TIME-VARYING CORRELATION IN CANADIAN HOUSING PRICES

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PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN FINANCE

In the Master of Science in Finance Program
of the
Faculty
of
Business Administration

SIMON FRASER UNIVERSITY

Fall 2015

Approval

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Degree: **Master of Science in Finance**

Title of Project: **TIME-VARYING CORRELATION IN CANADIAN HOUSING PRICE**

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Abstract

For some investors, the lesson learned from financial crisis, which caused by an increasing rate of subprime mortgage defaults in 2007, was that diversification of their portfolio no longer works. Recent study (Kiran Manda, 2010) established that the correlation of almost all financial assets increases greatly during a market downturn. The research (Zimmer, 2014) argues that correlations of housing price movements in the United States change over time and might strengthen during financial turmoil. Thus, CDOs might have less diversification benefits during extreme market shakeouts. This paper uses ARCH-GARCH Model to test housing price comovements between different Canadian cities, which are Vancouver, Toronto, Calgary and Montreal. The results document that the time-varying correlation of real estate price indices do not increase during a crisis. This suggests that geographic diversification in Canadian real estate offers an alternative diversification in the investment universe. CDOs might perform better in Canada than in the United States during a financial crisis.

Keywords: Housing price, Financial Crisis, ARMA-GARCH

Acknowledgements

We would like to thank Professor Andrey Pavlov and Dr Phil Goddard for expert guidance and consultative help as well as constructive suggestion that have improved the paper.

Table of Contents

List of Figures

List of Tables

1: Introduction

1.1 Research Objectives

Housing is not a typical investment because it was once considered too expensive or illiquid for most investors. However, investors can participate in real estate not only directly through investing in residences, commercial real estate and raw land, but also can be achieved through indirect investments, such as, index futures trading, investing in homebuilders and property management companies.

Recent research (Kiran Manda, 2010) demonstrates that the correlation between most asset classes increased significantly during the financial crisis of 2008, and the markets have become extremely volatile. Longin and Solnik (2001) argue that equity market correlation is mainly affected by market trend rather than volatility, but they also state that correlations tend to increase in bear markets due to the large negative returns. Through the research (Sing and Tan, 2013), the empirical results show that the conditional covariance between stock returns and direct real estate returns vary over time. They observed that the correlation increases in boom markets, but become weaker in market turmoil. Therefore, in today's environment, investors may have strong interest in real estate because they desire additional diversification.

Housing price, as a key factor, determines the return of the real estate investment. This paper firstly calculates raw correlations in percentage change of housing price. Using monthly time series data from 2000 to 2015 from different Canadian cities, the correlations indicate time varying change over time. Then this paper calculates time-varying correlation in housing price movements by applying ARMA-GARCH Model to consider autoregressive and conditionally heteroskedastic nature of monthly change of prices. The model indicates that the correlations do not increase during time of financial crisis. This paper also creates two indices for major markets (Vancouver, Calgary, Toronto, and Montreal) and smaller markets (the rest of Canada), which get the same results as the tests of correlations among the four major cities. Hence, although increased correlation between most asset classes reduces diversification benefits during crises, a portfolio with geographic diversification in real estate across asset classes offers benefits that are rare in the investment universe.

1.2 Literature Review

Recent research (Zimmer, 2014) shows that housing prices began falling all around U.S cities from early 2006, and CDOs had less diversification benefits than originally thought. Thus credit rating agencies received a lot of blame because they rated many CDOs higher than deserved. The statistical tools they used to test change of housing prices assumed that correlations in housing prices in different locations followed a multivariate normal distribution, which does not account extreme or unexpected market events.

The monthly data on housing prices come from the period February 1, 1989 to November 1, 2013 are used to test the time-varying correlations in four major US cities, which are Miami, Los Angeles, Phoenix, and New York City. Bivariate GARCH model is used to test whether correlations in housing price movements change over time. The estimator in this model predicts correlation react to previous month price changes in one location, which is referred as the “driver” city. The results state that correlations increase in the midst of market downturn in certain cities, notably Miami, Phoenix and New York.

2: Data and Methodology

Below are sample figures and tables.

2.1 Data

This paper uses monthly data from the city-specific Housing Price Indices to perform the analysis. The main conclusions of this paper can be made by focusing on four cities: Vancouver, Toronto, Calgary, and Montreal. Vancouver and Toronto are chosen because they are the two largest cities in Canada, and due to their distance, Vancouver represents the real estate market of West Coast Canada and Toronto represents the real estate market of East Coast Canada. Calgary is chosen because it is the third largest market in Canada and it represents the real estate market of middle Canada. Montreal is chosen because it is part of the Quebec province that is the only Canadian province that has a predominantly French-speaking population. In addition, two indices for large markets (Vancouver, Toronto, Calgary, and Montreal) and smaller markets (Victoria, Ottawa, Winnipeg, Edmonton, Hamilton, Quebec, Halifax) in Canada are created in order to study the correlation between major markets and smaller markets. The two indices are calculated by taking the average of HPI of the included cities of each time. Data come from the period October 1, 2000 to September 1, 2015, for a total of 180 monthly observations. Nation Bank House Price Index is estimated by using the repeat sales methodology. It is the same technique that is explained in Case and Shiller (1989).

Figure 1 shows monthly percent changes in housing prices in the four major cities. Prices fluctuate throughout the period from October 1, 2000 to September 1, 2015. In general, Figure 1 shows that four cities share the same pattern and housing prices in different areas tend to move in the similar direction.

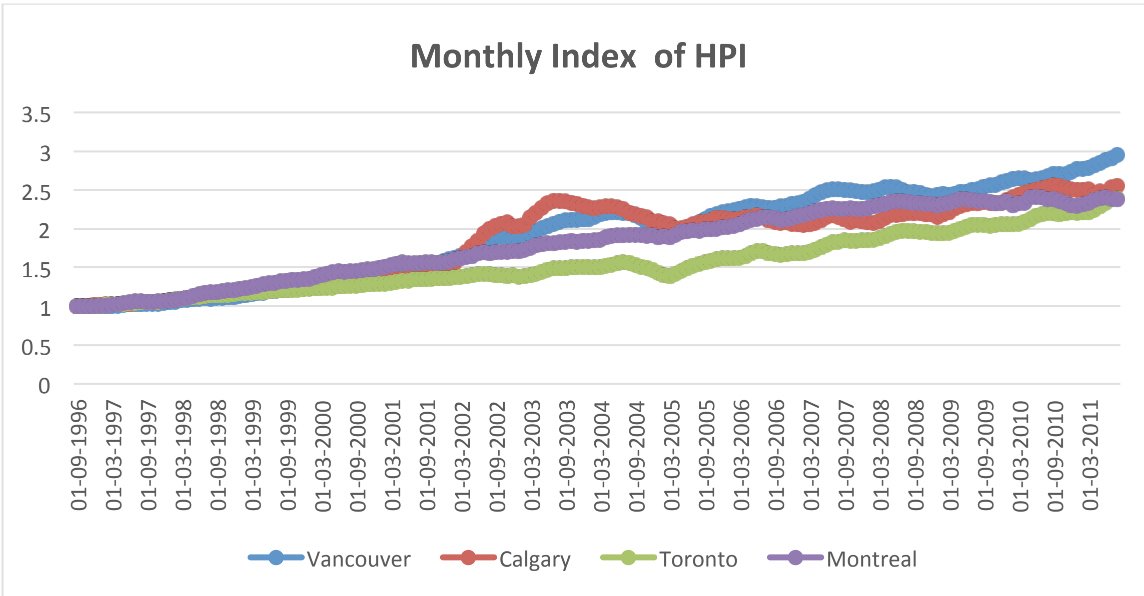

Figure 1 *Monthly percent changes in housing prices index for four major cities (Source: National Bank House Price Indices)*

Figure 2 and Figure 3 present the correlations between each pair of major cities using standardized residuals. The correlations are calculated using sliding 24-month windows, where each point represents the correlation between housing price movements for the previous 12 months and the next 12 months. Figure 2 suggests that the correlations are not always positive and correlations do not remain constant over time.

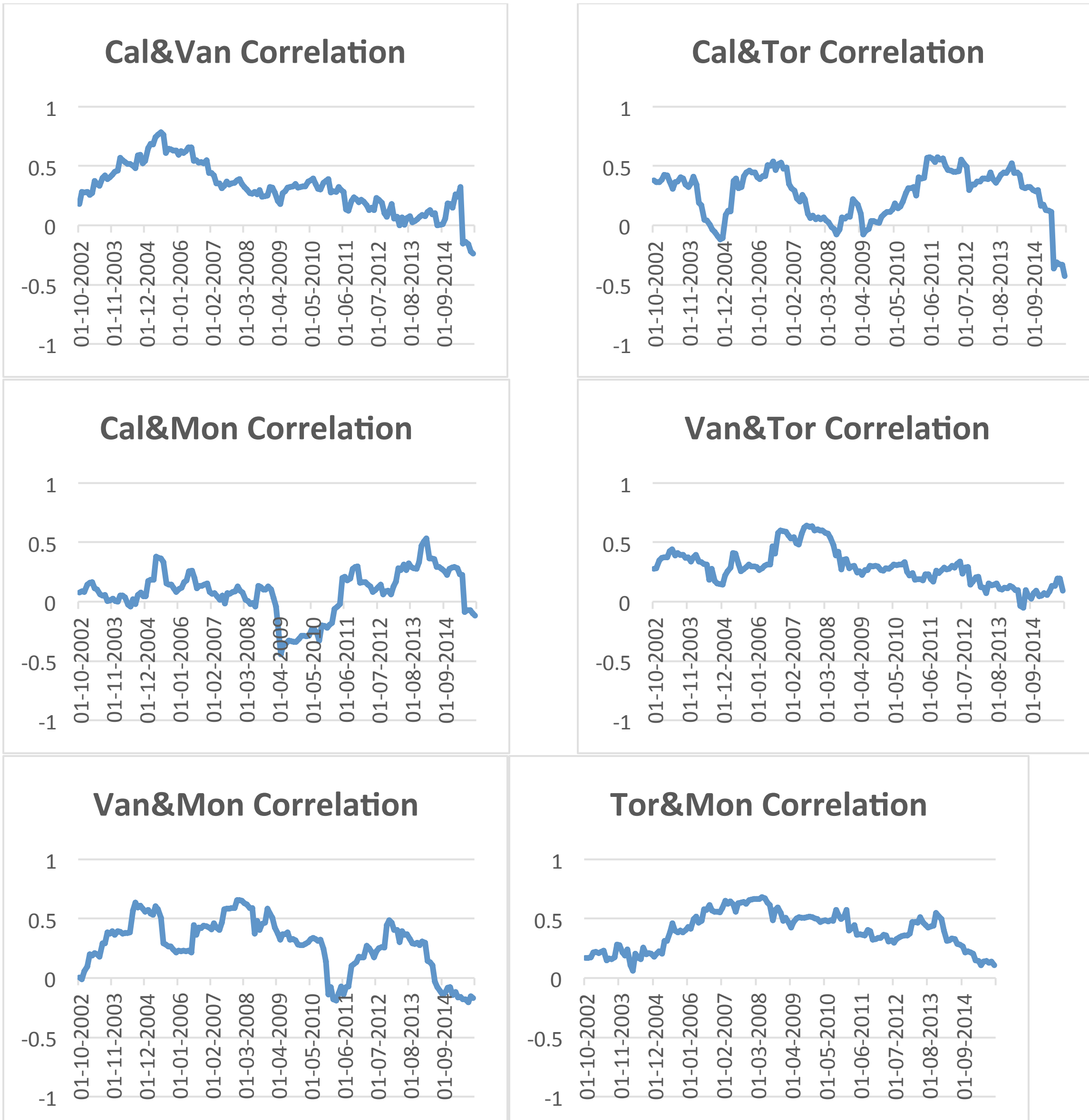

Figure 2 *Correlations in monthly percent changes in housing prices, calculated using 24-month sliding windows.*

In order to closely analyze the correlations during the financial crisis 2007-2008, Figure 3 shows the correlations between each pair of major cities in one graph from January 1, 2007 to December 31, 2009. In particular, the correlations between each two major cities do not appear to have strengthened during financial crisis. This indicates that the correlations of city-specific housing prices in Canada are different from those in the United States, where the correlations appear to have strengthened (Zimmer, 2014).

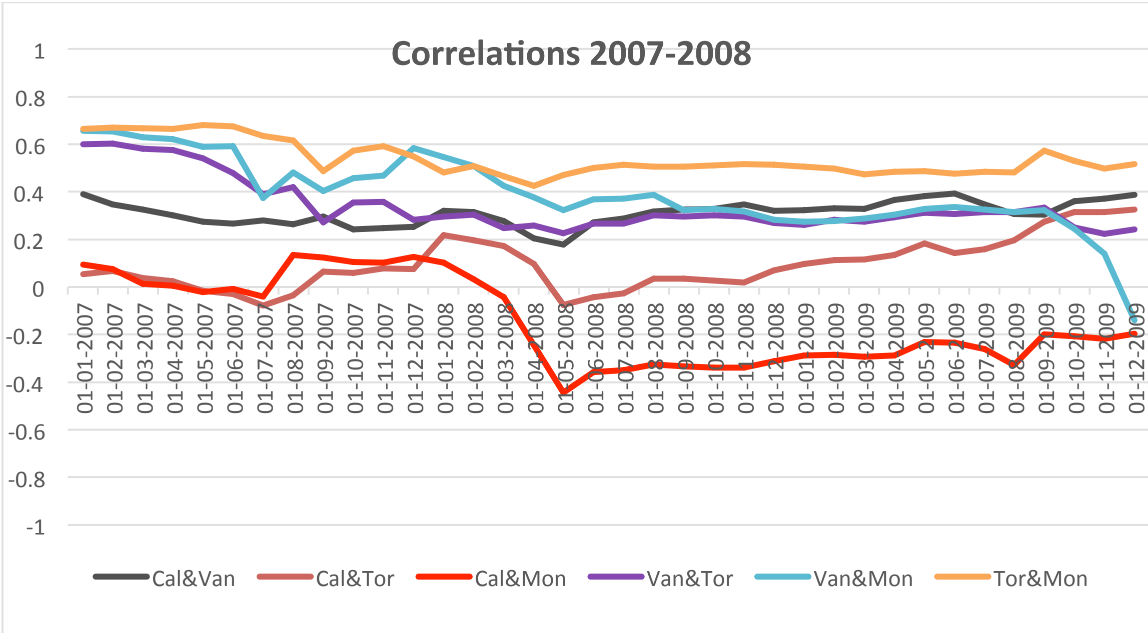

Figure 3 *Correlations in monthly percent changes in housing prices, with six pairs of cities in one graph*

Figure 4 and Figure 5 present the raw correlations (correlations of Log returns) between each pair of major cities. As indicated in Figure 4 and Figure 5, the correlations first increased and then decreased during the financial crisis from the end of 2007 to July, 2008. It is difficult to draw a clear conclusion on the correlations during financial crisis 2007-2008. The correlations calculated from Log returns are relatively similar as compared with the correlations calculated from standardized residuals. However, when explicitly modeling ARMA/GARCH effects, the results are much clearer that the correlations do not increase substantially during financial crisis.

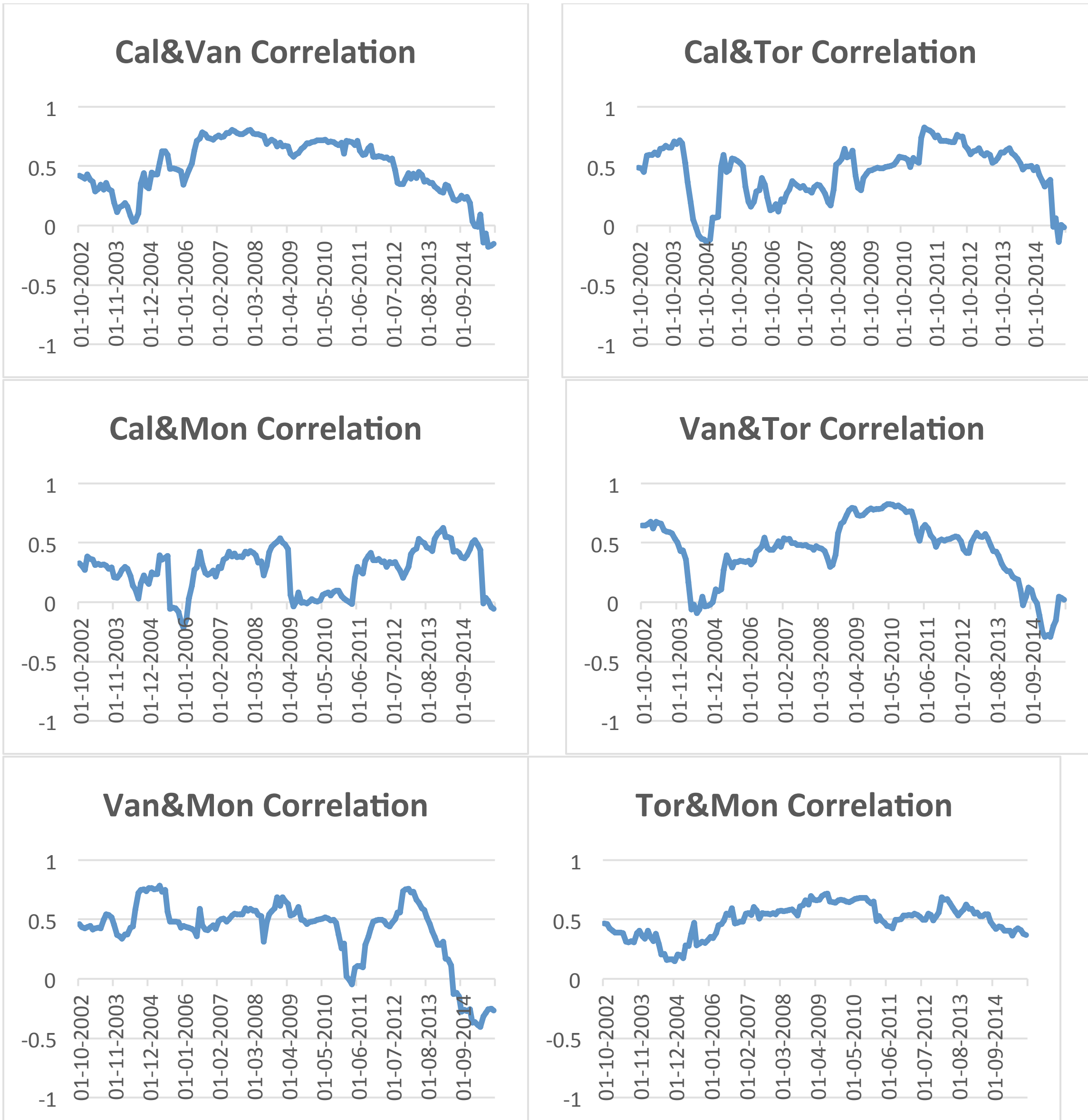

Figure 4 *Raw Correlations in monthly percent changes in housing prices, calculated using 24-month sliding windows.*

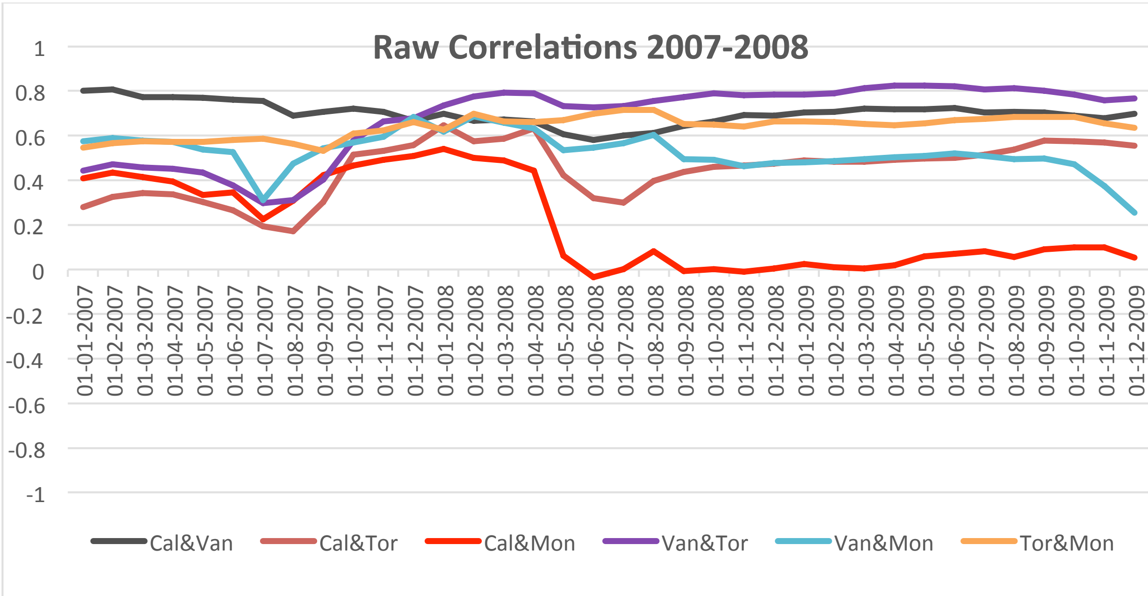

Figure 5 *Raw Correlations in monthly percent changes in housing prices, with six pairs of cities in one graph.*

In addition, as indicated in Figure 6, the correlations between large markets and smaller markets have also strengthened and then weakened during financial crisis from the end of 2007 to mid-2008.

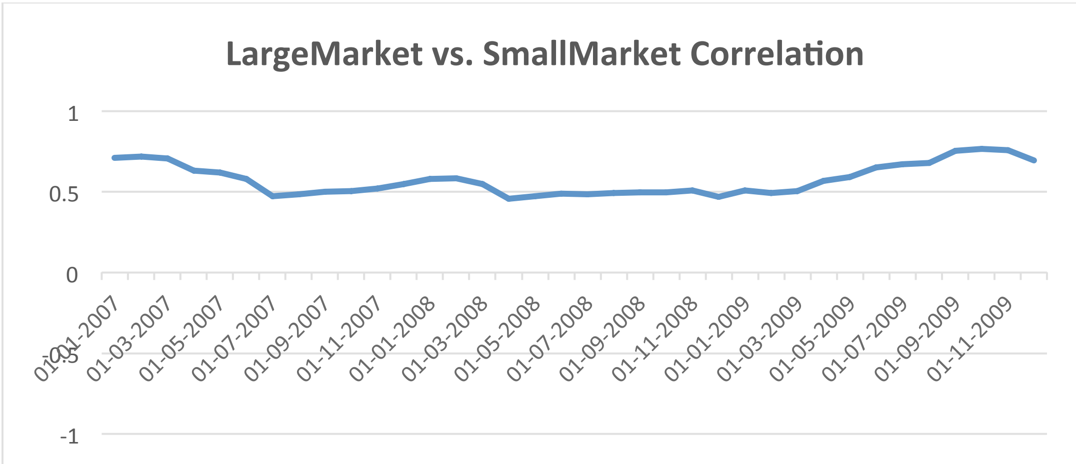

Figure 6 *Correlations in monthly percent changes in housing prices between large markets and smaller markets*

Figure. 7 shows the raw correlations between large markets and smaller markets. By comparing Figure 6 and Figure 7, the correlations calculated from standardized residuals and the raw correlations are slightly different in numbers but the trends of correlations are similar. Thus, from Figure7, the raw correlations between large markets and smaller markets have also strengthened and then weakened during financial crisis, especially in 2008. From Figure6 and Figure 7, the correlations between larger market and smaller market do not appear to have strengthened during financial crisis.

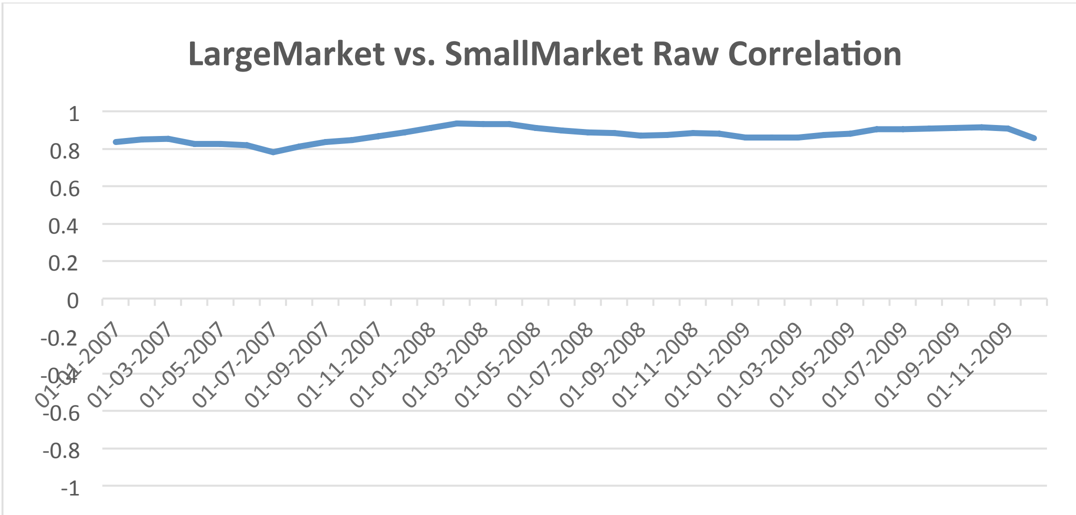

Figure 7 *Raw Correlations in monthly percent changes in housing prices between large markets and smaller markets*

In order to provide a deeper understanding of the time-varying correlation, the following section will illustrate the methodology that is used to calculation the correlations.

2.2 ARMA & GARCH Methodology

In figure 3, the correlations in monthly percentage change seem change over time; however, this picture does not consider autoregressive and conditionally heteroskedastic nature of monthly price movements, which is important to avoid mimic findings of correlation (Granger & Newbold 1974). In fact, time-varying volatility is more common than constant volatility with financial time series data. Researchers have noticed that the tail of the house price distribution tends to be heavier when experiencing a financial crisis. This section presents autoregressive moving average (ARMA) and generalized autoregressive conditional heteroskedasticity (GARCH) models. These models capture "shock" information, such as a surprise loss or unexpected event. However, in an ARMA model, which is a special case of a GARCH (0,1) model in which there are zero lagged forecast variances in the conditional variance, so it does not capture volatility clustering, which is a key phenomenon of financial time series. Thus, estimating ARMA/GARCH models not only accommodate heavy tail distributions, but also model conditional variances, which allow for testing time-varying correlation in housing price movements.

These models are used in order to retrieve the standardized residuals data. Then by using excel formula, correlations are calculated from the standardized residuals data in order to test whether correlations in housing price movements change over time and how correlations appear during a financial crisis.

An ARMA (p,q) model and GARCH(m,s) model is in the form of:

$$x_t = \phi_0 + \sum_{i=1}^{p} \phi_i x_{t-1} + \sum_{j=1}^{q} \theta_j a_{t-j} + a_t$$

$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{m} \beta_i a_{t-i}^2 + \sum_{j=1}^{s} \gamma_j \sigma_{t-j}^2$$

$$a_t = \sigma_t \varepsilon_t$$

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

with the constraints:

i) Positive variance requirement:

$$\beta_0 > 0$$

$$\beta_i \geq 0, \quad \forall i \leq m$$

$$\gamma_j \geq 0, \quad \forall j \leq s$$

ii) Variance stationarity requirement:

$$\sum_{i=1}^{\max(m,s)} (\beta_i + \gamma_i) < 1$$

For ARMA (p,q) and GARCH(m,s) models, the optimal order of models can only be determined by trial and error. Generally the trial starts with ARMA (1,1) and GARCH (1,1), and the order of models increase if error occurs. By using ARMA and GARCH models for each of the four major cities, the large markets index and the smaller markets index, standardized residuals data are retrieved for each major cities and the two indices.

These are the steps that have to be followed in order to retrieve the standardized residuals data from ARMA and GARCH models:

1. This method first plots the time series of the monthly HPI raw data.

2. Since the series contains a trend, the method then removes the trend by first taking the Log price and then using the Log return for further calculation.

3. Then a hypothesis test is performed for serial correlation by plotting ACF.

4. As serial correlation exists, this method fits the data into an ARMA model in order to remove the serial correlation.

5. Then a Matlab function "lbtest" is used to test for GARCH effect.

6. Since GARCH effect exists, the method starts by assuming a GARCH (1,1).

7. Residuals has to be verified whether it is white noise. A Matlab function "lbtest" is used to test for serial correlation. And constant volatility is tested by plotting ACF.

8. Matlab functions "ttest"and "vartest" are used to test zero mean and unit volatility for standardized residuals. In addition, also run skewness() and kurtosis() to test zero skewness and excess kurtosis.

9. Repeat a higher order GARCH model if the conditional variance estimates fail any of the tests

After the standardized residuals for the four major cities and two indices are retrieved, correlations are calculated with the Excel formula 'CORR (Standardized_Res1, Standardized_Res2)'. In the Excel spreadsheet, the correlations are calculated using sliding 24-month windows, where each point represents the correlation between housing price movements for the previous 12 months and the next 12 months.

2.3 Result

First, as indicated by Figure 2, correlations are not always positive and correlations do not remain constant over time. Second, Figure 3 and Figure 5 indicate that correlations between each two major cities do not appear to have strengthened during financial crisis. Third, Figure 6 and Figure 7 indicate that correlations between larger markets and smaller markets do not appear to have strengthened during financial crisis. To further analyze the data, Table 1 shows the detailed numerical numbers of correlations between each 2 major cities and the correlation between large markets and smaller markets from December 01, 2007 to June 01, 2008. As indicated in Table 1, the correlations first increase and then decrease during financial crisis. For example, the correlation between Calgary and Vancouver rises from 0.2535289 to 0.3211134 from December 01, 2007 to January 01, 2008 and the correlation between large markets and smaller markets rises from 0.549760763 to 0.578871235 from December 01, 2007 to January 01, 2008. In addition, the correlation between Calgary and Montreal drops from 0.127655 to -0.3582793 from December 01, 2007 to June 01, 2008 and the correlation between large markets and smaller markets drops from 0.578871235 to 0.474820045 from January 01, 2008 to May 01, 2008. Thus, co-movements in housing prices are strengthened and then weakened during financial crisis. As indicated from the table and the figures, during the financial crisis, the correlations between housing prices in Canada do not appear to be strengthened, which are different from the correlations in the United States, where the correlations appear to have strengthened. (Zimmer, 2014)

Date	Cal&Van	Cal&Tor	Cal&Mon	Van&Tor	Van&Mon	Tor&Mon		Two Indices
01/12/2007	0.2535289	0.0741577	0.127655	0.2817115	0.5845684	0.5486108		0.549760763
01/01/2008	0.3211134	0.2185728	0.1027963	0.295274	0.5446144	0.4820068		0.578871235
01/02/2008	0.3156599	0.1966698	0.0333009	0.3043767	0.5087246	0.5085585		0.582159176
01/03/2008	0.2759696	0.1720274	-0.0418253	0.2462802	0.4245997	0.4655586		0.547774443
01/04/2008	0.2040791	0.0975015	-0.2441755	0.2568844	0.3754288	0.4235544		0.456241381
01/05/2008	0.1780986	-0.0758483	-0.4443975	0.2250336	0.3224763	0.471115		0.474820045
01/06/2008	0.2713649	-0.0438924	-0.3582793	0.2650004	0.3679084	0.5013012		0.487396115

Table 1 *Correlations between each two major cities and the two indices*

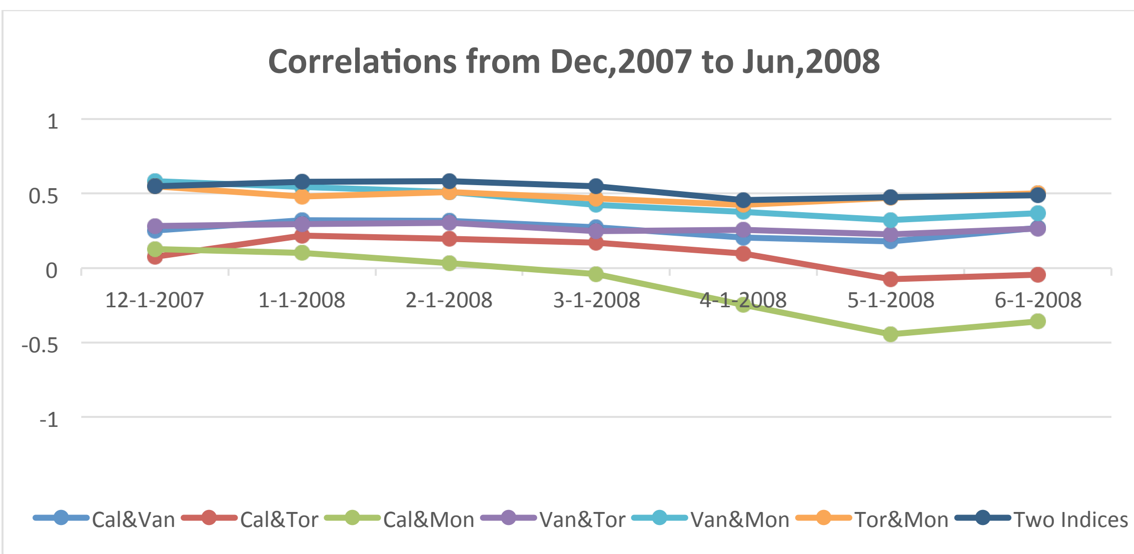

Figure 8 *Correlations between each two major cities and the two indices from Dec 2007 to Jun 2008*

3: Conclusion

Contagion shows that there could be a strong correlation in the behaviour of asset markets associated with economic booms or economic crisis (Pericoli & Sbracia 2003). Therefore, this phenomenon may limit the potential for portfolio diversification. However, the transmissions of shocks across the real estate markets differ from those across the equity markets, so some diversification gains still remain during periods of crisis across these asset classes (Shaun, Mardi & Renée 2004).

The results document that the time-varying correlation of real estate price indices do not increase during a crisis. This suggests that geographic diversification in Canadian real estate offers an alternative diversification in the investment universe. CDOs might perform better in Canada than in the United States during financial a crisis.

There are some potential explanations of why real estate market in Canada response differently from the market in the United States. Financing houses is different in Canada from in the United States. The real estate market in the United States is affected by one single factor, which has cause the financial crisis of 2007-2008. However, in Canada, the real estate market is affected by many factors, such as, immigration policies and exchange rates. First, Canada is a big immigration country. The change in immigration policies of Canada would affect the number of residents, which is an important factor to determine housing price. Before 2007, the immigration policy indicated that visa students only got one-year work permit after graduation. However, in 2007, the policy has revised to three-year work permit instead of a one-year work permit. This change has induced many international students to invest in the real estate during or after their study since they were going to stay longer in Canada. Most of the international students were in larger cities, and they tended to buy houses in larger cities such as Toronto and Vancouver. Secondly, in 2007 and 2008, the exchange rate between Canadian dollar and US dollar are relative small, in other words, Canadian dollar has more bargain power than the US dollar during financial crisis. Since financial crisis has the most impact in the US real estate market, investors might have switch their investments from US real estate market to Canadian real estate markets since investors thought there were potential of growth in the Canadian real estate markets. This might be the third reason why real estate market responded differently than typical financial assets in Canada during the financial crisis of 2007 and 2008.

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