C_VE_F4		DT_EXRET_C_NV_F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.001845	0.036366	0.009524	0.071995	0.003832	0.052516
AR(2)	0.001651	0.036067	0.006748	0.060193	0.003821	0.049603
AR(4)	0.001263	0.029340	0.005803	0.057533	0.002115	0.033944
ARMA(1,1)	0.001436	0.032219	0.005266	0.056747	0.002773	0.041658
ARMA(1,2)	0.001462	0.029911	0.004127	0.045114	0.002775	0.041681
ARMA(2,2)	0.001488	0.032419	0.003610	0.041450	0.002517	0.040039
ARMA(4,4)	0.001788	0.035353	0.004449	0.049960	0.002831	0.041966
AR(1)-ARCH(1)	0.001879	0.035905	0.009736	0.071306	0.003246	0.047899
AR(2)-ARCH(1)	0.001688	0.036809	0.007322	0.063595	0.003837	0.049972
AR(1)-ARCH(2)	0.001349	0.030554	0.009764	0.071431	0.003238	0.047780
AR(2)-ARCH(2)	0.001504	0.034347	0.007662	0.064257	0.003963	0.051565
AR(1)-GARCH(1,1)	0.001349	0.030554	0.009764	0.071431	0.003238	0.047780
AR(2)-GARCH(1,1)	0.001504	0.034347	0.007662	0.064257	0.003963	0.051565
AR(1)-EGARCH(1,1)	0.001760	0.034873	0.009459	0.070380	0.002881	0.044565
AR(2)-EGARCH(1,1)	0.001460	0.033602	0.006620	0.061514	0.003531	0.048549

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F2.03 – Toronto – Detached Bungalow – 4-Step-Ahead Forecasts – MSPE & MAPE

	DT EXRET B BU F4		DT EXRET B ET F4		DT EXRET B SC F4		DT EXRET B OA F4		DT EXRET B NT F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.001330	0.030508	0.002927	0.044035	0.002021	0.033338	0.003083	0.043672	0.008554	0.065841
AR(2)	0.001055	0.027354	0.002340	0.038642	0.001561	0.029401	0.002526	0.038385	0.010485	0.067134
AR(4)	0.001022	0.027322	0.001929	0.035903	0.001259	0.025490	0.002237	0.034346	0.009308	0.062518
ARMA(1,1)	0.000987	0.026718	0.001408	0.029050	0.001125	0.025158	0.001950	0.032750	0.008182	0.058841
ARMA(1,2)	0.001002	0.027048	0.001592	0.031878	0.001154	0.024385	0.001937	0.032208	0.008424	0.060086
ARMA(2,2)	0.001046	0.027648	0.001665	0.033278	0.001208	0.025008	0.002061	0.032555	0.008158	0.053650
ARMA(4,4)	0.001277	0.029063	0.001638	0.033081	0.001350	0.026064	0.002059	0.031626	0.009115	0.060898
AR(1)-ARCH(1)	0.001102	0.026627	0.002371	0.036724	0.001988	0.032516	0.002504	0.036438	0.008366	0.063376
AR(2)-ARCH(1)	0.001034	0.026261	0.002114	0.036291	0.001607	0.030094	0.002512	0.037798	0.009350	0.063854
AR(1)-ARCH(2)	0.001090	0.026079	0.002702	0.038550	0.002079	0.032339	0.002820	0.040583	0.008292	0.061247
AR(2)-ARCH(2)	0.001049	0.026521	0.002297	0.037289	0.001526	0.028778	0.002548	0.038333	0.009925	0.061813
AR(1)-GARCH(1,1)	0.001090	0.026079	0.002702	0.038550	0.002079	0.032339	0.002820	0.040583	0.008292	0.061247
AR(2)-GARCH(1,1)	0.001049	0.026521	0.002297	0.037289	0.001526	0.028778	0.002548	0.038333	0.009925	0.061813
AR(1)-EGARCH(1,1)	0.001375	0.031407	0.002472	0.037750	0.002122	0.034682	0.002807	0.039975	0.008259	0.061610
AR(2)-EGARCH(1,1)	0.001046	0.026222	0.002341	0.038132	0.001865	0.031824	0.002596	0.038112	0.009583	0.062057

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F2.04 – Toronto – Standard Condominium – 4-Step-Ahead Forecasts – MSPE & MAPE

	DT_EXRET_C_NT_F4		DT_EXRET_C_TA_F4		DT_EXRET_C_OA_F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	0.001522	0.034298	0.004762	0.047065	0.002571	0.042583
AR(2)	0.001274	0.031021	0.004715	0.039191	0.001850	0.035728
AR(4)	0.000938	0.024100	0.006408	0.053832	0.001168	0.025929
ARMA(1,1)	0.000752	0.021723	0.005348	0.046353	0.001090	0.026048
ARMA(1,2)	0.000951	0.019753	0.006005	0.051870	0.000962	0.024334
ARMA(2,2)	0.000807	0.021609	0.006037	0.051696	0.001094	0.025101
ARMA(4,4)	0.001150	0.026244	0.006555	0.051839	0.001129	0.023257
AR(1)-ARCH(1)	0.002032	0.040727	0.004570	0.039745	0.001894	0.034520
AR(2)-ARCH(1)	0.001689	0.036699	0.004881	0.040624	0.001565	0.031558
AR(1)-ARCH(2)	0.000900	0.022212	0.004692	0.036213	0.002330	0.039174
AR(2)-ARCH(2)	0.000730	0.017441	0.004814	0.039934	0.001591	0.032279
AR(1)-GARCH(1,1)	0.000900	0.022212	0.004692	0.036213	0.002330	0.039174
AR(2)-GARCH(1,1)	0.000730	0.017441	0.004814	0.039934	0.001591	0.032279
AR(1)-EGARCH(1,1)	0.000953	0.024309	0.004770	0.039629	0.001869	0.033570
AR(2)-EGARCH(1,1)	0.000761	0.018236	0.004677	0.039403	0.001633	0.032537

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F.3 – RLHPS – Annualized Quarterly Price Growth Rates – 1-Step-Ahead Forecasts

F3.01 – Vancouver – Detached Bungalow – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT_AQGR_B_VW_F1		DT_AQGR_B_VE_F1		DT_AQGR_B_WV_F1		DT_AQGR_B_NV_F1		DT_AQGR_B_SU_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	396.634	15.908	153.634	9.378	997.446	19.990	365.241	12.063	1216.129	14.852
AR(2)	345.587	14.656	153.982	9.478	1023.591	20.106	366.662	12.091	1231.978	15.051
AR(4)	270.610	12.106	165.869	9.620	651.046	16.970	285.059	11.148	1167.382	14.923
ARMA(1,1)	282.787	12.414	151.447	9.589	782.743	17.719	322.394	11.412	1329.045	15.840
ARMA(1,2)	307.304	12.793	155.173	9.485	891.421	20.453	309.512	11.064	1279.304	15.453
ARMA(2,2)	281.982	12.824	160.066	9.685	913.553	19.144	374.577	13.528	1222.517	14.887
ARMA(4,4)	296.434	12.673	192.586	10.727	806.548	19.974	376.851	13.196	1389.479	18.670
AR(1)-ARCH(1)	287.315	12.978	166.509	9.673	1024.824	20.245	412.712	12.818	1204.923	14.433
AR(2)-ARCH(1)	278.310	12.761	160.713	9.601	1028.462	20.043	415.691	12.939	1233.419	14.692
AR(1)-ARCH(2)	358.067	14.730	154.570	9.320	1021.191	19.976	449.487	13.787	1208.558	14.785
AR(2)-ARCH(2)	297.885	12.857	152.265	9.264	1506.056	23.905	461.062	14.114	1243.840	15.033
AR(1)-GARCH(1,1)	358.067	14.730	154.570	9.320	1021.191	19.976	449.487	13.787	1208.558	14.785
AR(2)-GARCH(1,1)	297.885	12.857	152.265	9.264	1506.056	23.905	461.062	14.114	1243.840	15.033
AR(1)-EGARCH(1,1)	277.561	12.350	148.734	9.232	1095.001	21.551	435.107	13.273	277.912	10.446
AR(2)-EGARCH(1,1)	274.598	12.438	154.474	9.605	1266.613	22.699	439.006	13.241	1388.317	15.625

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F3.02 – Vancouver – Standard Condominium – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT_AQGR_C_VW_F1		DT_AQGR_C_VE_F1		DT_AQGR_C_NV_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	194.771	9.416	324.252	13.024	335.136	11.730
AR(2)	189.985	9.374	328.351	12.838	338.842	12.120
AR(4)	165.832	8.774	354.258	13.613	275.036	10.921
ARMA(1,1)	176.587	8.592	330.870	13.357	340.902	12.400
ARMA(1,2)	188.986	9.372	371.444	13.873	343.759	12.603
ARMA(2,2)	193.491	9.332	450.753	16.036	350.561	13.277
ARMA(4,4)	215.327	10.752	417.860	15.839	428.475	15.698
AR(1)-ARCH(1)	191.866	9.336	367.409	14.471	336.232	11.931
AR(2)-ARCH(1)	176.238	9.040	357.629	14.090	354.781	12.447
AR(1)-ARCH(2)	183.383	9.174	311.111	12.576	345.316	12.287
AR(2)-ARCH(2)	167.899	8.680	312.850	12.777	356.877	12.380
AR(1)-GARCH(1,1)	183.383	9.174	311.111	12.576	345.316	12.287
AR(2)-GARCH(1,1)	167.899	8.680	312.850	12.777	356.877	12.380
AR(1)-EGARCH(1,1)	179.542	9.222	330.471	13.177	355.123	12.397
AR(2)-EGARCH(1,1)	180.298	8.971	336.420	13.075	351.335	11.954

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F3.03 – Toronto – Detached Bungalow – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT_AQGR_B_BU_F1		DT_AQGR_B_ET_F1		DT_AQGR_B_SC_F1		DT_AQGR_B_OA_F1		DT_AQGR_B_NT_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	150.634	8.881	455.513	14.077	212.464	9.724	277.856	10.489	1100.572	19.310
AR(2)	142.491	8.781	442.614	13.598	208.012	9.622	286.394	10.664	1081.787	19.235
AR(4)	135.601	8.958	413.527	12.695	205.997	9.932	288.253	10.803	994.073	18.253
ARMA(1,1)	124.283	8.395	447.779	12.728	204.719	10.489	277.129	10.472	924.642	17.430
ARMA(1,2)	132.870	8.823	464.365	12.782	211.929	10.250	275.641	10.564	956.909	18.055
ARMA(2,2)	141.177	9.086	440.890	12.903	229.478	11.115	265.958	10.737	953.728	18.627
ARMA(4,4)	185.301	11.222	487.489	14.144	244.943	11.351	304.298	11.968	1093.056	21.197
AR(1)-ARCH(1)	150.600	8.934	437.241	13.577	212.621	9.592	274.706	10.249	1195.671	20.121
AR(2)-ARCH(1)	145.484	9.018	434.939	13.376	209.326	9.520	286.579	10.876	1031.886	18.658
AR(1)-ARCH(2)	149.612	9.077	439.559	13.419	208.903	9.460	298.688	11.091	1199.256	20.167
AR(2)-ARCH(2)	147.027	9.115	445.771	13.507	213.114	9.792	298.248	11.005	1013.592	19.312
AR(1)-GARCH(1,1)	149.612	9.077	439.559	13.419	208.903	9.460	298.688	11.091	1199.256	20.167
AR(2)-GARCH(1,1)	147.027	9.115	445.771	13.507	213.114	9.792	298.248	11.005	1013.592	19.312
AR(1)-EGARCH(1,1)	152.966	8.970	458.678	13.949	235.661	10.385	327.447	11.929	1130.458	19.515
AR(2)-EGARCH(1,1)	141.365	8.953	468.093	14.003	219.054	10.181	297.382	11.310	1032.323	19.507

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F3.04 – Toronto – Standard Condominium – 1-Step-Ahead Forecasts – MSPE & MAPE

	DT_AQGR_C_NT_F1		DT_AQGR_C_TA_F1		DT_AQGR_C_OA_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	247.223	11.116	2058.226	25.631	257.277	10.633
AR(2)	252.700	11.331	2109.560	25.628	242.879	10.028
AR(4)	230.500	11.009	1782.392	25.739	212.223	9.274
ARMA(1,1)	314.590	13.007	2268.014	26.401	202.972	8.999
ARMA(1,2)	274.921	12.046	2087.042	27.569	214.339	9.101
ARMA(2,2)	243.905	11.230	2372.020	30.471	276.971	10.757
ARMA(4,4)	325.658	13.527	2014.880	27.285	246.146	9.843
AR(1)-ARCH(1)	247.408	10.839	1909.322	25.266	248.186	10.316
AR(2)-ARCH(1)	240.966	10.536	2004.561	26.238	235.136	9.787
AR(1)-ARCH(2)	259.170	10.712	1907.142	25.039	257.485	10.896
AR(2)-ARCH(2)	235.490	10.471	1996.101	25.986	256.473	10.273
AR(1)-GARCH(1,1)	259.170	10.712	1907.142	25.039	257.485	10.896
AR(2)-GARCH(1,1)	235.490	10.471	1996.101	25.986	256.473	10.273
AR(1)-EGARCH(1,1)	244.481	10.458	1960.675	25.599	252.692	10.488
AR(2)-EGARCH(1,1)	317.935	12.523	2043.799	25.850	236.061	10.035

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F.4 – RLHPS – Annualized Quarterly Price Growth Rates – 4-Step-Ahead Forecasts

F4.01 – Vancouver – Detached Bungalow – MSPE & MAPE

	DT AQGR B VW F4		DT AQGR B VE F4		DT AQGR B WV F4		DT AQGR B NV F4		DT AQGR B SU F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	493.727	17.820	169.219	9.625	1047.121	21.013	417.337	13.796	1232.954	14.973
AR(2)	433.142	16.437	171.826	9.823	964.965	20.394	408.709	13.630	1257.190	15.259
AR(4)	311.495	13.166	184.273	9.950	650.380	17.356	324.544	11.969	1215.513	15.793
ARMA(1,1)	295.208	12.295	160.286	9.575	814.208	18.028	359.116	12.496	1193.499	15.193
ARMA(1,2)	266.570	11.791	160.319	9.490	865.854	19.831	358.607	12.686	1194.677	15.255
ARMA(2,2)	268.634	11.711	161.999	9.806	814.012	18.811	381.557	13.242	1226.204	15.537
ARMA(4,4)	303.721	12.040	217.620	11.569	840.890	18.897	415.986	13.447	1315.453	17.995
AR(1)-ARCH(1)	375.738	14.847	170.015	9.581	990.002	19.826	382.309	13.444	1222.002	14.442
AR(2)-ARCH(1)	367.449	14.772	172.770	9.848	923.645	19.615	408.461	13.556	1257.917	14.774
AR(1)-ARCH(2)	433.866	16.326	168.842	9.552	983.723	19.544	418.362	13.732	1231.510	14.965
AR(2)-ARCH(2)	378.109	15.035	170.689	9.734	1096.318	21.271	443.231	14.203	1261.052	15.023
AR(1)-GARCH(1,1)	433.866	16.326	168.842	9.552	983.723	19.544	418.362	13.732	1231.510	14.965
AR(2)-GARCH(1,1)	378.109	15.035	170.689	9.734	1096.318	21.271	443.231	14.203	1261.052	15.023
AR(1)-EGARCH(1,1)	393.507	14.832	158.864	9.285	1017.947	20.409	449.300	14.382	1289.418	15.161
AR(2)-EGARCH(1,1)	358.748	14.275	169.927	9.638	1281.580	23.967	444.839	14.463	1440.411	15.844

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F4.02 – Vancouver – Standard Condominium – MSPE & MAPE

	DT_AQGR_C_VW_F4		DT_AQGR_C_VE_F4		DT_AQGR_C_NV_F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	237.999	10.441	343.721	13.725	334.700	11.447
AR(2)	220.366	10.189	344.228	13.451	329.689	11.729
AR(4)	180.195	9.123	360.558	14.091	270.735	10.595
ARMA(1,1)	198.980	9.387	339.976	13.621	316.380	12.109
ARMA(1,2)	206.999	9.731	374.373	14.113	332.185	11.837
ARMA(2,2)	202.511	9.588	453.765	15.926	329.232	12.818
ARMA(4,4)	200.321	9.887	456.947	16.760	322.596	13.572
AR(1)-ARCH(1)	235.530	10.425	339.386	13.640	338.848	11.642
AR(2)-ARCH(1)	176.810	8.991	340.620	13.563	338.951	12.049
AR(1)-ARCH(2)	206.957	9.825	328.846	13.206	336.291	11.505
AR(2)-ARCH(2)	176.685	9.109	330.750	13.391	334.961	11.473
AR(1)-GARCH(1,1)	206.957	9.825	328.846	13.206	336.291	11.505
AR(2)-GARCH(1,1)	176.685	9.109	330.750	13.391	334.961	11.473
AR(1)-EGARCH(1,1)	212.005	9.902	322.797	13.100	316.769	11.053
AR(2)-EGARCH(1,1)	184.436	9.245	332.075	13.424	321.420	11.654

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F4.03 – Toronto – Detached Bungalow – MSPE & MAPE

	DT_AQGR_B_BU_F4		DT_AQGR_B_ET_F4		DT_AQGR_B_SC_F4		DT_AQGR_B_OA_F4		DT_AQGR_B_NT_F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	157.583	9.123	532.910	17.168	215.064	9.758	255.659	9.798	959.179	18.708
AR(2)	149.684	8.904	512.025	16.190	208.430	9.462	259.066	10.038	929.655	17.991
AR(4)	139.569	8.871	465.044	13.875	185.234	8.848	265.756	10.322	840.015	16.458
ARMA(1,1)	134.722	8.486	470.876	13.441	194.091	9.894	261.029	10.105	821.972	17.136
ARMA(1,2)	144.153	8.977	510.206	13.758	187.494	8.919	263.160	10.201	790.984	16.598
ARMA(2,2)	138.790	9.158	474.170	13.575	188.209	9.400	264.332	10.415	816.740	17.290
ARMA(4,4)	154.590	9.469	517.105	14.938	172.919	9.884	304.138	12.346	953.400	19.043
AR(1)-ARCH(1)	157.361	9.147	508.554	16.381	217.672	9.725	266.376	10.072	1037.128	19.803
AR(2)-ARCH(1)	145.601	8.849	494.751	15.237	214.012	9.555	263.721	10.164	886.930	17.783
AR(1)-ARCH(2)	152.605	8.989	482.972	15.475	218.446	9.806	248.050	9.819	1070.689	19.948
AR(2)-ARCH(2)	146.093	8.880	499.781	15.167	212.800	9.632	262.311	10.175	894.805	18.235
AR(1)-GARCH(1,1)	152.605	8.989	482.972	15.475	218.446	9.806	248.050	9.819	1070.689	19.948
AR(2)-GARCH(1,1)	146.093	8.880	499.781	15.167	212.800	9.632	262.311	10.175	894.805	18.235
AR(1)-EGARCH(1,1)	157.331	9.150	503.730	16.437	215.526	9.846	245.435	9.965	1016.149	19.386
AR(2)-EGARCH(1,1)	144.750	8.880	522.155	15.755	203.189	9.611	258.273	10.023	939.433	18.869

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

F4.04 – Toronto – Standard Condominium – MSPE & MAPE

	DT AQGR C NT F4		DT AQGR C TA F4		DT AQGR C OA F4	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	314.323	13.317	1850.807	24.007	283.866	11.932
AR(2)	310.066	13.239	1904.876	25.265	266.306	11.205
AR(4)	201.924	9.865	1663.548	25.510	216.393	9.477
ARMA(1,1)	332.280	13.788	1894.194	25.024	219.714	9.224
ARMA(1,2)	233.798	10.153	2047.477	28.145	224.498	9.425
ARMA(2,2)	216.577	9.817	2197.882	30.691	282.514	11.253
ARMA(4,4)	220.882	11.192	1575.932	25.165	208.126	9.300
AR(1)-ARCH(1)	310.816	13.049	1849.194	24.501	238.293	10.719
AR(2)-ARCH(1)	258.462	11.215	1920.334	26.385	214.874	9.785
AR(1)-ARCH(2)	242.479	11.017	1840.870	24.133	259.841	11.184
AR(2)-ARCH(2)	209.222	10.295	1901.604	25.771	248.572	10.433
AR(1)-GARCH(1,1)	242.479	11.017	1840.870	24.133	259.841	11.184
AR(2)-GARCH(1,1)	209.222	10.295	1901.604	25.771	248.572	10.433
AR(1)-EGARCH(1,1)	250.572	11.480	1858.010	24.630	212.022	10.376
AR(2)-EGARCH(1,1)	349.661	14.040	2095.741	27.875	156.293	8.546

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

Section G – TNBHPI – Forecast Mean Squared Prediction Errors (MSPE) & Mean Absolute Prediction Errors (MAPE)

G.1 – TNBHPI – Annualized Monthly Index Growth Rates – 1-Step-Ahead Forecasts

G1.01 – Composite 6, Composite 11, Vancouver and Toronto – MSPE & MAPE

	DT_AMGR_COMP_6_F1		DT_AMGR_COMP_11_F1		DT_AMGR_VAN_F1		DT_AMGR_TOR_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	29.591	4.065	27.768	3.883	59.229	5.633	60.102	6.000
AR(2)	29.206	3.998	28.608	3.961	60.039	5.642	59.382	5.762
AR(4)	27.814	3.983	27.362	3.914	62.630	5.752	52.108	5.400
ARMA(1,1)	31.160	4.240	28.340	3.926	59.672	5.630	60.477	5.635
ARMA(1,2)	29.568	4.011	28.225	3.844	61.264	5.645	51.108	5.523
ARMA(2,2)	29.206	3.938	28.235	3.890	63.617	5.756	51.679	5.553
ARMA(4,4)	32.157	4.209	33.814	4.147	66.618	6.049	57.848	5.834
AR(1)-ARCH(1)	30.846	4.108	29.544	3.993	57.857	5.676	56.987	5.720
AR(2)-ARCH(1)	31.481	4.167	28.970	4.011	67.479	6.050	62.048	5.621
AR(1)-ARCH(2)	29.553	4.074	29.564	3.979	56.118	5.596	57.722	5.766
AR(2)-ARCH(2)	31.332	4.110	30.176	4.003	54.607	5.524	62.757	5.759
AR(1)-GARCH(1,1)	29.553	4.074	29.564	3.979	56.118	5.596	57.722	5.766
AR(2)-GARCH(1,1)	31.332	4.110	30.176	4.003	54.607	5.524	62.757	5.759
AR(1)-EGARCH(1,1)	29.914	4.087	28.750	3.944	56.626	5.542	55.712	5.636
AR(2)-EGARCH(1,1)	30.431	4.090	29.071	3.966	56.904	5.578	61.737	5.671

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

G.2 – TNBHPI – Annualized Monthly Index Growth Rates – 3-Step-Ahead Forecasts

G2.01 – Composite 6, Composite 11, Vancouver and Toronto – MSPE & MAPE

	DT AMGR COMP 6 F3		DT AMGR COMP 11 F3		DT AMGR VAN F3		DT AMGR TOR F3	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	61.497	5.602	58.289	5.401	102.301	7.163	103.187	7.454
AR(2)	57.066	5.309	54.757	5.259	100.635	7.063	101.186	7.135
AR(4)	53.282	5.241	51.315	5.196	107.661	7.429	94.143	6.869
ARMA(1,1)	57.279	5.574	55.645	5.318	100.973	7.108	100.444	6.861
ARMA(1,2)	57.516	5.583	55.339	5.286	104.424	7.278	88.336	7.212
ARMA(2,2)	56.116	5.348	53.974	5.134	108.135	7.475	89.583	7.367
ARMA(4,4)	60.211	5.645	47.445	4.781	107.049	7.783	105.658	7.919
AR(1)-ARCH(1)	71.665	5.794	69.143	5.768	93.946	7.101	103.409	7.291
AR(2)-ARCH(1)	67.595	5.755	62.371	5.599	99.864	7.295	108.226	7.209
AR(1)-ARCH(2)	69.323	5.795	69.046	5.754	91.137	7.047	104.924	7.334
AR(2)-ARCH(2)	57.452	5.472	63.488	5.545	86.883	6.826	110.574	7.360
AR(1)-GARCH(1,1)	69.323	5.795	69.046	5.754	91.137	7.047	104.924	7.334
AR(2)-GARCH(1,1)	57.452	5.472	63.488	5.545	86.883	6.826	110.574	7.360
AR(1)-EGARCH(1,1)	63.747	5.665	65.396	5.634	96.587	7.198	104.845	7.312
AR(2)-EGARCH(1,1)	61.817	5.433	59.376	5.341	91.089	6.974	106.740	7.113

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

G.3 – TNBHPI – Annualized Monthly Index Growth Rates – 12-Step-Ahead Forecasts

G3.01 – Composite 6, Composite 11, Vancouver and Toronto – MSPE & MAPE

	DT AMGR COMP 6 F12		DT AMGR COMP 11 F12		DT AMGR VAN F12		DT AMGR TOR F12	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	109.590	8.004	105.356	7.699	178.887	9.730	120.906	8.214
AR(2)	114.975	7.851	108.176	7.681	203.970	10.246	122.139	8.092
AR(4)	114.643	7.688	111.229	7.730	205.995	10.224	121.249	8.029
ARMA(1,1)	107.689	7.869	109.301	7.757	206.108	10.300	110.359	7.213
ARMA(1,2)	101.633	8.054	121.298	8.392	205.987	10.384	118.232	8.220
ARMA(2,2)	122.912	8.343	120.311	8.246	198.011	10.246	119.496	8.328
ARMA(4,4)	162.367	9.193	102.363	7.745	198.945	10.452	127.378	8.828
AR(1)-ARCH(1)	202.235	10.446	228.302	10.985	148.282	9.382	126.294	8.365
AR(2)-ARCH(1)	206.565	10.402	204.814	10.267	159.421	9.432	127.626	8.033
AR(1)-ARCH(2)	210.330	10.485	232.472	11.133	140.012	9.156	127.522	8.461
AR(2)-ARCH(2)	107.263	7.926	228.696	10.776	136.430	9.014	129.003	8.243
AR(1)-GARCH(1,1)	210.330	10.485	232.472	11.133	140.012	9.156	127.522	8.461
AR(2)-GARCH(1,1)	107.263	7.926	228.696	10.776	136.430	9.014	129.003	8.243
AR(1)-EGARCH(1,1)	120.295	8.525	169.286	9.812	151.723	9.199	125.107	8.221
AR(2)-EGARCH(1,1)	160.175	9.368	169.800	9.673	154.922	9.075	126.354	8.012

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

Section H – NHPI – Forecast Mean Squared Prediction Errors (MSPE) & Mean Absolute Prediction Errors (MAPE)

H.1 – NHPI – Annualized Monthly Index Growth Rates – 1-Step-Ahead Forecasts

H1.01 – Canada, British Columbia, Ontario, Vancouver and Toronto – MSPE & MAPE

	DT_AMGR_CA_HL_F1		DT_AMGR_BC_HL_F1		DT_AMGR_ON_HL_F1		DT_AMGR_VAN_HL_F1		DT_AMGR_TOR_HL_F1	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	11.579	2.457	52.174	4.695	18.965	3.268	60.663	5.110	36.865	4.373
AR(2)	10.312	2.278	45.685	4.405	16.242	2.905	54.645	4.784	31.636	3.856
AR(4)	10.367	2.245	45.635	4.385	15.482	2.720	54.992	4.769	30.693	3.666
ARMA(1,1)	10.301	2.235	44.731	4.364	14.596	2.759	52.993	4.660	27.477	3.637
ARMA(1,2)	10.502	2.269	45.433	4.411	14.734	2.781	53.808	4.703	28.711	3.707
ARMA(2,2)	10.448	2.280	45.821	4.497	14.919	2.816	54.542	4.793	29.690	3.799
ARMA(4,4)	11.930	2.516	45.820	4.549	17.838	3.034	62.806	5.272	36.092	3.961
AR(1)-ARCH(1)	11.925	2.480	54.458	4.805	19.161	3.303	62.451	5.095	36.554	4.397
AR(2)-ARCH(1)	10.526	2.294	45.884	4.477	15.997	2.841	56.716	4.903	30.632	3.727
AR(1)-ARCH(2)	11.809	2.454	54.998	4.813	19.385	3.260	60.734	5.045	36.409	4.347
AR(2)-ARCH(2)	10.546	2.287	48.203	4.497	16.034	2.878	55.011	4.757	36.086	3.921
AR(1)-GARCH(1,1)	11.809	2.454	54.998	4.813	19.385	3.260	60.734	5.045	36.409	4.347
AR(2)-GARCH(1,1)	10.546	2.287	48.203	4.497	16.034	2.878	55.011	4.757	36.086	3.921
AR(1)-EGARCH(1,1)	11.489	2.443	55.961	4.909	20.227	3.343	62.424	5.119	36.633	4.409
AR(2)-EGARCH(1,1)	10.301	2.272	46.780	4.433	16.149	2.856	55.521	4.757	30.975	3.783

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

H.2 – NHPI – Annualized Monthly Index Growth Rates – 3-Step-Ahead Forecasts

H2.01 – Canada, British Columbia, Ontario, Vancouver and Toronto – MSPE & MAPE

	DT AMGR CA HL F3		DT AMGR BC HL F3		DT AMGR ON HL F3		DT AMGR VAN HL F3		DT AMGR TOR HL F3	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	11.302	2.518	52.258	4.895	18.468	3.385	60.382	5.313	35.062	4.668
AR(2)	10.477	2.364	46.971	4.539	14.924	2.852	55.831	4.952	27.823	3.844
AR(4)	10.503	2.316	48.130	4.580	14.348	2.692	57.481	5.032	27.190	3.685
ARMA(1,1)	10.905	2.378	48.121	4.650	14.273	2.791	55.949	4.905	24.490	3.567
ARMA(1,2)	11.545	2.425	48.325	4.650	13.897	2.721	55.692	4.923	26.158	3.665
ARMA(2,2)	11.315	2.412	48.365	4.651	14.459	2.782	56.658	5.049	26.134	3.712
ARMA(4,4)	12.425	2.573	50.664	4.693	16.129	2.853	62.295	5.308	31.917	3.876
AR(1)-ARCH(1)	11.757	2.553	50.395	4.752	16.455	3.127	59.317	5.166	31.867	4.363
AR(2)-ARCH(1)	10.769	2.386	46.793	4.538	14.500	2.729	55.857	4.985	27.352	3.700
AR(1)-ARCH(2)	11.734	2.541	50.358	4.774	17.213	3.156	59.324	5.167	32.772	4.468
AR(2)-ARCH(2)	11.085	2.424	47.734	4.584	14.137	2.737	56.033	4.964	30.798	3.786
AR(1)-GARCH(1,1)	11.734	2.541	50.358	4.774	17.213	3.156	59.324	5.167	32.772	4.468
AR(2)-GARCH(1,1)	11.085	2.424	47.734	4.584	14.137	2.737	56.033	4.964	30.798	3.786
AR(1)-EGARCH(1,1)	11.477	2.546	52.268	4.933	19.146	3.299	56.467	5.091	33.986	4.523
AR(2)-EGARCH(1,1)	10.263	2.337	48.484	4.581	14.475	2.734	56.241	4.987	27.556	3.759

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

H.3 – NHPI – Annualized Monthly Index Growth Rates – 12-Step-Ahead Forecasts

H3.01 – Canada, British Columbia, Ontario, Vancouver and Toronto – MSPE & MAPE

	DT_AMGR_CA_HL_F12		DT_AMGR_BC_HL_F12		DT_AMGR_ON_HL_F12		DT_AMGR_VAN_HL_F12		DT_AMGR_TOR_HL_F12	
	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE	MSPE	MAPE
AR(1)	18.208	3.145	62.921	5.638	32.750	4.746	64.811	5.530	53.712	6.003
AR(2)	16.757	3.043	58.517	5.204	25.581	4.041	64.056	5.411	41.744	5.035
AR(4)	14.898	2.855	54.484	4.845	20.278	3.329	62.456	5.365	33.733	4.275
ARMA(1,1)	14.317	2.766	55.620	5.110	18.597	3.215	59.810	5.247	30.783	4.042
ARMA(1,2)	14.488	2.802	54.926	5.058	17.845	3.086	61.525	5.404	30.419	4.043
ARMA(2,2)	14.376	2.812	55.063	5.047	18.898	3.200	62.139	5.443	30.065	4.106
ARMA(4,4)	19.236	3.191	58.094	5.116	18.095	3.063	64.394	5.584	31.910	4.111
AR(1)-ARCH(1)	19.235	3.227	59.851	5.379	28.797	4.430	63.761	5.418	47.483	5.573
AR(2)-ARCH(1)	17.604	3.106	57.288	5.100	24.730	3.887	63.442	5.396	42.374	4.936
AR(1)-ARCH(2)	19.145	3.231	60.057	5.405	30.727	4.514	64.163	5.444	48.215	5.675
AR(2)-ARCH(2)	17.823	3.116	57.724	5.064	24.453	3.805	63.143	5.347	63.613	5.480
AR(1)-GARCH(1,1)	19.145	3.231	60.057	5.405	30.727	4.514	64.163	5.444	48.215	5.675
AR(2)-GARCH(1,1)	17.823	3.116	57.724	5.064	24.453	3.805	63.143	5.347	63.613	5.480
AR(1)-EGARCH(1,1)	17.679	3.099	61.796	5.461	35.876	4.748	64.815	5.488	49.112	5.733
AR(2)-EGARCH(1,1)	16.295	2.991	58.835	5.175	23.070	3.725	63.384	5.374	42.344	5.054

Notes: Highlighted Cells Indicate Minimum Values; MSPE units are squared percentages, MAPE units are in percentages.

Section I – Forecasts (Next Page)

I.1 – RLHPS – 2013 Annualized Quarterly Price Growth Forecasts

I1.01 – RLHPS – Vancouver Detached Bungalows

Detached Bungalows	1-Step-Ahead				4-Step-Ahead			
	M1	M2	M3	Avg.	M1	M2	M3	Avg.
Vancouver West	9.35%			9.35%	16.34%	17.42%		16.88%
	(12.58)				(36.48)	(38.00)		
Vancouver East	0.02%			0.02%	-0.18%			-0.18%
	(12.09)				(20.18)			
West Vancouver	22.97%			22.97%	0.12%			0.12%
	(27.16)				(38.99)			
North Vancouver	24.64%	16.33%		20.49%	3.74%			3.74%
	(17.03)	(17.55)			(26.30)			
Surrey	-0.25%	0.58%		0.16%	8.11%			8.11%
	(34.27)	(34.09)			(39.14)			

** Forecast Standard Errors in Parentheses*

I1.02 – RLHPS – Vancouver Standard Condominiums

Standard Condominiums	1-Step-Ahead				4-Step-Ahead			
	M1	M2	M3	Avg.	M1	M2	M3	Avg.
Vancouver West	-3.49%			-3.49%	-2.44%			-2.44%
	(12.60)				(18.83)			
Vancouver East	-4.12%			-4.12%	-0.53%			-0.53%
	(17.25)				(22.44)			
North Vancouver	10.47%			10.47%	1.99%			1.99%
	(17.30)				(22.30)			

** Forecast Standard Errors in Parentheses*

I1.03 – RLHPS – Toronto Detached Bungalows

Detached Bungalows	1-Step-Ahead				4-Step-Ahead			
	M1	M2	M3	Avg.	M1	M2	M3	Avg.
Burlington	6.29%			6.29%	5.56%			5.56%
	(15.79)				(16.23)			
Etobicoke**	N / A				N / A			
	N / A				N / A			
Scarborough	7.25%	4.10%	3.51%	4.95%	4.25%	2.98%		3.61%
	(19.72)	(19.01)	(16.87)		(20.20)	(21.29)		
Oakville	3.41%	-0.57%		1.42%	0.00%	0.00%		0.00%
	(17.58)	(15.22)			(16.95)	(18.10)		
North Toronto	0.17%			0.17%	-0.30%	1.11%		0.40%
	(29.90)				(30.57)	(29.70)		

** Forecast Standard Errors in Parentheses*

*** Series ends in 2011*

I1.04 – RLHPS – Toronto Standard Condominiums

Standard Condominiums	1-Step-Ahead				4-Step-Ahead			
	M1	M2	M3	Avg.	M1	M2	M3	Avg.
North Toronto	18.55%	5.23%		11.89%	8.39%	13.49%		10.94%
	(22.46)	(18.53)			(25.74)	(25.47)		
The Annex	5.79%	-0.35%	0.62%	2.02%	-7.25%	0.00%		-3.63%
	(33.84)	(26.17)	(27.63)		(34.74)	(38.50)		
Oakville	11.26%			11.26%	3.01%			3.01%
	(23.05)				(26.63)			

** Forecast Standard Errors in Parentheses*

I.2 – TNBHPI – 2013 Annualized Monthly Growth Rate Forecasts

I2.01 – TNBHPI – Composite 6, Composite 11, Vancouver and Toronto

	1-Step-Ahead			3-Step-Ahead			12-Step-Ahead		
	M1	M2	Avg.	M1	M2	Avg.	M1	M2	Avg.
Composite 6	1.72%		1.72%	1.27%	1.30%	1.29%	0.58%		0.58%
	(4.45)			(1.80)	(5.50)		(6.74)		
Composite 11	1.07%		1.07%	-0.16%		-0.16%	0.04%		0.04%
	(8.69)			(10.12)			(10.72)		
Vancouver	7.06%	6.60%	6.83%	6.88%	5.79%	6.33%	5.40%	4.49%	4.95%
	(6.68)	(6.80)		(7.34)	(7.86)		(8.55)	(8.74)	
Toronto	-4.25%		-4.25%	-3.23%	-3.25%	-3.24%	-0.97%		-0.97%
	(9.85)			(10.70)	(10.63)		(11.53)		

** Forecast Standard Errors in Parentheses*

I.3 – NHPI – 2013 Annualized Monthly Growth Rate Forecasts

I3.01 – NHPI – Canada, British Columbia, Ontario, Vancouver and Toronto

	1-Step-Ahead			3-Step-Ahead			12-Step-Ahead		
	M1	M2	Avg.	M1	M2	Avg.	M1	M2	Avg.
Canada	1.72%		1.72%	1.27%	1.30%	1.29%	0.58%		0.58%
	(4.45)			(1.80)	(5.50)		(6.74)		
British Columbia	1.07%		1.07%	-0.16%		-0.16%	0.04%		0.04%
	(8.69)			(10.12)			(10.72)		
Ontario	7.06%	6.60%	6.83%	6.88%	5.79%	6.33%	5.40%	4.49%	4.95%
	(6.68)	(6.80)		(7.34)	(7.86)		(8.55)	(8.74)	
Vancouver	-4.25%		-4.25%	-3.23%	-3.25%	-3.24%	-0.97%		-0.97%
	(9.85)			(10.70)	(10.63)		(11.53)		
Toronto	7.08%		7.08%	5.89%	0.00%	2.94%	2.06%		2.06%
	(10.06)			(11.27)	(0.00)		(12.96)		

** Forecast Standard Errors in Parenthesis*

Section Z – Nomenclature and Explanations

Z1.01 – Royal LePage Housing Price Survey (RLHPS) – Geographical Area Nomenclature

- BU – Burlington
- ET – Etobicoke – Islington / Kingsway
- NT – North Toronto
- NV – North Vancouver
- OA – Oakville
- SC – Scarborough – Central
- SU – Surrey
- TA – The Annex
- VE – Vancouver East
- VW – Vancouver West
- WV – West Vancouver

Z1.02 – Royal LePage Housing Price Survey (RLHPS) – Descriptive Nomenclature

- B – Detached Bungalow
- C – Standard Condominium
- EXRET – Excess Returns
- P – Estimated Housing Prices
- R – Estimated Rental Value
- ST – Short Term (Used to indicate the average 3 month Canadian Treasury Bill Rate was used in calculating the particular series).
- T – Estimated Property Taxes

Z1.03 – Teranet National Bank Housing Price Index (TNBHPI) – Related Nomenclature

- COMP_6 – Teranet Composite 6 Index
- COMP_11 – Teranet Composite 11 Index
- TOR – Toronto
- VAN – Vancouver

Z1.04 – Statistics Canada New Housing Price Index (NHPI) – Geographical Area Nomenclature

- BC – British Columbia
- CA - Canada
- ON – Ontario
- TOR – Toronto
- VAN – Vancouver

Z1.05 – Statistics Canada New Housing Price Index (NHPI) – Related Nomenclature

- H – House Only
- HL – House and Land
- L – Land Only

Z1.06 – General Descriptive Nomenclature

- ADF –Augmented Dickey-Fuller Unit Root Test
- AMGR – Annualized Monthly Growth Rate
- AQGR – Annualized Quarterly Growth Rate
- DT – Detrended
- F1 – 1-Step-Ahead Forecast
- F3 – 3-Step-Ahead Forecast
- F4 – 4-Step-Ahead Forecast
- F12 – 12-Step-Ahead Forecast
- MAPE – Mean Absolute Error
- MSPE – Mean Squared Error