Monthly House Price Indices and Their Applications in New Zealand

A thesis presented in fulfilment of the requirements for the degree of Doctor of Philosophy

Song Shi

Department of Economics and Finance
College of Business
Massey University

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ABSTRACT

Developing timely and reliable house price indices is of interest worldwide, because these measures influence consumer behaviour, inflation targeting, and spot and futures markets. Several techniques for constructing a constant quality price index are available in the literature, but these methods are difficult to apply in localities where market transaction data is limited. Since house price movements are a local phenomena, improving the timeliness of a quality controlled price index at local housing market levels in small countries like New Zealand is a challenge.

This thesis comprises three essays that focused on improving the timeliness of reported house price indices at the local market levels. The timeliness issue examined in this thesis has not previously been rigorously investigated and this makes the results of this thesis both important and unique for the benefit of both academic research and practical application. Essay One reviews the sale price appraisal ratio (SPAR) method, which has been applied since the 1960s for producing local house price indices at a semi-annual and quarterly basis in New Zealand. Utilizing a variety of statistical tests and comparing this index with the repeat sales and median price index result in the study highlighting the potential of, as well as the problems associated with, a price index produced by the SPAR method at a monthly level. In the following two essays, monthly price indices are tested using empirical real estate research methods in order to examine their usefulness in exploring the research questions as well as revealing the statistical differences between them. Essay Two studies the relationship between sale price and trading volume, and the ripple effect of local house price comovements. The results show that the trading volume generally leads the sale price in the long-run and the ripple effect is most likely constrained within regions. In Essay Two, the monthly SPAR index produces similar statistical results to those estimated by the repeat sales index for large cities. Essay Three is a study on the market efficiency of housing markets. It is found the local housing market is neither weak-form nor semi-strong form efficient. Local house price movements are strongly correlated and are mean reverting towards their long-run equilibrium. It is further concluded that monthly price indices for small cities are problematic due to the problem of small sample size.

Overall, the findings in this thesis show monthly house price indices can be generated by using the SPAR method at local market levels. However, this potential is limited to large cities. Further research can focus on improving the quality of monthly price indices for large cities.

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RELATED RESEARCH

Accepted Journal Articles

Shi, S., Young, M., and Hargreaves, B. (2009). Issues in measuring a monthly house price index in New Zealand. *Journal of Housing Economics,* ***18***(4), 336-350.

Shi, S., Young, M., and Hargreaves, B. (2009). House price-volume dynamics: evidence from 12 cities in New Zealand. *Journal of Real Estate Research, forthcoming.*

Shi, S., Young, M., and Hargreaves, B. (2009). The ripple effect of local house price movements in New Zealand. *Journal of Property Research,* ***26***(1), 1-24.

Journal Articles under Editorial Review

Shi, S., Young, M., and Hargreaves, B. (2009). Testing for predictability of local house price movements in New Zealand. *Journal of Real Estate Finance and Economics, under editorial review.*

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This thesis contributes to the literature on the development of high frequency house price indices at a monthly level in New Zealand and their applications in the empirical research of local house price dynamics. The study consists of three interrelated essays, which focus on two major research questions. First, are the current available data sufficient to support the construction of a reliable and timely reported house price index? Second, how do high frequency price indices perform in empirical real estate research in terms of their usefulness in exploring the research questions as well as revealing the statistical differences between them?

Developing a quality controlled house price index at a high frequency reporting level, is important for both academic research and practical application. Unless users are certain about the quality of a housing price index, it is unlikely that our understanding of property cycles, market efficiency and housing affordability will be extended. Academic research shows that a house price index should be estimated using the finest possible disaggregation of the time variable (Englund, Quigley, & Redfearn, 1999; Geltner & Ling, 2006). A timely and frequently reported price index will unsmooth the true price movement and as such will benefit the research in volatility-based studies. However, there is a trade-off between the statistical quality per period and the sample size, which often sets the limit on how frequently an index can be reported. Given that the index tends to become more volatile as reporting frequency levels get higher, there is a point at which an increased level of reporting frequency becomes less useful.

In small countries like New Zealand, where housing market transaction volume per period is limited, reporting a quality controlled house price index other than at a quarterly level for local markets can be a challenge. There are few academic works on the development of a quality controlled house price index at a monthly level in countries like New Zealand. For this reason this thesis is unique and important.

In order to achieve the above two main research objectives, the thesis explored firstly the issues involved in measuring a monthly house price index. Particular attention was given to using the sale price appraisal ratio (SPAR) method to construct a house price index. Using house price indices developed in the first essay, the thesis further applied these indices in empirical real estate research. In the second essay the studies included house price and trading volume dynamics and the ripple effect of local house price movements, and the third essay investigated the predictability of local house price movements. Apart from contributing to the knowledge of local house price dynamics, one of objectives of the second and third essays was to compare the results of various price indices. From these comparisons, the value and robustness of these newly developed monthly house price indices to be further examined.

The remainder of this chapter is organised as follows: Section 1.2 provides an overview of the importance of having a reliable and timely house price index and Section 1.3 introduces the contemporary housing markets in New Zealand. The next three sections of this chapter provide an overview of each of the three essays. This includes the academic contributions of each essay and, in particular, the relationships between them. The description of how the remainder of the thesis is presented is presented in Section 1.7.

1.2 OVERVIEW OF TIMELINESS AND RELIABILITY ISSUES FOR A HOUSE PRICE INDEX

Throughout the recent worldwide housing boom, there has been a strong demand from both the public and policy makers for a reliable and timely price index in order to monitor frequently the housing market price movements. Housing is often the single largest household asset. Persistent high house prices present a substantial financial barrier to the first home buyers but a windfall capital gain to the existing home owners. In its news release dated 8 of March, the Reserve Bank of New Zealand (2007) expressed its concern about a resurgence in the housing market. It stated "Our concern is that the recent pick-up in housing and domestic demand may gain momentum ... This could reverse the rebalancing of the economy that has been underway since late 2005 and present substantial risks to the medium-term inflation outlook".

Economists are very interested in house price movements since housing loans make up a large proportion of the credit creation in an economy. Changes in property values can affect mortgage security (such as in the sub-prime mortgage market in the US) and further influence macroeconomic performance. All these require reliable and timely house price indices to be analysed at a local market level.

However, since real estate is a heterogeneous product and less often seldom traded, accurately measuring its price movement is difficult. Depending on the methodology, scope, coverage and timing, there are different house price measures published regularly. Economists and central bankers are concerned about the quality of various house price measurements available for their work in targeting inflation. The public is confused by the conflicting signals of various published house price measures, particularly regarding the timing of turning points in the house price cycle. For example, the media often report the latest movement in house price changes. In its news article dated 19 April, the New Zealand Herald (2007) stated "New Zealand house prices hit a new record high last month, ignoring central bank attempts to take some heat out of the market, according to the Real Estate Institute of New Zealand (REINZ)". However, what the article does not tell the readers is that the "prices" it referred to were median house prices which do not have a control for constant quality.

In 2006 the Chicago Mercantile Exchange (the MERC) commenced trading housing futures contracts allowing people to participate in the ups and downs of the housing market. The index used by Standard & Poor's is based on the work of Case and Shiller (1987) covering 10 metropolitan markets in the U.S. This was a milestone in the workings of the real estate market given the fact that residential real estate has represented a large portion of our wealth for many years. A similar derivative product is proposed for Australian housing market, where people can take out a future contract based on the ASX property indices[1] quoted on the share market. If New Zealand is going to establish a futures market in property derivatives like the models in the UK,

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[1] The ASX property index is based on a representative sample of properties in each local housing market compiled by RP Data and Rismark International. The index is reported on a monthly and quarterly basis covering each of the five major capital cities in Australia. More information about the index can be found on the website: http://www.rpdata.com/indices

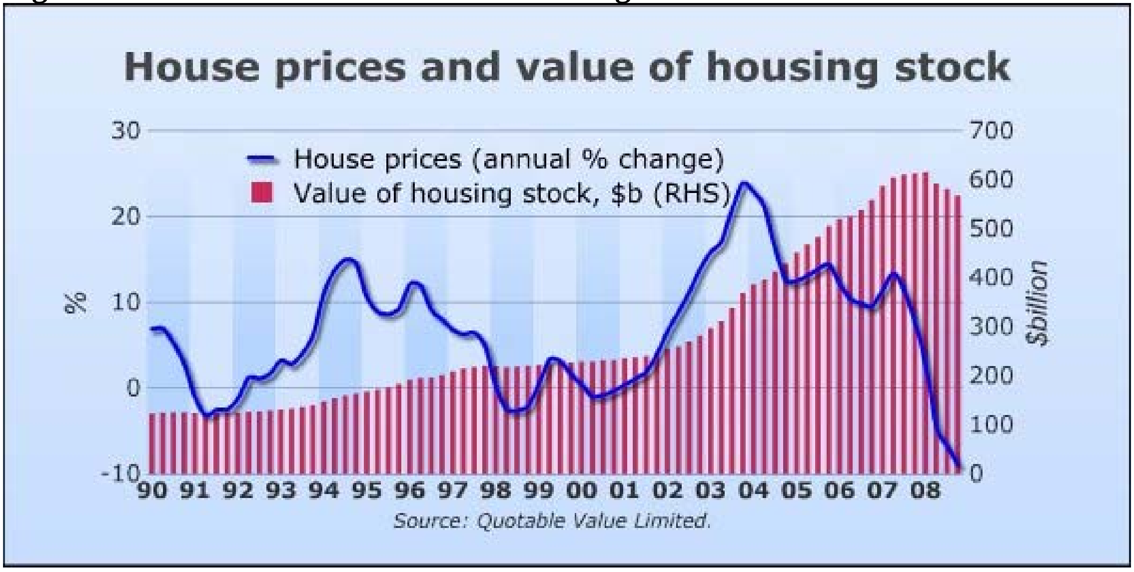
US and Australia, then the reliability of the index and its timely reporting are very important.

1.3 CONTEMPORARY HOUSING MARKETS IN NEW ZEALAND

New Zealand is an island country in the south-west Pacific with two main islands, the North Island and South Island, with a total population in 2008 of approximate 4.3 million. Auckland is the country's commercial capital and largest city with a population of over 1 million. Wellington is the country's capital and political centre. Workers in Wellington City have the highest average wage in the country with a large proportion of them being government employees. Christchurch is the largest and city in the South Island, where the local economy is mainly reliant on the surrounding farming sector and manufactured exports. Overall, the whole country's economy is strongly trade orientated, particularly in agricultural protein products (dairy, meat and wool).

Similar to many countries, there was a boom in house prices in New Zealand in recent years and from 2001 to 2007 house prices doubled during this period. At the end of 2007, the housing stock value of all private sector residential dwellings in New Zealand was more than $600 billion. See Figure 1.1 for details.

Figure 1.1 House Prices and Value of Housing Stock



Source: Reserve Bank of New Zealand, (2009)

The buoyant housing market was primarily driven by easy credit and population growth. Home ownership is a dominant feature of the New Zealand housing market. The 2006 Census showed that 66 percent of households owned their own homes, although this percentage has been steadily falling in recent years. Apart from some speculative activities in the housing market, many people still regard home ownership as a key means of independence and saving for their retirement. Research by Bollard, Hodgetts, Phil and Mark (2006) showed the net worth of the household sector in New Zealand had almost doubled in nominal terms between 2001 to 2005. In 2005 house value represented nearly 75 percent of household net worth, a significant increase from 60% in 2001.

The high interest rate policy imposed by the Reserve Bank of New Zealand and the global credit crunch in 2007 resulted in the New Zealand housing market retreating from its peak at the end of 2007 to decrease in value by about 10% in 2008. Recently, there have been some positive signs in the housing market, including increased turnover rates and a lowering of mortgage interest rates. Whether these factors indicate a short-term market rebound or a long-run market recovery is yet to be established.

1.4 ESSAY ONE

This examined the issues of house price indices based on the Sale Price Appraisal Ratio (SPAR) method. This method, which takes the ratios of current sale prices and their previous assessed values to construct an index, is simple and is the method that has been used since the 1960's for producing the official house price index in New Zealand. Using local housing market transaction data in New Zealand for the period 1994 – 2004, the first essay examined the impact of temporal aggregation, assessment errors in the assessed values, and the frequency of reassessment on the SPAR index. The results in general supported the use of the SPAR index at a monthly level.

Essay One did not attempt to provide a comprehensive review of the literature on all alternative index construction methods. Instead, it focused on the issues faced by the SPAR index itself. The results from this first essay contributed to the existing body of knowledge in several ways. Firstly, it contributed to the house price index literature for the SPAR method as an alternative to repeat sales methodology. So far only a few countries in the world use the SPAR technique to produce house price indices, and there is limited literature concerning testing the reliability of the SPAR index. Secondly, it added to the knowledge for producing a SPAR index at a monthly level. A SPAR index, at a high frequency reporting interval rather than on a quarterly basis in a small market, has not been rigorously investigated before. Thus exploring the possibility of a monthly SPAR index can potentially contribute to the literature on the value of utilising high frequency data for empirical real estate research in small countries, such as New Zealand.

Using the repeat sales index as a benchmark, the study compared the estimated SPAR index against the repeat sales index. One of findings was that the correlation of index returns between the two indices was high at a quarterly level but low at a monthly level. The low correlation at the monthly level suggested there was a lot of price noise in monthly price indices. This led to the next main research question: What are the statistical performances of monthly price indices in empirical real estate research? For monthly SPAR indices to be successful, similar statistical results are expected from a monthly SPAR index and the benchmark index.

1.5 ESSAY TWO

The second essay is an extension of the first essay in that it provides an investigation of the monthly price indices in empirical research. Two relationships were examined in the second essay. The first was the dynamics between sale price and trading volume, and the second was the ripple effect of local house price movements between cities. For the purpose of index comparisons, the intention was to use the least estimated variables in the proposed analysis. In the study of price and volume dynamics, sales volumes are already available in the data set. In the research on the ripple effect, only local market house price indices are utilised. Thus, results between various price indices were able to be compared.

The contribution of the research to the real estate literature presented in the second essay is as follows. Firstly, it adds to the existing body of knowledge about local house price dynamics. It is well-established in real estate literature that volumes and prices are positively correlated, however it has not been clearly determined whether price leads volume or vice versa. A similar situation exists for the study of the ripple effect on local house price movements. Although the ripple effect has been observed, particularly in the UK housing market, it is difficult to explain it in theory. Economic theory suggests that regional house prices should not move together, as house prices are believed to be a phenomenon caused by local market supply and demand factors. Secondly, this research highlighted the problem of the choice of price indices in empirical real estate research. Past research shows that all these observed relationships may vary depending on the local market studied, time period examined and the house price indices adopted.

Using monthly data for the selected local markets in New Zealand, the second essay revealed that changes in trading volume leads the price change across most local markets in New Zealand. However, it showed that price movement in Auckland has little impact on price change in Wellington and Christchurch. Overall, the results showed some contradictory evidence between various price indices but the problem is limited mainly to small cities. Due to the possibility that both the SPAR and repeat sales indices may suffer from the problem of small sample sizes at a monthly basis for small cities, further research is required to confirm the performance of the monthly house price indices, particularly for small cities.

1.6 ESSAY THREE

To further examine the problem of monthly price indices for small cities as revealed in Essay Two, the third essay chose the study of local housing market efficiency for the research. This is because an efficient market hypothesis study in the housing market is more inclined than others to suffer from the problem of measurements error in price indices. Any results from an efficient market hypothesis study in real estate could be an artefact of the price index adopted rather than a real feature of the market (Cho, 1996). Due to the use of various house price indices for the selected local markets by the size category, the findings in the third essay were of interest, particularly when evaluating statistical performance of house price indices developed for small cities.

The third essay contributed to the existing body of knowledge in the following ways. Firstly, it added to our knowledge of the efficient market hypothesis study for the New Zealand housing market. There is no scholarly work on the study of housing market efficiency in New Zealand using quality controlled house price indices at a monthly level. The findings added to the debate about the application of the efficient market hypothesis in relation to housing markets. In addition, the problem of the choice of appropriate price indices in the efficient market hypothesis study was further revealed. Therefore, the performance of various monthly price indices in empirical research can be observed.

Using the previously developed monthly house price indices, the third essay provided some convincing evidence against the efficient market hypothesis. The results showed the housing market in New Zealand was neither weak-form nor semi-strong form efficient. Local house price movements were strongly correlated and were subject to mean reversion in the long-run. Monthly price indices for small cities were shown to be very "noisy" and their empirical findings were opposite to the results obtained for large cities. Once again the SPAR index for large cities reported similar statistical results as to that of the repeat sales index. The findings further supported a monthly SPAR index for large cities but not for small cities.

1.7 ORGANISATION OF THE THESIS

The remainder of this thesis is structured as follows. Chapter 2, which is the first essay, examined issues of house price indices, particularly for indices based on the SPAR technique. This section was designed to fill the research gap in previous research on the SPAR index methodology and in particular the feasibility for developing a monthly SPAR house price index.

Chapter 3, which is the second essay, presented the results of testing various monthly house price indices in empirical research beginning with house price and trading volume dynamics and then continuing with the ripple effect on local house price movements in New Zealand. The results also provided a critical evaluation of monthly house price indices in an empirical real estate research setting.

Chapter 4, the third essay, investigated the application of the efficient market hypothesis to housing markets. Using the monthly price indices developed in the first essay, both the weak-form and semi-strong form efficiency were examined and the performances of various monthly price indices were compared. The results added further evidence to the quality of the monthly price indices estimated in the first essay.

Chapter 5 contains the conclusions and summarises the entire thesis. Contributions to the academic literature and policy implications of the study's findings are contained in this section. The chapter ended with a discussion on the limitations of the research and suggestions for further research.

CHAPTER 2

ESSAY ONE

Issues in Measuring a Monthly House Price Index in New Zealand

2.1 INTRODUCTION

In New Zealand the official house price index is produced by the Sale Price Appraisal Ratio (SPAR) method. The method, which takes the ratios of the current sale prices and their previous assessed values to construct an index, can be viewed as a simplified arithmetic form of the repeat sales method proposed by Shiller (1991).

So far only a few countries in the world including New Zealand, Denmark and Sweden use the SPAR technique to produce house price indices. For this reason it is not surprising that there is limited literature concerning testing the reliability of the SPAR technique. Recent scholarly works include Bourassa et al. (2006), Wal et al. (2006) and Rossini and Kershaw (2006). Bourassa et al. (2006) compared the SPAR index with other alternatives including repeat sales and hedonic models. They promoted the use of the SPAR index technique on a semi-annual basis as an alternative to other methods. The measurement errors in assessment values by producing the SPAR index itself and the temporal aggregation effect on the index's stability were not investigated. Based on house price data in the Netherlands, Wal et al. (2006) achieved similar results to Bourassa et al. (2006) but they were cautious about the reliability of the appraisal data set utilised in the SPAR index as a whole. Rossini and Kershaw (2006) tested the temporal aggregation effect on the SPAR index in South Australia. They found that the SPAR index outperformed others at a weekly level in terms of reduced volatility.

By using a rich property transaction data set for various jurisdictions in New Zealand over an 11 year period, the first essay explored the possibility of producing a monthly house price index by using the SPAR method. The motivation was driven by the question of the need for a monthly price index in New Zealand. In this case, although housing market transaction volume per period is limited, there is a robust standard nationwide rating system for taxation purposes. This study examined the impact of temporal aggregation, random assessment errors in assessed values, and frequency of reassessment on the SPAR index. In addition, it compared the SPAR index with the repeat sales and median price indices.

It is well known in the indexing literature that there is a trade-off between statistical quality per period and the sample size, and this relates to the frequency of index reporting. There is a limit on how frequently an index can be reported. For quarterly indices examples are: the Office of Federal Housing Enterprise Oversight (OFHEO) house price index (HPI) index in the US which uses the repeat sales method, the Australian Bureau of Statistics (ABS) house price index which uses the stratification approach and the Quotable Value house price index in New Zealand which uses the SPAR technique. Some indices are reported at monthly intervals, such as the Halifax index and Nationwide house price index in the UK, both of which are derived from mortgage data by using the hedonic technique. Having a robust quality-controlled house price index at a monthly level is an obvious improvement on quarterly indices. Timely measurement of house price inflation is important for the Reserve Bank (the central bank of New Zealand) interest rate settings and will add housing market transparency. From an academic viewpoint, a monthly index will unsmooth the true price movement (Englund et al., 1999; Geltner & Ling, 2006), and will be useful for other analyses such as housing market efficiency studies.

Two criteria were used in this study to evaluate the temporal aggregation effect on the SPAR index. The first one was each period's index stability when the index itself is revised due to lagged sales. The second was the index volatility as a whole over time. Ascertaining the index's stability per reporting period will provide important information on the appropriate time lag for data collection before reporting the index. This is because analysts often collect only a percentage of sales in a period in order to produce a timely index. Of course this practice is subject to a predetermined minimum number of sales per period for index reporting purposes. The index's volatility over time will indicate the lumpiness of an index as a whole. It is generally believed that the real estate market is much less volatile in the long run than the stock market. However, in the short run the real estate market can suffer from the problem of a small number of observations and is subject to "noise" trading (Geltner, Miller, Clayton, & Eichholtz, 2007). Therefore lumpiness is an important consideration when constructing a real estate index with varying time intervals.

Measurement errors in assessed values will obviously have a direct effect on the accuracy of the SPAR index. Research shows that assessment errors can both systematically and randomly exist throughout the whole housing stock (Berry & Bednarz, 1975; Goolsby, 1997). Since systematic assessment errors are discouraged and audited by various statistical tests at the time of general revaluation in New Zealand, there are good reasons to believe the systematic error is small[2]. Thus this study concentrated on assessing the random measurement error of the reported SPAR index in New Zealand.

[2] Some key minimum compliance requirements for a revaluation in New Zealand include: the coefficient of dispersion must be less than 12, median value price ratio is within the range 0.90 to 1.10 and price related differential lies between 0.98 and 1.03.

One other factor to consider with respect to the SPAR index is the effect of frequency of revaluation on its accuracy. For rating (tax) purposes, property values are regularly reassessed. In New Zealand, this is usually done by contract valuers employed by local authorities on a 3 yearly basis although some local authorities, such as Wellington City Council, reassess on an annual basis. One obvious benefit from annual reassessment is that the assessed values will be more up to date and this is believed to improve the SPAR index accuracy. However one weakness is the problem of inconsistency, meaning the price index differs significantly when based on the first valuation compared to when based on the second valuation. This inconsistency is caused by the systematic error in the assessed values between reassessments and will have an impact on the SPAR index as a whole. Accordingly, this study has also investigated the trade-offs between annual revaluation and 3 yearly revaluations.

Finally, the comparisons between the SPAR index and the repeat sales and median price indices showed how well the SPAR index is correlated to other alternative indexing models. A high correlation to the benchmark index appears to be essential if the proposed monthly SPAR index is going to be acceptable in New Zealand.

The first essay is organised as follows. Section 2.2 provided background information about the New Zealand house price index and rating system. Section 2.3 reviewed the housing price indices mainly focusing on the repeat sales method, the assessed value method and the SPAR technique. Section 2.4 described the New Zealand data utilised in this research. Section 2.5 described the methodology. Section 2.6 discussed the empirical results. Finally, Section 2.7 provided the conclusions.

2.2 THE NEW ZEALAND HOUSE PRICE INDEX AND RATING SYSTEM

Two sources of measuring house price movements are available in New Zealand. One is the officially published Quotable Value house price index (QVHPI) and the other is the median house prices reported by the Real Estate Institute of New Zealand (REINZ). The QVHPI index collects sales data through the legal reporting system when a sale is settled and reports the index on a quarterly basis with an approximately three-month lag. By using the real estate agency reporting system, the REINZ median house price is reported on a monthly basis with only a few weeks' lag.

The main problem with the QVHPI index is timeliness. A quarterly reporting interval, has been seen as too long by many market participants and policy makers, particularly when the market is not stable. On the other hand, reliance on the REINZ monthly median house price (not quality controlled) tends to overstate price increases as houses are getting bigger and more elaborate over time. Thus the REINZ statistics may mislead investors and policy makers.

Under the Rating Valuations Act 1998, all residential properties in New Zealand are required to be reassessed on a regular basis. This is often done by the local authorities every three years. In theory the assessment values (known in New Zealand as "Capital Values") should be equal to the market value less value of chattels (i.e. fixed floor coverings, blinds, drapes, light fittings and removable appliances) as at the assessment date. This is defined by the Capital Value under the Rating Valuations Act 1998 and also emphasized in the Rating Valuations Rules 2002 in New Zealand. In practice, assessment errors do exist. Rating valuations tend to be conservative but not necessarily in a uniform way. They tend to overvalue the lower value properties and undervalue more expensive houses. There are several sources for assessment errors, including the use of past sale price information to infer the rating values as at the assessment date. Also, the assessor (or "valuer" in New Zealand) may not have complete market knowledge or information required for a sales analysis, especially when there are non-notified property changes or limited comparable sales. Other sources of error may include time and budget constraints, subjectivity on the part of the assessor, and the valuation methodology used.

However, rating valuations have to meet the minimum compliance requirements in New Zealand[3]. All open market sales received within the three months prior to the effective date of the revaluation will be utilised by the Valuer General for statistical analysis. For statistical reason the minimum sample size is 50 sales for statistical testing. The statistical rules for testing the variation between revaluations and net sale prices include[4]:

- Coefficient of Dispersion (COD)
- Median Value Price Ratio
- Price Related Differential (PRD)
- Comparison of Average Value Changes

The COD, which is the ratio of the average absolute difference of individual assessment ratios (assessed value/net sale price) over the median level of assessment expressed as a percentage, must be equal to or less than 12. This is for the purpose of keeping uniformity between the proposed rating values of the sale property samples

[3] See the Rating Valuations Rules version 3.1 prepared by the Office of the Valuer-General (2002) for compliance requirements.
[4] See Appendix A1 for practical example of how to calculate these valuation statistics.

and their sale prices. The median value price ratio, which is the median level of the capital value to net sale price ratio of the sale sample range, must be within the range of 0.90 to 1.10. The PRD, which is the ratio of the number weighted mean over the value weighted mean, must lie between 0.98 and 1.03. This is to ensure that lower value properties have increased by the same percentage as higher value properties or vice versa. Finally, the comparison of average value changes, which is the difference in the average value change between sold and unsold properties, must be less than 5%. This is to ensure that the capital values of sold properties have moved at the same levels as those of unsold properties.

With respect to the methodology used in valuing residential properties for rating valuation purposes, the sales comparison approach is the underlying method used for housing and is supported by using the index technique and the lump sum adjustment. The index technique is similar to the automated valuation models (AVMs) where the calculation of the value of a property is a statistical function of certain weighted characteristics. The lump sum adjustment is applied to the individual property when: a) notification is made of changes in property details; b) appeals are made by the home owners; and c) general property inspections are undertaken.

Statistical studies commissioned by the Office of Valuer General in New Zealand show that the overall measurement errors in assessed values in New Zealand are small throughout the whole housing stock, and the assessed values are very close to their net sale prices (total sale prices less value of chattels) as at the assessment date. The coefficient of dispersion (COD), which measures the average absolute deviation from the median price ratio in percentage terms, was found to be 7.11 for the 2006/2007 general revaluations. The 95% lower and upper confidence intervals for this estimate were extremely narrow, at 7.01 and 7.24, respectively. By way of background, the International Association of Assessing Officers (IAAO) merely requires that the COD is less than 15 for older single-family units. Research by the New Zealand Valuer General further shows that all of the other estimates and their 95 percent confidence interval boundaries are well within the IAAO standard[5].

2.3 HOUSE PRICE INDEX LITERATURE

There are many challenges associated with the construction of house price indices. These include timeliness, sample selection bias and changes in quality. Over the past few decades a number of researchers have investigated methods for developing a constant quality house price index. These include the hedonic, repeat sales and hybrid methods. However, there is not a simple solution in the literature so far for dealing with three problems identified above.

The hedonic model has been seen as a preferred method by many researchers but relies heavily on data collection in terms of the amount of structural and location information required. On the other hand, the repeat sales model may have less of a requirement for data but suffers more from data selection bias as only the repeated-sales rather than all transactions are considered when building the index. The hybrid method takes advantage of the information that is present in repeat sales, without ignoring information on single sales. The hybrid method is data intensive, but it represents an obvious improvement over the repeat sales method (B. Case & Quigley,

[5] For example, the median price ratio, which is defined as the median of the ratios of assessed values to net sale prices, was found to be on average 0.96 for the 2006/2007 general revaluations in New Zealand. The IAAO standard for the median price ratio is between 0.90 and 1.10.

1991; Englund et al., 1999). Due to the scope and purpose of this thesis, it primarily focuses on the repeat sales and the SPAR methods.

2.3.1 The Repeat Sales Method

The use of multiple regression analysis on repeat sales was first proposed by Bailey, Muth, and Nourse (1963) and is often referred to in the literature as the "BMN method". The method turns the problem of estimating price changes of repeat sales of properties into a regression problem. When the same asset sells twice, the change in its price is a "quality-controlled" price change, thereby avoiding the variable selection and functional form selection issues that afflict the competing hedonic model.

Based on the BMN method, Case and Shiller (1987; 1989) further developed the repeat sales method into the Weighted Repeat Sales (WRS) method. Their main point is that the variance of the error term is related to the time interval between sales rather than being constant in the BMN method. By running a three-step weighted least squares regression to down-weight the influence from sales with longer time intervals, the WRS method has become the primary approach for developing house price indices. In the early 1990s Abraham and Schauman (1991) proposed a modified version of Case and Shiller's method. Their method was used to produce the HPI index by the U.S. Office of Federal Housing Enterprise Oversight (Calhoun, 1996). Since then the literature on the repeat sales method has primarily focused on sample selection bias, constant quality change and index revision problems (B. Case, Pollakowski, & Wachter, 1997; Clapham, Englund, Quigley, & Redfearn, 2006; J.M. Clapp & Giaccotto, 1992b; Englund et al., 1999; Goetzmann & Spiegel, 1995; Haurin & Hendershott, 1991).

One way to deal with some of the problems associated with the repeat sales method is to bring the assessed values into the traditional BMN method. The method is called the Assessed Value (AV) method. In Clapp and Giaccotto (1992a), for instance, they used both repeat sales data and single sales data together with the assessed value of each sale to produce price indices for five cities in the US. This result is encouraging as it appears to show an improved statistical result in terms of smaller index change standard errors and higher index change correlations when compared to the standard repeat sales method (BMN). Gatzlaff and Ling (1994) further compared the assessed value technique to other alternative index methods in Miami (Dade County), Florida. Their research shows that the assessed value technique performed even better than the restricted hedonic model and similar to the standard repeat sales (BMN) method.

2.3.2 The Arithmetic Repeat Sales Method

Based on the BMN method, Shiller (1991) proposed the arithmetic repeat sales method. In an equally weighted arithmetic repeat sales form, the price index in period t can be expressed as the average of the ratio of the sale prices of houses sold in period t divided by their respective sale prices in the base period 0. For those houses which are not actually sold in the base period, their base period sale prices are inferred from other sale prices by using the estimated index. The estimator is given by equation (2.1).

$$\hat{\beta}_t^{-1} = \frac{\sum_{i=1}^{n_t} \frac{P_{it}}{\hat{\beta}_{t'} P_{it'}}}{n_t} \qquad (2.1)$$

where n_t is the number of sales in period t. P_{it} is the i^{th} property sale price at time period t and $\hat{\beta}_t$ is the estimated coefficient at the time period t in the BMN regression.

2.3.3 The SPAR Method

The SPAR index, is formulated by relating property sale prices to their respective assessed values and can be viewed as an arithmetic form of the repeat sales method proposed by Shiller (1991). The only difference between the SPAR technique and Shiller's arithmetic forms of the repeat sales method is assessed values are used as the base-period sale prices in the SPAR technique rather than being "inferred from their other prices using the estimated index" (Shiller, 1991). This implies that for the SPAR method, if it is to be effectively applied, the assessed value must be very close to the property's market value (sale price) at the base period. In terms of the AV method, it assumes that the vertical equity parameter, c, is 1 or very close to 1 (See equation 4, Clapp and Giaccotto (1992a)).

The equally weighted form of a SPAR index, which is utilised in the study, is given as follows:

$$\begin{cases} SPAR_t = \dfrac{\sum_{i=1}^{n_t} P_{it} / V_{i0}}{n_t} \\ I_t = \dfrac{SPAR_t}{SPAR_{t-1}} I_{t-1} \end{cases} \tag{2.2}$$

where $SPAR_t$ is the SPAR ratio at time period t. I_t is the SPAR index at time period t. n_t is the total number of sales at time period t. P_{it} represents the i^{th} property sold at time period t. V_{i0} is the i^{th} property's assessed value.

One feature of the SPAR technique is each period's SPAR index is relative to its base period's price index. Thus, sales only affect their own period's estimate but do not affect other periods' estimates. Also, provided the base period SPAR ratio is accurately measured, the precision of the SPAR index in time period t only depends on the estimation of the SPAR ratio in that period. Often the base period is chosen as the time when the general revaluation took place. This is because the SPAR ratio is very likely to be accurately assessed and close to 1 at that time. This avoids the complexity of calculating the variance of the SPAR index from the two SPAR ratios (t and t-1) in equation (2.2) and can be seen from the following algebraic exercise:

$$\begin{aligned}
\because I_1 &= \frac{SPAR_1}{SPAR_0} I_0, \ldots, I_{t-1} = \frac{SPAR_{t-1}}{SPAR_{t-2}} I_{t-2}, I_t = \frac{SPAR_t}{SPAR_{t-1}} I_{t-1} \\
\therefore I_t &= \frac{SPAR_t}{SPAR_{t-1}} \times \frac{SPAR_{t-1}}{SPAR_{t-2}} \times \ldots \times \frac{SPAR_1}{SPAR_0} I_0 \\
&= \frac{SPAR_t}{SPAR_0} I_0
\end{aligned} \tag{2.3}$$

Equation (2.3) shows that the SPAR index is superior to the repeat sales method when indices are revised due to lagged sales. However, there is a problem associated with the above equation (2.3) in that rating values are required to be reassessed on a regular basis. When assessed values are updated, the new assessed values will be used to calculate the next sequence of SPAR ratios. This is illustrated in the following equation (2.4).

$$For\ P=1:\quad I_{1,t}=\frac{SPAR_{1,t}}{SPAR_{1,0}}\times I_{1,0}\quad t=1,\ldots,n-1$$

$$I_{1,0}=1{,}000\,(for\ example)$$

$$For\ P=2:\quad I_{2,t}=\frac{SPAR_{2,t}}{SPAR_{2,0}}\times I_{2,0}\quad t=1,\ldots,n-1$$

$$I_{2,0}=\frac{SPAR_{1,n}}{SPAR_{1,n-1}}\times I_{1,n-1}$$

$$\vdots$$

$$For\ P=m:\quad I_{m,t}=\frac{SPAR_{m,t}}{SPAR_{m,0}}\times I_{m,0}\quad t=1,\ldots,n-1$$

$$I_{m,0}=\frac{SPAR_{m-1,n}}{SPAR_{m-1,n-1}}\times I_{m-1,n-1} \qquad (2.4)$$

where *P* represents the reassessment period and *n* is the number of index reporting periods within the reassessment period.

In this process the new base period index ($I_{m,0}$) for the next sequence of index periods is calculated by using the previous assessment values ($SPAR_{m-1}$) in order to chain the index over the two assessment periods. Two issues need to be clarified here. The first issue is the precision of $I_{m,0}$. Obviously this will have a direct impact on the index accuracy as any random measurement error in $I_{m,0}$. is carried forward to each subsequent index period until the next reassessment. From equation (2.3), the precision of $I_{m,0}$ can be estimated by the confidence interval of its SPAR ratio in that period, which is then influenced by its sample size (number of sales) and sample standard deviation, assuming a normal distribution[6]. The second issue is the inconsistency bias between reassessments, which means the price index differs

[6] Please note the confidence limits of the $I_{m,0}$ are referring to the median of the SPAR ratios at that period.

significantly when based on the first valuation as compared to the second valuation. This is caused by the systematic error in the assessed values and quantified as the difference of the two systematic errors between reassessments in this study. As discussed before, the systematic errors themselves are assumed to be small, but the difference between them (inconsistency bias) will have an impact on the SPAR index as a whole. Cornia and Slade (2005) analysed the uniformity of assessed valuations for apartments in Maricopa County, Arizona over a five year period from 1998 to 2002. This County was revaluing property on an annual basis. Cornia and Slade showed the vertical inequity parameter, as estimated from the Cheng (1974) model, was changing over time, that is from 0.93 in 1998 to 1.02 in 2002. Furthermore, as pointed out by Geltner et al. (2007) the dispersion of this kind of bias due to real estate appraisals is not necessarily random. As a result, the overall impact of such inconsistency bias on the SPAR index cannot be underestimated, particularly when appraisals are repeated at a short time interval.

2.4 THE DATA AND THEIR PREPARATIONS

This research utilises a rich data set of 449,221 freehold open market transactions of detached or semi-detached houses in selected urban areas in New Zealand between 1994 and 2004. The data was supplied from Quotable Value (QV) New Zealand, the official database of all property transactions in New Zealand. This data is considered to be comprehensive and highly reliable in terms of individual property details.

Each transaction includes a property ID, total selling price, value of chattels, sale date, the two most recent assessed values and respective valuation dates prior to the sale date, one most relevant assessed value and valuation date post the sale date, year house built and latest date of receiving building notice of changes (building permit) prior to the sale either from the local authority or from the home owners. Unfortunately the building permit data for Auckland City was not available in this data set.

The selected 12 urban areas include:

- Auckland Region

  North Shore City, Waitakere City, Auckland City, Manukau City, Papakura district

- Wellington Region

  Porirua City, Upper Hutt City, Hutt City, Wellington City

- Christchurch Region

  Christchurch City

- Other cities

  Nelson City and Palmerston North City

The primary reasons for choosing the Auckland region, Wellington region and Christchurch City in this study are because of their significant weights on the overall New Zealand housing stock and large periodical sales volume. Census data for 2006 from Statistics New Zealand shows that the combined population of the above three areas was more than half (52.8%) of the total national population, and the combined number of private dwellings was about half (50.3%) the number of dwellings at a national level[7]. Sales volume figures from Quotable Value New Zealand indicate the combined quarterly sales of 2005 Q3 for the above three areas were about 71.8% of

[7] See Table A.2 in Appendix A2 for more information.

the total sales of main urban areas and 43.5% at the national level[8]. Therefore the results of this study will be expected to be statistically important both at the regional and national levels.

In this study, the North Shore, Waitakere, Auckland, Manukau, Wellington and Christchurch cities are regarded as large cities because they have average quarterly sales of above 800. Hutt City, Nelson City and Palmerston North City are regarded as medium cities because they have average quarterly sales between 300 and 500. Porirua City, Upper Hutt City and Papakura District are regarded as small cities with average quarterly sales below 200. They are all included in this study in order to test how well the SPAR method performs in large cities in comparison to medium or small cities/districts.

For the estimation of the SPAR index for each local housing market, actual sale price less the value of chattels was used as "sale price" to form the SPAR ratios. Any ratio more than 2.4 or less than 0.4 was treated as an outlier and removed from the analysis. This data cleaning process is in line with the method utilised by the QVHPI index.

As the repeat sales method is vulnerable to outliers (R. Meese & Wallace, 1997), all multiple sales where the second sale price is less than 0.7 or more than 2.5 times the first sale price were eliminated from the repeat sales analysis due to prior knowledge of the housing market price movement. Moreover, since the supplied QV data includes building consent information, it is possible to further identify the quality

[8] See Table A.3 in Appendix A2 for more information.

changed repeat sales in this study and this minimised the constant quality problem faced by the standard repeat sales method.

2.5 METHODOLOGY

2.5.1 The BMN Method

In general the i^{th} property log sale price (p_{it}) at time *t* can be expressed in a regression model as follows:

$$p_{it} = C_t + \beta_{t1} X_{it1} + \beta_{t2} X_{it2} + ... + \beta_{tk} X_{itk} + \mu_{it} \qquad (2.5)$$

Equation (2.5) shows that the sale price may be explained by (1) constant C_t, or citywide price at time t, (2) i^{th} property characteristics including both structural and neighbourhood variables and (3) the residual u_{it}. If the same property is sold at an earlier time t, then the difference in log prices $r_{itt'} = p_{it} - p_{it'}$ is given by

$$r_{itt'} = C_{t'} - C_t + \beta_{t'1} X_{it'1} - \beta_{t1} X_{it1} + ... + \beta_{t'k} X_{it'k} - \beta_{tk} X_{itk} + \mu_{it'} - \mu_{it} \qquad (2.6)$$

If for the same property the time period between sale dates is not long, it can be assumed that there are likely to have been no structural changes or changes in neighbourhood characteristics. In fact $\beta_{t'k} X_{it'k} - \beta_{tk} X_{itk} = 0$. The regression model can then be written as follows:

$$r_{itt'} = C_1 T_{i1} + ... + C_t T_{it} + \mu_{itt'} \qquad (2.7)$$

where C_t is the citywide price index for each period. T_{it} is +1 if it indicates the second sale, is -1 for the first sale and is 0 for no sale. $u_{itt'}$ are the residuals in log form and are assumed to have zero means, the same variances σ^2 and uncorrelated with each other.

Equation (2.7) can be also rewritten in a matrix format, which is

$$r = bx + u \tag{2.8}$$

where r and u are n dimensional column vectors; n is the total numbers of pair transactions; b is a T dimensional column vectors of unknown log price index; and x is a $n \times \mathrm{T}$ matrix with -1, 0, 1 similar to the above T_{it}.

2.5.2 The WRS Method

The error term in equation (2.7) is unlikely to be homoskedastic because the variance of the house prices around the mean is likely to increase depending on the length of time between sales. Therefore ordinary least square (OLS) used by the BMN method is not efficient in estimating C_t. Two main methods are proposed to deal with the above problem.

Case and Shiller (1987; 1989) introduced a Gaussian random walk component for the error term $u_{itt'}$, such that

$$u_{itt'} = H_{it'} - H_{it} + N_{it'} - N_{it} \tag{2.9}$$

where the H_{it} is a Gaussian random walk representing idiosyncratic variation in individual house prices and N_{it} is a white noise which describes the random disturbance term. The assumptions for equation (2.9) are given as follows:

$$E(H_{it'} - H_{it}) = 0 \tag{2.10}$$

$$E\left((H_{it'} - H_{it})^2\right) = \alpha + \varphi(t' - t) + \omega \tag{2.11}$$

The fitted values which are calculated from the equation (2.11), are then taken by the square root to use as weights (w_i) in a generalised least squares (GLS) regression. The weighted regression model can be expressed as follows:

$$r_{itt'}/w_i = C_1 T_{i1}/w_i + \ldots + C_t T_{it}/w_i + \mu_{itt'}/w_i \tag{2.12}$$

Abraham and Schauman (1991) modified the equation (2.11) since they questioned that the variance cannot grow over time without limitations. They proposed:

$$E\left((H_{it'} - H_{it})^2\right) = A(t' - t) + B(t' - t)^2 + C \tag{2.13}$$

The fitted values from equation (2.13) are then taken in square root to use as weights in a GLS regression similar to equation (2.12).

2.5.3 The SPAR Method

In New Zealand between 1961 and 1982, a value-weighted SPAR method had been used for house price index calculation. From 1982 until the September quarter 2004, the index method shifted to an equally weighted SPAR method. Currently the index employs a mixed formula by combining the value-weighted SPAR method and the average value of the housing stock for each local authority. In this study, the SPAR index was produced by the equally weighted SPAR method, calculated by applying equation (2.2) and is further illustrated in Table 2.1.

Table 2.1 Example of Calculation for the Equally Weighted SPAR Index

Property	1	2	3	4	5	Average
Current period sales:						
Sale Price	120,000	125,000	85,000	80,000	110,000	
Government Valuation	90,000	118,000	85,000	85,000	125,000	
Price/Value Ratio	1.333	1.059	1.000	0.941	0.880	1.043
Previous period sales:						
Sale Price	110,000	120,000	75,000	95,000		
Government Valuation	130,000	125,000	65,000	90,000		
Price/Value Ratio	0.846	0.960	1.154	1.056		1.004

	Index numbers	Index ratios
Previous	2385	1.004
Current	2477	1.043

Notes:

1. The previous price index was assumed at 2385.
2. Example was taken from Quotable Value (2004).

In Table 2.1, there were five houses sold in the current period and four in the previous period. For all properties, an assessed value (Government Valuation or Capital Value in New Zealand) was available as of the base time period. For the equally weighted SPAR index, the price/value ratios are calculated for each property and then averaged. For the current period, the average price/value ratio is 1.043. For the previous period, the average price/value ratio is 1.004. Then the current ratio is divided by the previous ratio and multiplied by the index number for the previous period. Assuming the previous index number is 2,385, the current period index number is 2,477.

2.5.4 Statistical Tools

To test the temporal aggregation effect on the SPAR index's stability per reporting period, the study employed a bootstrap approach for simulating the variation of SPAR ratios under various sample sizes. The statistical tool for evaluating the simulation results is the relative standard error (RSE), which is shown in the following equation:

$$RSE = \frac{SE}{\overline{X}} \qquad (2.14)$$

where SE stands for the standard error estimated by the standard deviation of the simulated means of the SPAR ratios, $\overline{X}$ is the mean of the means of the SPAR ratios in the bootstrap simulation.

For measuring the overall index's lumpiness, the index rate of change per period was first calculated, and then the overall index's lumpiness estimated by the coefficient of variation (COV) in the following equation:

$$COV = \frac{\sigma}{\mu} \qquad (2.15)$$

where σ is the standard deviation of the index rate of changes over the 11-year time period and μ is the mean of the index rate of change over the same time period.

It is noted that equation (2.14) and equation (2.15) are similar, but they differ in that the RSE is a measure of the variability among the estimates from these possible samples, which is what the bootstrap simulation test is designed to quantify. By contrast the COV is a relative measure of the variation relating the standard deviation to the single mean. Therefore the RSE indicates the uncertainty around the estimate of the mean measurement and the COV shows how widely scattered the measurement is.

For estimating the precision of the SPAR index, both the confidence interval (CI) and the statistics suggested by Case and Shiller (1987) have been used. In Case and Shiller (1987), the index precision was evaluated using the ratio of the standard deviation of the log price index to the average standard error of the estimates. In order to do this the standard error (SE) of the SPAR index for each period (*t*) had to be computed first. As discussed for equation (2.3), this can be done by calculating the SE for period *t*'s SPAR ratio. The equation is as follows:

$$SE = \frac{\sigma}{\sqrt{n}} \tag{2.16}$$

where σ is the standard deviation of the SPAR ratio at the period *t*, *n* is the sample size at period *t*.

For a large sample a 95% CI around its mean expressed as a percentage can be calculated as follows:

$$\left(1 \pm 2 \bullet rse(\overline{X})\right) \times 100 \tag{2.17}$$

where *rse* is the relative standard error.

As stated in the Section 2.3, the inconsistency bias is the difference of the two systematic errors between reassessments. Its impact on the SPAR index with respect to the base period is accumulated and can be expressed in the following equation when assuming d_i is small. (See Appendix A3 for proof).

$$(1+d_1)(1+d_2)...(1+d_n) \approx (1+\bar{d})^n \tag{2.18}$$

where d_i is the inconsistency bias between reassessments i, n is the total number of reassessments over the whole indexing period, and $\bar{d}$ is the mean of the inconsistency bias d_i over the whole indexing period.

The accumulated effect due to the inconsistency bias within the SPAR index could be exaggerated as the number of reassessments carried out over the whole indexing period increases, if d_i is not random. Further the number of reassessments is inversely proportional to that of the frequency of reassessment. For example, if the frequency of reassessment is 3 yearly, the inconsistency bias (d_i), should there be any, will be compounded by a factor of 3 over a 10-year indexing period. By contrast, if the frequency of reassessment is annual, it will be compounded by a factor of 10 over the same time period.

One way to solve equation (2.18) is to estimate $\bar{d}$ to approximate the total accumulated impact. The inconsistency bias d_i can be measured by the index rate of change (growth rate) by using both the current and previous assessed values. The analysis examines what difference it makes if more recent assessments are substituted for the original assessments. The formula is presented as follows:

$$\bar{d} = \frac{\sum_{i=1}^{n} \left(\Delta I\%_{i,p} - \Delta I\%_{i,c} \right)}{n} \qquad (2.19)$$

where i is the index period, n is the total number of index periods over an eleven year time period, $\Delta I\%_{i,p}$ is the index rate of change as measured by using the previous assessments and $\Delta I\%_{i,c}$ is the index rate of change as measured by using the current assessments.

If the estimated $\bar{d}$ is statistically different from zero, this implies there is inconsistency bias between reassessments. For $\bar{d}$ >0, the SPAR index is upwardly biased overall, and vice versa.

Finally, the study relies on the repeat sales method and various statistics applied by Case and Shiller (1987) to ascertain the benchmark index for comparisons. Correlation tests are applied among various indices. Data analysis is by using EViews5 throughout the whole thesis.

2.6 EMPIRICAL RESULTS

2.6.1 Simulation of Index's Stability per Reporting Period

As illustrated by equation (2.3), the lagged sales affect their SPAR ratios only in the period where the sales occur, rather than other periods' estimates. A bootstrap approach for simulating the effect of lagged sales on SPAR ratios was set up as follows. The percentages of late sales were assumed at 50%, 40%, 30%, 20% and

10% of all sales per period. In other words, the simulation sample size was assumed at 50%, 60%, 70%, 80% and 90% of all sales per period. The result helped to determine the percentage of total sales to be collected before index reporting in order to bring the late sales impact on index revision under a certain level. The simulation procedure was designed as follows:

1. Identify all sales for each indexing period.
2. The simulation sample size is predetermined at 50%, 60%, 70%, 80% and 90% of all sales per period.
3. For each simulation sample size, randomly select sale observations from all sales without replacement.
4. The SPAR ratio per indexing period for the predetermined sample size is calculated accordingly.
5. Steps 3 and 4 are repeated 500 times.
6. Record the calculated mean of these 500 simulated SPAR ratios and its standard deviation of the mean. Estimate its RSE by equation (2.14)
7. Perform steps 1 to 6 for the next time period.
8. Perform steps 2 to 7 for the next simulated sample size

Table 2.2 reports the averaged RSEs for the simulation test. For quarterly SPAR indices, the average RSEs are much more stable over different sample sizes. If for large cities an RSE of 0.005 at any index level was chosen as a criterion for evaluating the stability of that index, 50% of the total sales for each period will be required for index reporting. For medium cities the requirement was at least 60% to 70% of total sales for each period and for small cities at least 70%. If the same criterion was applied to evaluate the monthly SPAR index, the sample size would need to be increased to 70% for large cities, 80% for medium cities and 90% for small cities. Of course the above percentages are subject to the minimum number of sales per period required for index reporting purposes, which is then related to the predetermined index's precision level. In New Zealand for the quarterly published QVHPI index, the minimum number of sales for index reporting purposes was predetermined at 50 sales per quarter.

The simulation results implied that there is room to improve the timeliness of index reporting in large cities but not for medium and small cities. Since the size of the sample of transactions cannot be increased, improving the precision of a monthly SPAR index requires a higher percentage of sales data per period to be collected earlier. Obviously, there is no advantage reporting a monthly index with a 3-month lag time. In New Zealand the lag time for the quarterly published QVHPI index is about 3 months, and in this situation approximately 80-90% of sales for the quarter in large cities and 60-80% of sales for the quarter in medium cities will be collected. However, this is likely to improve as the mechanism for sales reporting is moving from paper-based to electronic.

Table 2.2 Results of Bootstrap Simulation on the Stability of SPAR Index

	Sample Sizes					No. of sales per period		
	50%	60%	70%	80%	90%	Max	Min	Mean
Large Cities:								
North Shore City								
Months	0.0073	0.0060	0.0048	0.0037	0.0024	650	181	378
Quarters	0.0043	0.0034	0.0028	0.0021	0.0014	1,724	689	1,134
Waitakere City								
Months	0.0078	0.0064	0.0051	0.0039	0.0026	646	193	358
Quarters	0.0045	0.0037	0.0029	0.0023	0.0015	1,798	658	1,073
Auckland City								
Months	0.0073	0.0059	0.0048	0.0036	0.0024	1,075	195	607
Quarters	0.0042	0.0034	0.0027	0.0021	0.0014	2,763	920	1,821
Manukau City								
Months	0.0072	0.0059	0.0047	0.0036	0.0024	783	218	409
Quarters	0.0042	0.0034	0.0027	0.0021	0.0014	2,170	778	1,228
Wellington City								
Months	0.0068	0.0055	0.0044	0.0034	0.0022	414	181	267
Quarters	0.0039	0.0032	0.0026	0.0020	0.0013	1,082	598	802
Christchurch City								
Months	0.0050	0.0041	0.0033	0.0025	0.0017	1,192	398	698
Quarters	0.0029	0.0024	0.0019	0.0015	0.0010	3,143	1,316	2,095
Medium Cities:								
Hutt City								
Months	0.0097	0.0080	0.0064	0.0048	0.0032	264	76	264
Quarters	0.0057	0.0047	0.0037	0.0028	0.0019	643	348	490
Palmerston North City								
Months	0.0084	0.0070	0.0055	0.0042	0.0027	188	59	128
Quarters	0.0049	0.0040	0.0032	0.0025	0.0017	515	252	385
Nelson City								
Months	0.0107	0.0088	0.0070	0.0054	0.0034	160	57	98
Quarters	0.0064	0.0052	0.0042	0.0032	0.0021	446	193	295
Small Cities:								
Porirua City								
Months	0.0156	0.0128	0.0102	0.0077	0.0049	104	40	69
Quarters	0.0093	0.0076	0.0061	0.0046	0.0031	276	144	207
Upper Hutt City								
Months	0.0124	0.0102	0.0082	0.0061	0.0038	94	32	62
Quarters	0.0076	0.0061	0.0049	0.0037	0.0025	254	106	186
Papakura District								
Months	0.0173	0.0142	0.0113	0.0085	0.0054	114	19	57
Quarters	0.0103	0.0085	0.0067	0.0052	0.0034	285	90	170

Notes:

1. The percentages of late sales are predetermined at 50%, 40%, 30%, 20% and 10% of all sales per period. The presented results are the average relative standard errors (RSE) of the SPAR ratios over the 11-year time period.
2. 500 simulations may be excessive for some small cities where the average number of monthly sales is below 80. For medium cities, the number of times monthly sales are below 80 are very few, being once for Palmerston North City and three times for Nelson City over the entire 11-year time period.
3. The need for a minimum of 80 sales for 500 simulations is proved as follows: when the simulated sample size at 90% of the total period sales, $C_{80}^{72} = C_{80}^{8} = 612 \rangle 500$.

One argument is that since house sales data are not randomly entered into the reporting system (i.e. the later sales will be normally be notified later), this will cause problems when the sale samples are randomly drawn from the each period's total sales. Furthermore, the direction and size of this kind of bias is difficult to predict. It is arguable there may not be a clear pattern to indicate why some sales are reported later than others, although it appeared delayed settlement and human error were the main causes for this. The assumption regarding random samples in the simulation test appeared to be supportable because the sample size of such delayed sales was often small given the lag time allowed for index reporting purposes. Unfortunately late sales were not able to be identified in the data set supplied.

2.6.2 Overall Index Volatility (Lumpiness)

Unlike the stock market where share prices exhibit volatility on a daily basis, the housing market is thought to be more stable. For example, it seems unrealistic that today's housing prices are much different from yesterday's prices. Therefore the overall index's volatility due to temporal aggregation is another important consideration, particularly when dealing with a small sample size. In this section the SPAR index's overall volatility was measured by the coefficient of variation (COV) of index rate of change by using equation (2.15). A higher COV indicates the index itself is more volatile. The results are summarised in Table 2.3.

Table 2.3 Overall Volatility of SPAR Index Rate of Change

	Coefficient of variations (COVs)		
Cities	Quarters	Months	No. of sales
Large Cities:			
North Shore City	1.417	2.214	51,887
Waitakere City	1.846	2.722	49,915
Auckland City	1.295	1.902	83,268
Manukau City	1.272	2.387	56,434
Wellington City	0.954	1.894	36,362
Christchurch City	1.458	2.443	93,766
	1.374	*2.261*	
Medium Cities:			
Hutt City	1.080	3.128	21,838
Palmerston North City	1.733	4.162	17,143
Nelson City	2.319	3.844	13,141
	1.711	*3.711*	
Small Cities:			
Papakura District	1.561	5.137	7,977
Porirua City	1.158	4.286	9,187
Upper Hutt City	1.274	3.871	8,303
	1.331	*4.432*	
Overall Values	1.447	3.166	449,221

Notes:

1. The coefficient of variation is calculated by the following equation:

$$COV = \frac{\sigma}{\mu}$$

where μ is the mean of index rate of change over the 11-year time period and σ is the associated standard deviation.

2. The figures in italics are the average COVs for the respective large, medium and small cities.
3. The index rate of change ΔI% is measured by $(I_{t+1} - I_t)/I_t$, where It is the SPAR index in level at time

On average, the monthly SPAR indices reflected a less-smooth price movement volatility, indicated by an average COV of 2.3 for large cities, 3.7 for medium cities and 4.4 for small cities. This compared to the equivalent quarterly COV of 1.4, 1.7 and 1.3. Although there is no criterion for determining whether a COV was too large, it appeared that the overall volatility of the monthly SPAR index was acceptable, particularly for large cities (See Figure 2.1 and Table 2.7 for index comparison).

2.6.3 Measurement Errors in Assessed Values

Random measurement errors in assessed values are measured by the overall precision of the SPAR index. In this process the SE for each period's SPAR ratio was first calculated by using equation (2.16) and then applying equation (2.14) for calculating its RSE. The overall precision of the index is thereafter measured by the average RSE over the whole indexing period. Finally, a 95% CI around the average RSE expressed as a percentage was estimated by using equation (2.17). Applying the ratio as suggested by Case and Shiller (1987) first transforms the estimates of the SPAR index and its estimated SE in log form and then calculates the ratio of the standard deviation of the log price to the average standard error of the estimates. The results are presented in Table 2.4.

It was found that, provided the sample size is sufficiently large, the overall precision of a monthly index as indicated by a 95% CI in percentage terms could be between 1.0% to 1.6% for large cities, 1.7% to 2.2% for medium cities and between 2.6% to 3.6% for small cities. This implies that if a reported monthly index is 2000 and its associated 95% CI in percentage terms is 1.5%, the estimated 95% CI around the reported index of 2000 is ±30. The SPAR index is more accurately measured as indicated by the ratio of Case and Shiller (1987) when compared to the repeat sales indices (see Table 2.7 for index comparison).

Among all the large cities, the Wellington City SPAR indices (both quarterly and monthly indices) are the most accurate. This is not surprising as Wellington City Council reassesses all properties annually in contrast to the majority of other large cities where property values are reassessed on a 3 yearly basis.

Table 2.4 Overall Precision of SPAR Index, 1994 - 2004

	Months			Quarters		
Cities	RSE	95% CI (in percentage)	Ratio of SDV to SE	RSE	95% CI (in percentage)	Ratio of SDV to SE
Large Cities:						
North Shore City						
mean	0.0074	1.47%	24.605	0.0043	0.86%	41.923
Std.	0.0015			0.0008		
Waitakere City						
mean	0.0079	1.58%	23.603	0.0046	0.93%	38.220
Std.	0.0018			0.0009		
Auckland City						
mean	0.0070	1.40%	33.209	0.0042	0.83%	56.296
Std.	0.0013			0.0007		
Manukau City						
mean	0.0073	1.47%	23.610	0.0043	0.86%	40.218
Std.	0.0014			0.0007		
Wellington City						
mean	0.0070	1.39%	35.236	0.0042	0.83%	57.248
Std.	0.0012			0.0005		
Christchurch City						
mean	0.0051	1.01%	29.395	0.0030	0.60%	50.336
Std.	0.0008			0.0005		
Medium Cities:						
Hutt City						
mean	0.0099	1.99%	21.418	0.0058	1.16%	36.269
Std.	0.0018			0.0010		
Palmerston North City						
mean	0.0086	1.73%	12.564	0.0051	1.02%	22.902
Std.	0.0019			0.0008		
Nelson City						
mean	0.0111	2.21%	19.626	0.0065	1.29%	33.926
Std.	0.0025			0.0013		
Small Cities:						
Papakura District						
mean	0.0183	3.67%	8.769	0.0107	2.15%	15.212
Std.	0.0061			0.0022		
Porirua City						
mean	0.0163	3.27%	13.589	0.0095	1.90%	22.251
Std.	0.0032			0.0013		
Upper Hutt City						
mean	0.0130	2.60%	14.113	0.0077	1.55%	23.912
Std.	0.0033			0.0017		

Notes:

1. The RSE stands for the relative standard error, which is calculated by the following equation:

$$RSE = \frac{SE}{\overline{X}}$$

where SE is the standard error of the SPAR index and $\overline{X}$ is the index itself. The figures presented in the table are the average RSE over the 11-year period.

2. The ratio of SDV to SE is the standard deviation of the log index in level to the average standard error of the log price estimates (see Case and Shiller (1987) for details).

2.6.4 Frequency of Reassessments

In this analysis, the sample of transactions was limited to properties for which no improvements were recorded between the assessment date and the transaction date. The results for the estimated $\bar{d}$ for all cities with different reassessment frequencies are presented in Table 2.5.

In this data set the average inconsistency bias $\bar{d}$ between reassessments was quite small and statistically insignificant for all cities over time except for Wellington City. As such its overall impact on the SPAR index over time was minimal. The index rate of change as measured by both sets of assessed values was well correlated. For large cities at the monthly level the correlations are between 0.85 and 0.90, and more than 0.95 at the quarterly level. The exception is Auckland City where no building permit data was available. For medium cities the correlations were mostly between 0.80 and 0.85 at the monthly level and between 0.85 and 0.95 at the quarterly level.

The result for Wellington City is interesting. Wellington reported a large and statistically significant inconsistency bias ($\bar{d}$) in both the monthly and quarterly SPAR indices. Revaluations were on an annual basis and normally by the same valuation organisation. Due to resource constraints and a short time frame for completing reassessments, the inconsistency bias d_i between annual reassessments would not be expected to be random. This suggests annual revaluations improved the index accuracy per period as discussed before, but the inconsistency bias on the index accuracy as a whole cannot be ignored. Equation (2.18) approximates the total effect of this inconsistency bias on the SPAR indices for Wellington City. The results show that a total upward bias of 4.61% could exist for a quarterly reported SPAR index and of 1.47% for a monthly reported index over the whole indexing period between 1994 and 2004[9]. The result provides motivation for future research to check the vertical assessment inequity over time for Wellington. It is noted that after 2009 Wellington City will re-introduce three-yearly revaluations.

Table 2.5 The Estimated Average Inconsistency Bias of SPAR Index, 1994 - 2004

Cities		$\bar{d}$	Std.Dev	t-Test	Correlation	Freq of Av (yearly)
Large Cities:						
North Shore City						3
	Months	0.0001	0.0073	0.1185	0.8973	
	Quarters	-0.0001	0.0044	-0.1966	0.9887	
Waitakere City						3
	Months	-0.0001	0.0107	-0.1318	0.8539	
	Quarters	-0.0018	0.0135	-0.8012	0.9381	
Auckland City						2 and 3
	Months	0.0000	0.0515	0.2234	0.3937	
	Quarters	-0.0021	0.0362	-0.3512	0.6215	
Manukau City						3
	Months	0.0002	0.0088	0.1953	0.8592	
	Quarters	-0.0006	0.0052	-0.7233	0.9773	
Christchurch City						3
	Months	0.0000	0.0199	0.0088	0.8701	
	Quarters	0.0020	0.0102	1.1615	0.9286	
Wellington City						1
	Months	0.0015	0.0089	1.7226	0.8315	
	Quarters	0.0045	0.0071	3.0513	0.9379	
Medium Cities:						
Hutt City						1 and 3
	Months	-0.0003	0.0120	-0.3197	0.7752	
	Quarters	0.0010	0.0075	0.7482	0.9019	
Palmerston North City						3
	Months	0.0006	0.0118	0.5236	0.7966	
	Quarters	0.0011	0.0091	0.7172	0.8815	
Nelson City						3
	Months	0.0001	0.0106	0.0857	0.8787	
	Quarters	0.0012	0.0111	0.6275	0.9499	
Small Cities:						
Papakura District						3
	Months	0.0012	0.0448	0.2860	0.6033	
	Quarters	0.0014	0.0760	0.1115	0.4792	
Porirua City						3
	Months	-0.0005	0.0153	-0.3649	0.8901	
	Quarters	-0.0005	0.0107	-0.2550	0.9325	
Upper Hutt City						3

[9] The estimated impacts of inconsistency bias on the SPAR index for the selected local markets are available in Appendix A4.

Months	0.0001	0.0131	0.1088	0.8681
Quarters	0.0021	0.0091	1.3685	0.8930

Notes:

1. Building permit data is unavailable for Auckland City in this study.
2. $\bar{d}$ is calculated by the following equation:

$$\bar{d} = \frac{\sum_{i=1}^{n}\left(\Delta I\%_{i,p} - \Delta I\%_{i,c}\right)}{n}$$

where $\Delta I\%_{i,p}$ and $\Delta I\%_{i,c}$ are the index rate of change as measured by the previous and current assessments, respectively.

3. The null hypothesis for the t-Test is $\bar{d}$ is zero.
4. The correlation test is between the $\Delta I\%_{i,p}$ and $\Delta I\%_{i,c}$.
5. The last column of table is the frequency of reassessment.

2.6.5 Model Comparison

This study followed the argument of Gatzlaff and Ling (1994) by using the repeat sales method as the benchmark house price index for index comparisons at a monthly level. Table 2.6 illustrates the distribution of house sales and number of dwellings. On average almost two thirds (65%) of all sales or 43% of all dwellings sold during the sample period were repeat sales (sold at least twice). Therefore the repeat sales sample size in this study were considered rich and sample selection bias in the repeat sales method was minimised. Moreover, the building information supplied helped to identify the quality changed repeat sales and thereby minimised the constant quality problem faced by the standard repeat sales method.

Table 2.6 Number of Dwellings and Sales, 1994 - 2004

Number of Sales	Large Cities						Provincial & Small Cities						Total	
	North Shore City	Waitakere City	Auckland City	Manukau City	Wellington City	Christchurch City	Hutt City	Palmerston North City	Nelson City	Papakura District	Porirua City	Upper Hutt City		
	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Dwellings	Sales
1	16,966	15,649	33,332	19,730	13,003	31,413	8,352	5,782	4,374	2,627	3,200	3,093	157,521	157,521
2	9,402	9,254	14,298	10,333	6,605	16,939	4,136	3,276	2,389	1,463	1,684	1,564	81,343	162,686
3	3,691	3,511	4,829	3,574	2,411	6,489	1,250	1,141	918	543	612	514	29,483	88,449
4	951	984	1,248	953	602	1,712	303	274	241	159	157	99	7,683	30,732
5	185	207	275	208	84	349	42	49	42	27	26	25	1,519	7,595
6	36	32	68	58	13	50	7	5	9	4	3	2	287	1,722
7	5	4	10	10	0	6	0	1	1	0	1	1	39	273
8	1	1	1	1	0	3	0	1	0	0	0	0	8	64
9	1	1	0	1	0	3	0	0	0	0	0	0	6	54
>=10	3	1	0	1	1	2	0	0	0	0	0	0	8	125
Total	31,241	29,644	54,061	34,869	22,719	56,966	14,090	10,529	7,974	4,823	5,683	5,298	277,897	449,221
Percentage*	45.69%	47.21%	38.34%	43.42%	42.77%	44.86%	40.72%	45.09%	45.15%	45.53%	43.69%	41.62%	43.32%	64.93%

Notes: The percentages* are indicating for multiple sales.

Next it tested various repeat sales models in order to determine the benchmark index for this New Zealand data set. For convenience the weighted repeat sales index was specified as the WRS index and a quality controlled WRS index was denoted as WRSQ. Similar specifications were applied for the BMN and BMNQ indices. The methodology of Case and Shiller (1987) was followed and testing results were presented in Table 2.7. As measured by the WRS method, the ratio of the standard deviation of the log price index to the average standard error of the log price estimates was somewhere between 15 to 18 for large cities, 7 and 11 for medium cities, and 4 to 6 for small cities. The results for large cities were in line with the findings of Case and Shiller (1987). It was also found that there is no obvious difference in index accuracy between the BMN method and WRS method.

Table 2.7 Accuracy of Monthly Repeat Sales Log Price Indices, 1994 - 2004

	Models			
Cities	WRS	WRSQ	BMN	BMNQ
Large Cities:				
North Shore City				
Ratio of SDV to SE	16.125	16.180	16.116	16.159
Adjusted R^2	0.535	0.553	0.564	0.581
S.E.E.	1.004	1.004	0.133	0.126
No. of Observations	20,124	18,652	20,124	18,652
Waitakere City				
Ratio of SDV to SE	14.184	14.036	14.203	14.048
Adjusted R^2	0.533	0.554	0.544	0.560
S.E.E.	1.003	1.004	0.142	0.137
No. of Observations	19,470	17712	19470	17712
Auckland City				
Ratio of SDV to SE	18.610		18.451	
Adjusted R^2	0.371		0.416	
S.E.E.	1.002		0.173	
No. of Observations	27,628		27,628	
Manukau City				
Ratio of SDV to SE	11.273	10.922	11.294	10.927
Adjusted R^2	0.313	0.331	0.322	0.334
S.E.E.	1.003	1.004	0.156	0.152
No. of Observations	20,416	17,992	20,416	17,992
Wellington City				

Ratio of SDV to SE	15.059	14.696	15.135	14.741
Adjusted R^2	0.387	0.402	0.473	0.497
S.E.E.	1.006	1.007	0.144	0.133
No. of Observations	13,332	11,183	13,332	11,183
Christchurch City				
Ratio of SDV to SE	18.420	18.598	18.414	18.615
Adjusted R^2	0.464	0.496	0.486	0.509
S.E.E.	1.002	1.002	0.137	0.129
No. of Observations	35,154	32,186	35,154	32,186
Medium Cities:				
Hutt City				
Ratio of SDV to SE	8.494	8.274	8.569	8.336
Adjusted R^2	0.310	0.313	0.353	0.354
S.E.E.	1.009	1.010	0.154	0.143
No. of Observations	7,541	6,594	7,541	6,594
Palmerston North City				
Ratio of SDV to SE	7.459	7.247	7.415	7.186
Adjusted R^2	0.427	0.432	0.458	0.460
S.E.E.	1.010	1.012	0.122	0.111
No. of Observations	6,526	5,748	6,526	5,748
Nelson City				
Ratio of SDV to SE	11.109	11.033	11.173	11.097
Adjusted R^2	0.713	0.726	0.729	0.742
S.E.E.	1.014	1.016	0.124	0.114
No. of Observations	5,068	4,295	5,068	4,295
Small Cities:				
Papakura District				
Ratio of SDV to SE	4.652	4.683	4.643	4.660
Adjusted R^2	0.527	0.562	0.511	0.536
S.E.E.	1.023	1.026	0.133	0.127
No. of Observations	2,973	2,623	2,973	2,623
Porirua City				
Ratio of SDV to SE	6.011	5.646	6.128	5.688
Adjusted R^2	0.341	0.328	0.449	0.447
S.E.E.	1.021	1.023	0.141	0.136
No. of Observations	3,437	3,084	3,437	3,084
Upper Hutt City				
Ratio of SDV to SE	5.727	5.658	5.925	5.795
Adjusted R^2	0.429	0.463	0.499	0.524
S.E.E.	1.023	1.028	0.128	0.115
No. of Observations	2,964	2,509	2,964	2,509

Notes:

1. The statistical calculations follow those of Case and Shiller (1987).
2. Building permit data is unavailable for Auckland City.

The study further calculated the standard deviation of price noise in the WRS method applied by Case and Shiller (1987), where noise was estimated in the second stage of the WRS regression by dividing the constant term by 2 and taking the square root. These results are presented in Table 2.8. On average the standard deviation of price noise was between 8% and 10%. It is possible that this price noise could be due to quality changes between sales, both notified and non-notified, rather than what would normally be considered 'noise'. After controlling for the notified quality changes, the WRSQ index reduced such price noise to less than 1% in this study. Therefore, the author is confident about using the WRSQ model as a benchmark for index comparisons.

Table 2.8 Standard Deviation of Price Noise for Monthly Repeat Sales Indices

	Models	
Cities	WRS	WRSQ
Large Cities:		
North Shore City	8.44%	8.01%
Waitakere City	9.70%	9.45%
Auckland City	11.08%	
Manukau City	10.86%	10.66%
Wellington City	8.93%	8.12%
Christchurch City	9.06%	8.74%
Medium Cities:		
Hutt City	10.21%	9.53%
Palmerston North City	7.31%	6.74%
Nelson City	7.83%	7.18%
Small Cities:		
Papakura District	9.50%	9.17%
Porirua City	8.23%	7.77%
Upper Hutt City	7.88%	7.20%

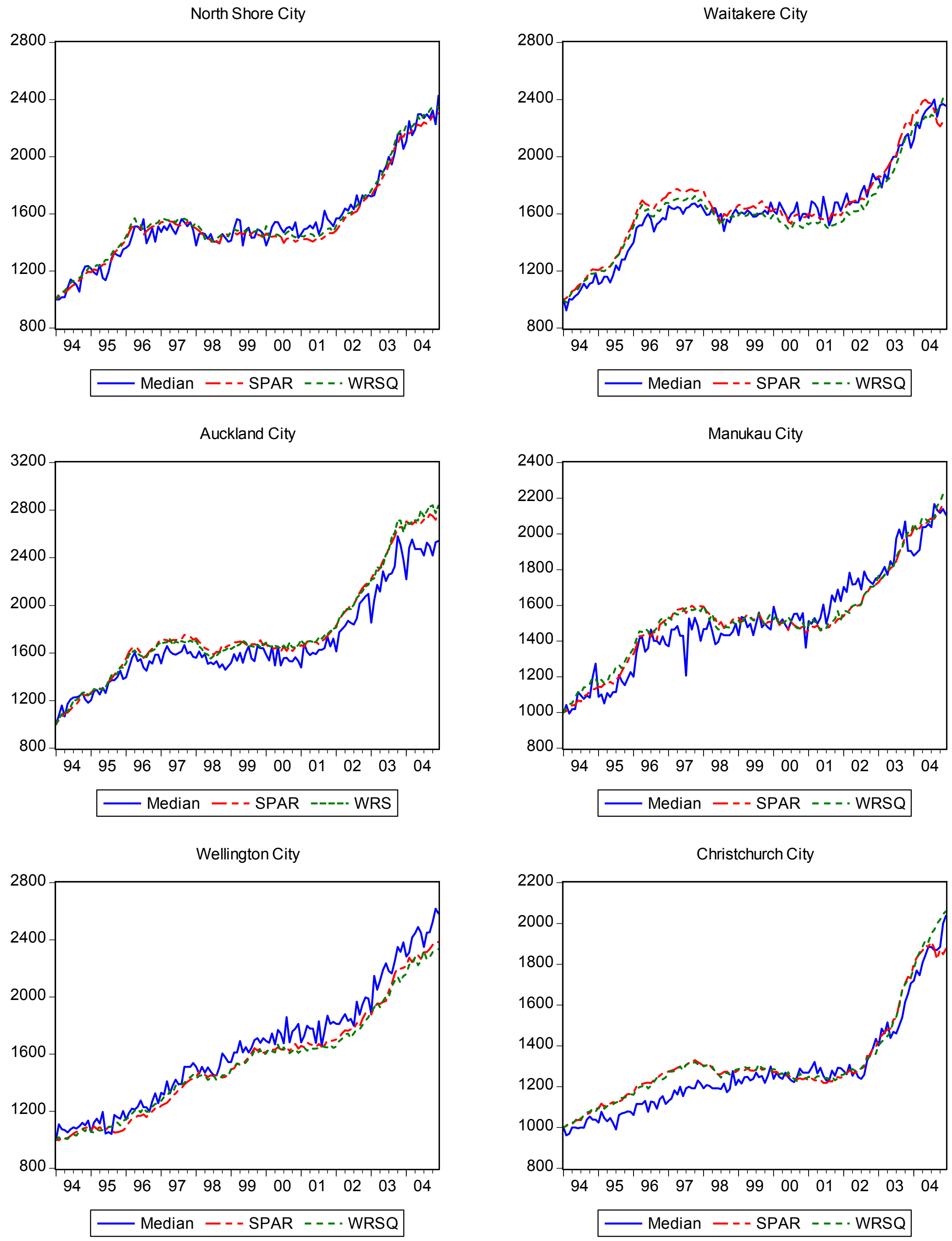
Notes:

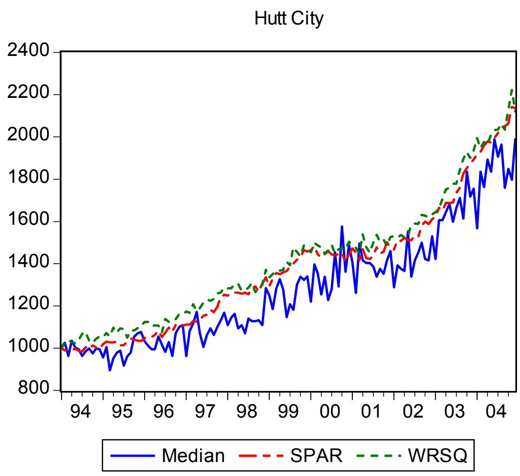
1. The statistical calculations follow those of Case and Shiller (1987).
2. Building permit data is unavailable for Auckland City, therefore the WRSQ index for Auckland cannot be calculated.

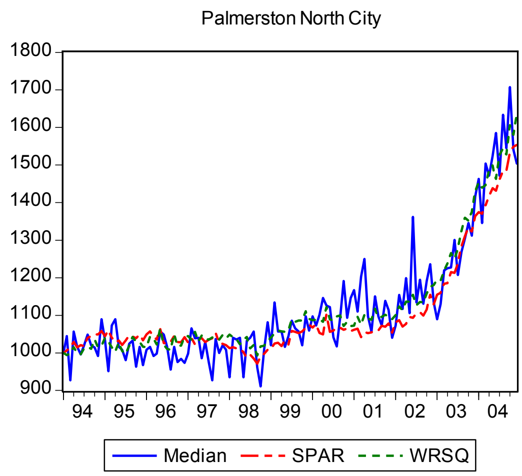
Finally, monthly house price movements, as measured by the three different indices, are graphed in Figure 2.1. The median price was included in this study since it is reported in a timely manner and widely quoted in the media for measuring house price movements in New Zealand. The monthly SPAR and WRSQ indices showed similar index volatility and were closely related to each other, except for Upper Hutt City. Conversely, the monthly reported median price index appeared to be much more volatile than its equivalent SPAR and weighted repeat sales indices. The estimated index rate of change and correlations between the indices are reported in Table 2.9. Overall, the correlations of the SPAR and WRSQ indices were high at a quarterly level but appeared low at a monthly level. Correlations of the monthly repeat sales index were compared with the quarterly index. It was found that the correlations between them were very high at a quarterly level but generally low at a monthly level[10]. Both the repeat sales and SPAR indices may suffer from the problem of small sample sizes at the monthly level, particularly for medium and small cities. More results of regression analysis for the estimated indices are presented in Appendix A5. Again, the findings suggested future research should include the AV method for index comparisons.

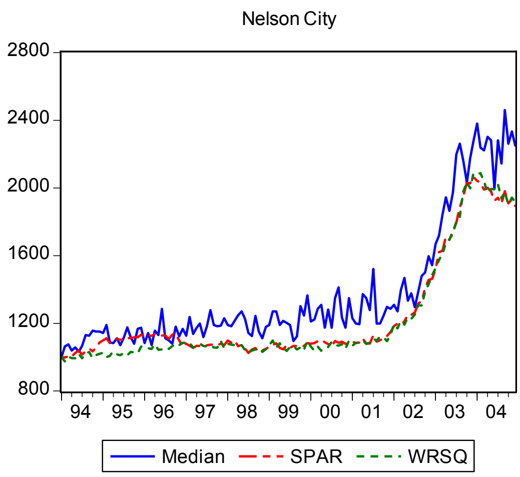
[10] The statistical results are available in Appendix A6.

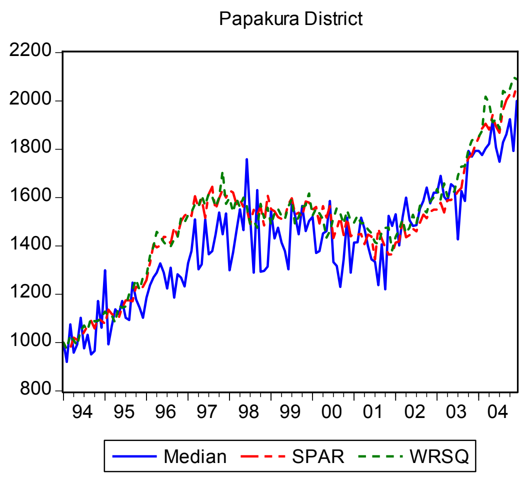
Figure 2.1 Monthly House Price Indices, 1994 - 2004

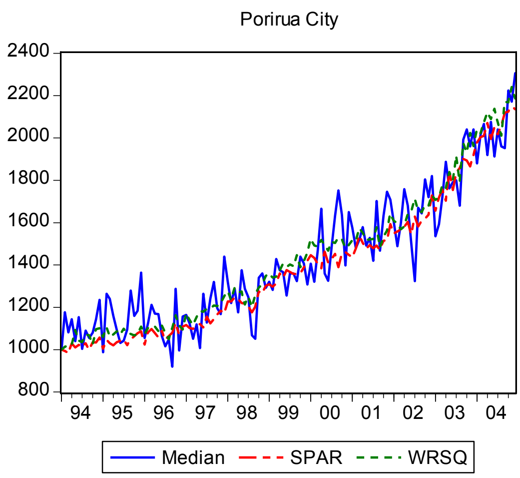



Hutt City
2400
2200
2000
1800
1600
1400
1200
1000
800
94 95 96 97 98 99 00 01 02 03 04
Median
SPAR
WRSQ


Palmerston North City
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
94 95 96 97 98 99 00 01 02 03 04
Median
SPAR
WRSQ


Nelson City
2800
2400
2000
1600
1200
800
94 95 96 97 98 99 00 01 02 03 04
Median
SPAR
WRSQ


Papakura District
2200
2000
1800
1600
1400
1200
1000
800
94 95 96 97 98 99 00 01 02 03 04
Median
SPAR
WRSQ


Porirua City
2400
2200
2000
1800
1600
1400
1200
1000
800
94 95 96 97 98 99 00 01 02 03 04
Median
SPAR
WRSQ

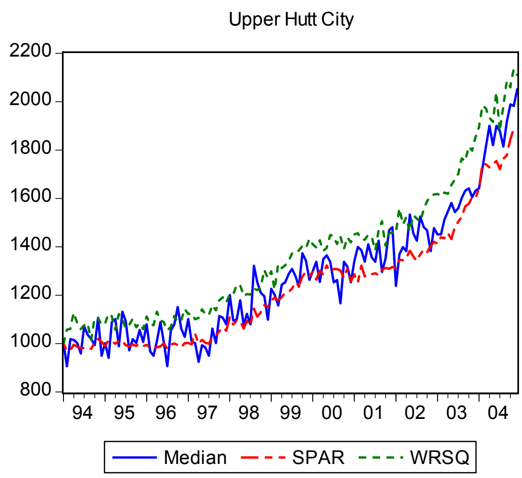

Upper Hutt City
2200
2000
1800
1600
1400
1200
1000
800
94 95 96 97 98 99 00 01 02 03 04
Median
SPAR
WRSQ

Table 2.9 Index Rate of Change, 1994 - 2004

		Monthly Index			Quarterly Index	
Cities	Mean	Std. Dev.	Correlation	Mean	Std. Dev.	Correlation
Large Cities:						
North Shore City						
Median	0.0076	0.0393	0.096	0.020	0.037	0.632
SPAR	0.0065	0.0144	0.593	0.020	0.028	0.905
WRSQ	0.0066	0.0161	1.000	0.020	0.028	1.000
Waitakere City						
Median	0.0072	0.0348	0.295	0.021	0.035	0.821
SPAR	0.0063	0.0173	0.674	0.019	0.035	0.914
WRSQ	0.0067	0.0169	1.000	0.021	0.033	1.000
Auckland City						
Median	0.0082	0.0458	0.180	0.021	0.037	0.676
SPAR	0.0073	0.0198	0.418	0.024	0.031	0.937
WRS*	0.0081	0.0172	1.000	0.024	0.030	1.000
Manukau City						
Median	0.0069	0.0504	0.192	0.018	0.037	0.483
SPAR	0.0060	0.0144	0.495	0.018	0.023	0.880
WRSQ	0.0064	0.0184	1.000	0.018	0.024	1.000
Wellington City						
Median	0.0082	0.0435	0.072	0.022	0.028	0.303
SPAR	0.0067	0.0128	0.353	0.021	0.020	0.759
WRSQ	0.0066	0.0157	1.000	0.020	0.017	1.000
Christchurch City						
Median	0.0058	0.0263	0.203	0.017	0.025	0.625
SPAR	0.0049	0.0119	0.594	0.016	0.023	0.874
WRSQ	0.0056	0.0122	1.000	0.017	0.023	1.000
Medium Cities:						
Hutt City						
Median	0.0076	0.0691	-0.091	0.016	0.044	0.095
SPAR	0.0052	0.0164	0.298	0.018	0.015	0.596
WRSQ	0.0060	0.0208	1.000	0.018	0.018	1.000
Palmerston North City						
Median	0.0051	0.0637	0.213	0.012	0.039	0.419
SPAR	0.0035	0.0144	0.562	0.011	0.019	0.865
WRSQ	0.0039	0.0176	1.000	0.011	0.019	1.000
Nelson City						
Median	0.0085	0.0686	0.209	0.020	0.059	0.503
SPAR	0.0051	0.0195	0.507	0.015	0.035	0.917
WRSQ	0.0052	0.0231	1.000	0.016	0.035	1.000
Small Cities:						
Papakura District						
Median	0.0093	0.0903	-0.048	0.018	0.062	0.185
SPAR	0.0060	0.0309	0.359	0.018	0.029	0.683
WRSQ	0.0061	0.0311	1.000	0.018	0.034	1.000
Porirua City						
Median	0.0119	0.1077	0.241	0.019	0.075	0.490
SPAR	0.0062	0.0264	0.418	0.017	0.020	0.716
WRSQ	0.0064	0.0303	1.000	0.018	0.019	1.000
Upper Hutt City						
Median	0.0077	0.0678	0.073	0.018	0.044	0.058
SPAR	0.0051	0.0197	0.299	0.015	0.019	0.762
WRSQ	0.0062	0.0311	1.000	0.017	0.024	1.000

Note:
1. Building permit data is unavailable for Auckland City.

In terms of house value appreciation, Table 2.9 indicates the SPAR index appreciated least among the three indices during the period of 1994 to 2004. The exception was for Wellington City, which on average was about 0.04% less than the WRSQ index at monthly level and equivalent to 0.48% on an annual basis. In the mean time the median price index for all cites during the same period showed a large appreciation rate of about 0.1% to 0.5% over the WRSQ index at monthly level. This finding is consistent with the literature showing the repeat sales method tended to overstate the true market appreciation in an upward market due to sample selection bias of repeated sales and the problem of sample quality changes. Hendershott and Thibodeau (1990) found that the median house price was consistently overvaluing house prices by about 2% per year when compared to the hedonic and repeat sales index. Finally, the faster appreciation rate of the SPAR index in Wellington compared to its WRSQ index appears to support the previous findings that the SPAR index in Wellington has been upwardly biased during this specific period, which caused the SPAR index to appear to be appreciating faster than it should. Among all the cities studied Wellington City and Hutt City have had the lowest correlation relationship between their SPAR indices and the WRSQ indices. These results further highlighted the importance of frequency of reassessment in the construction of a house price index by using the SPAR method.

2.7 CONCLUSIONS

The first essay focused on how and if a monthly house price index could be constructed in New Zealand. The SPAR method was explored in the following three areas: temporal aggregation, measurement errors and frequency of assessments, and model comparisons.

With temporal aggregation, the index's stability per period was tested first by lagged sales through a simulation approach and then the overall volatility of the index over various time intervals was estimated. The results showed that reporting a SPAR index at a monthly time interval is possible for large cities within New Zealand, but is difficult to apply for medium and small cities due to insufficient sales.

Random measurement errors in assessed values were not important for most cities as long as there were sufficient sales. On the other hand, frequent reassessment exercises marginally improved the precision of a SPAR index but also introduced a significant inconsistency bias between reassessments. Further, the total effect of the inconsistency bias, if it existed, was exaggerated in a more frequently reassessed SPAR index.

Finally, the quality controlled weighted repeat sales index was used as a benchmark for model comparisons. The correlation of index returns between the SPAR and repeat sales index was high at a quarterly level but low at a monthly level. The low correlation at the monthly level suggested a lot of noise in monthly price changes relative to the amount of signal in those changes.

Given the inconsistency problem found in the Wellington SPAR index and the low correlations between the SPAR index and the repeat sales index at a monthly level, some useful ideas for future research are suggested. Firstly, could the SPAR index be improved by calculating the vertical inequity coefficient for each city? Uniformity of assessed values for local areas is of significant concern in this context. Research in this direction could be further pursued by providing explanations on why the assessment could be inconsistent over time and what systematic changes in assessment practices leads to the inconsistencies. In a subtle form, McMillen and Weber (2008) found in a thin market the number of sales has some partial influence on the assessment uniformity. The second direction includes using the assessed value model for comparison with the SPAR index. As proposed by Gatzlaff and Ling (1994) and by Clapp and Giaccotto (1992a), the assessed value method using the same data set as the SPAR method, may overcome the data selection bias faced by the repeat sales method and improve the SPAR method by allowing for the systematic error in valuations. More empirical research such as out of sample tests in forecasting could also be applied in order to compare the SPAR index's performance with other alternative indexing methods.

CHAPTER 3

ESSAY TWO

House Price-Volume Dynamics and the Ripple Effect of Local House Price Movements in New Zealand

3.1 INTRODUCTION

In this essay, two empirical issues were investigated: 1) house price and trading volume dynamics and 2) the ripple effect of local market house price movements. These issues were examined under three different house price indices developed in the first essay - namely, the median house price, the SPAR index and the weighted repeat sales index. The reason for this empirical research is the importance of these two issues to the New Zealand housing market and because there are few additional variables required in the statistical tests. This made the results more transparent for index comparisons.

This chapter is structured as follows: Section 3.2 reviewed the literature with both the price-volume dynamics and local house price comovements reviewed in this section. Next, Section 3.3 described the data utilised and Section 3.4 provided the methodology. Section 3.5 reported the empirical results. Finally, Section 3.6 concluded with an overall summary of this chapter.

3.2 LITERATURE

3.2.1 House Price and Trading Volume Relationship

The real estate literature generally supports the hypothesis that real estate markets are less efficient than financial markets (K. E. Case & Shiller, 1989; 1990; Jim Clayton, 1998; Gu, 2002). Due to real estate market imperfections (heterogeneous products, illiquid characteristics and high transaction costs), house price movements may not respond to all new information over a short time period. During the information absorption process, some housing market participants adjust their demand curves, but most people may adopt a 'wait and see' strategy hoping for more information. Amongst all relevant information, trading volume is believed to be valuable, and this can be observed by market participants when updating their beliefs. If the number of houses listed for sale on the market is maintained at a constant rate, a substantially reduced trading volume can be interpreted as more houses on the market for sale but fewer buyers for them. Therefore, the supply and demand equation will eventually force prices to drop, or houses to be withdrawn from the market.

According to the literature on asset price bubbles this positive price and volume relationship can also be expected. In finance, the present value model of stock prices indicates that a stock price will equal the expected present value of future cash flows (fundamental value component) plus the expected discounted stock price at some time in the future (bubble component). When the investment horizon increases, the expected value of the discounted stock price converges to zero (Campbell, Lo, & MacKinlay, 1997). If the convergence assumption does not hold, i.e. investors include the expectation of the future price in their price formation process a speculative bubble will be present. In the presence of speculative bubbles, investors are betting they will be able to sell the stock for an even higher price in the future, which in fact is not justified by fundamentals. A feature of speculative bubbles is their self-fulfilling expectations on asset price movements. Price movements can be very persistent over a specific period of time. This will in turn have a significant influence on the investor's demand and supply function for an asset. A positive expectation of a future price rise will increase the demand for the asset, thus increasing the transaction volumes and vice versa. As with many other asset markets, there are speculative activities in the housing market. A housing bubble is viewed as home buyers being willing to pay inflated prices for houses today in anticipation of an unrealistically high housing appreciation in the future (Himmelberg, Mayer, & Sinai, 2005, September). This happens when temporally high housing prices are sustained largely by investors' enthusiasm (Shiller, 2005). Changes in trading volumes will provide a useful signal to market participants tracking the market sentiment about house price speculation. A substantially reduced trading volume for housing will indicate investors' enthusiasm has receded and as a result house prices will drop.

Three theoretical models reported in the real estate literature consider the price and volume relationship. These are the down-payment model developed by Stein (1995), the search model proposed by Berkovec and Goodman (1996) and the loss aversion model suggested by Genesove and Mayer (2001). The down payment model assumes a significant down payment requirement produces a self-reinforcing effect on trading volume and price. However, this model may not be applicable in a period when the down payment requirement is not a severe obstacle, such as before the global credit crunch in 2007.

In the search model, it is assumed changes in trading volume can be used as a proxy for measuring the changes in demand. Under this model a trade is only made when the buyer's appraisal price equals or exceeds the seller's reserve price. If not, the buyer continues the search and the seller changes the reserve price relative to time on the market. Information lags and changing price expectations for buyers and sellers are also part of the process. One important feature of the search model is trading volumes respond more rapidly to demand shocks than to prices.

The third explanation of the price and volume relationship is the loss aversion model. This model implies that sellers are averse to realising nominal losses and lag buyers when adjusting to new market conditions. In a bull market, the buyer's price expectation is often higher than the seller's reserve, resulting in both increased prices and sales. On the other hand, in a bear market the seller's price expectation is higher than the buyer's expectation. Therefore it takes a longer time to sell and this results in decreased prices and volumes.

In addition to the theoretical model development, empirical analysis of real estate trading volume and price has been made. Using a monthly median house price data set for the US housing market, Zhou (1997) found that volume and price were cointegrated and the Granger causality went from price to volume. By using Swedish housing market data, Hort (2000) supported the search model position that volumes responded ahead of prices. Her research was based on a VAR approach assuming volumes and prices were cointegrated. Leung, Lau and Leong (2002) found there was a robust positive correlation between volumes and prices in the Hong Kong residential market. In contrast, Leung and Feng (2005) explored the dynamics between prices and volumes in the Hong Kong commercial real estate market. They found there was little correlation between sale prices and trading volumes. This finding was in sharp contrast to what has been found in the residential market. They further concluded that the commercial market may behave very differently from the residential market.

Using a panel of 101 markets in the US from 1980 - 2006, Wheaton and Lee (2008) found joint causality between trading volume and sale price, but volume reacted negatively to prior price changes. Their findings support the frictional search model.

Clayton, Miller and Peng (2008) also found joint causality when they analysed a large data set of 114 housing markets in the US from 1990 – 2002. One of their findings was that the positive price volume relationship was caused mainly by the comovement components of price and volume due to exogenous variables such as the average household income, the unemployment rate and interest rates. Clayton, MacKinnon and Peng (2008) further extended the search model by providing explanations of why home buyers tended to respond more quickly than sellers in updating property value estimates. Using trading volume as the proxy for measuring market liquidity, they found little evidence of causality between price and volume with the quarterly data but that causality from volume to price existed at the annual level. They concluded the dynamic adjustment between price and volume was through their long run equilibrium.

3.2.2 House Price Comovements

Comovements of regional house prices are frequently discussed in the real estate literature. These shed some light on the extent to which regional housing markets are interrelated. Since housing is perhaps the single largest asset for many households, the long term price difference between regions may cause a significant distortion on wealth distribution. The phenomenon for house prices of some regions rising or falling first and then gradually spreading out to surrounding regions over time is called the "ripple effect". This has been well-discussed, particularly with respect to the UK housing market. In their study on modelling regional house prices in the UK, Giussani and Hadjimatheou (1991) provided empirical evidence on the existence of the ripple effect. Their approach was firstly based on the Granger causality test and then followed by the cointegration approach to regional model specification and estimation. By including the seasonal adjustments to their statistical test, Alexander and Barrow (1994) also found a similar ripple effect in house prices across regions in the UK. Recent scholarly work includes Worthington and Higgs (2003) and Holmes and Grimes (2005). They all found that regional property markets in the UK were highly integrated and were significantly causally related in the long run. Apart from the analysis of the spatial ripple effect across various regions, Ho, Ma and Haurin (2008) found that in Hong Kong the ripple effect can occur within a single housing market across different quality tiers.

Although empirical studies have observed the ripple effect, it is difficult to explain it theoretically. Economic theory suggests that regional house prices should not move together. This is because house prices are believed to be dependent on the local housing market supply and demand factors which can be substantially different between regions due to differences in regional economics and demographics. Meen (1996; 1999) and Giussani and Hadjimatheou (1991) suggested some economic reasons commonly used as an explanation for this ripple effect. These included external migration to the region, economic conditions in the region, equity transfer between regions (relocating) and spatial arbitrage between regions (trading). In New Zealand, Grimes and Aitken (2006) found the similarity in regional economic structure could help to explain the strong comovement in prices observed between Hamilton City and Waikato region over the time period from 1980 to 2005.

3.3 DATA AND PREPARATION

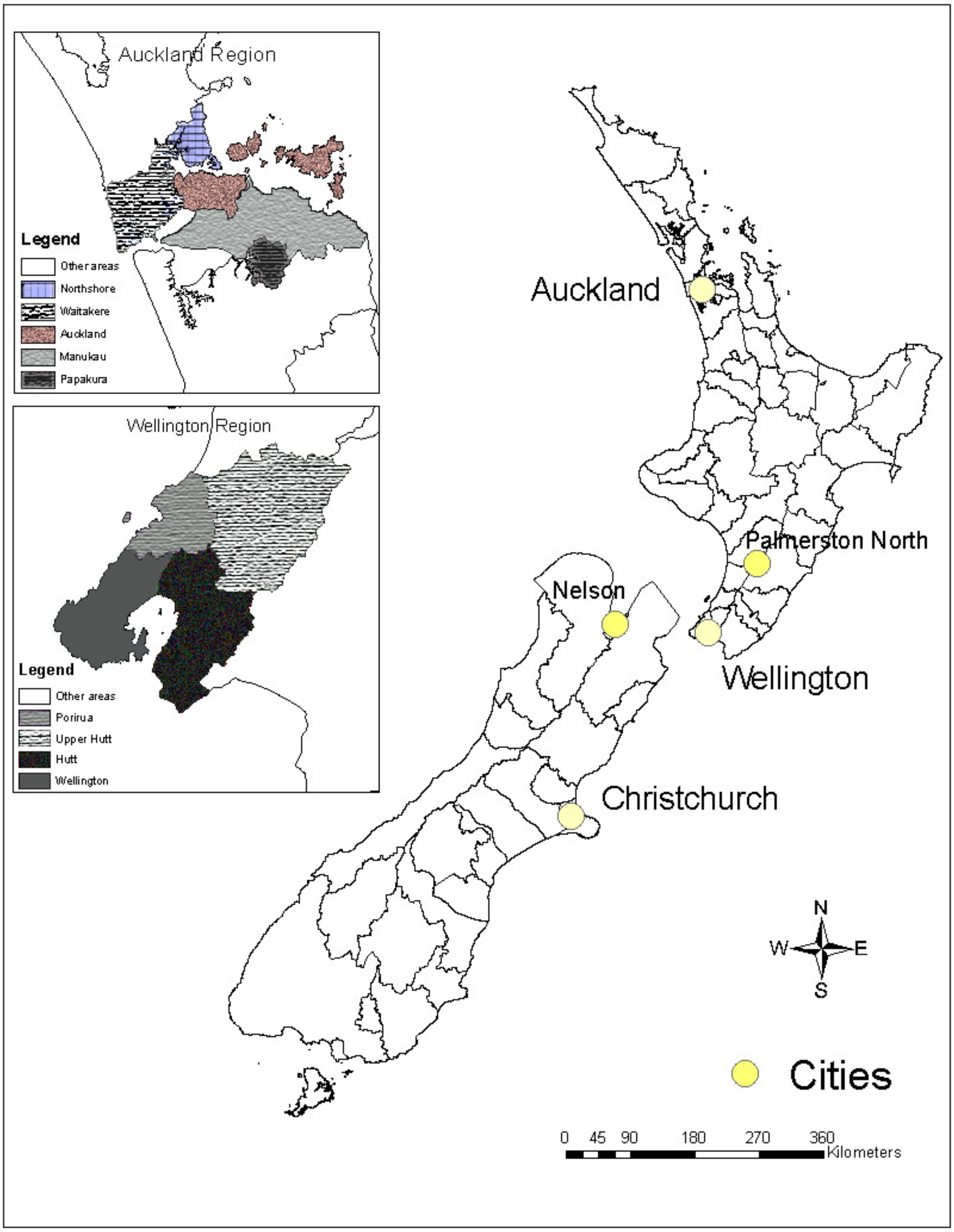
Within this research each local market's house price movement was separately measured at a monthly level by three different indexing methods – the median, SPAR and repeat sales methods. All these price series were developed in the first essay. Among them, the repeat sales index was used as a benchmark for index comparisons. The SPAR index was included for comparison because it is the official house price index in New Zealand, produced by Quotable Value Ltd (QV). The rationale for using median house prices in this research is that median house price data is available one to two months earlier than the quality controlled price indices.

All time series were constructed using nominal data and using natural logarithmic transformations[11]. Nominal data instead of real data on price movements were used because the price series were estimated at a monthly level. Inflation should not have much effect on monthly house price changes. Moreover, when referring to the relationship between price and volume, market participants tend to rely on nominal data such as in the loss aversion theory proposed by Genesove and Mayer (2001).

Figure 3.1 presents the geographical locations of the selected cities. With New Zealand's relatively narrow shape and separation into two main islands it was interesting to see if the ripple effect could spread from one island to the other. Moreover, the economic structure in local housing markets is quite different between regions. The Auckland region is generally regarded as the country's leading economic centre. Wellington is the capital city and political centre. Christchurch is the largest city in the South Island, where the local economy is mainly reliant on the primary produce of its surrounds. This research provides useful information on the extent to which the ripple effect spreads over the different geographic and economic zones, thus testing the existing economic theory for explaining the ripple effect.

[11] The reasons for using natural logarithmic transformations are discussed in Appendix B1.

Figure 3.1 Geographical Locations of Selected Urban Areas



3.4 METHODOLOGY

3.4.1 Unit Root Test

It is well documented in economic text books that if a dependent variable $\{y_t\}$ is I(1) and at least some of the explanatory variables are I(1), the regression results may be spurious (Wooldridge, 2006). Granger and Newbold (1974) find that a simple regression involving two independent I(1) series often results in a significant *t* statistic. This phenomenon is called the "problem of spurious regression", and describes a situation where even though the two variables are unrelated the regression result arrived at using the *t* statistics will often indicate a relationship.

Therefore the unit root test is a routine check used in modern econometric studies prior to carrying out a regression analysis. The common method for conducting a unit root test is known as the Dickey-Fuller (DF) test after Dickey and Fuller (1979), which can be expressed as:

$$\Delta y_t = \alpha + \theta y_{t-1} + e_t \qquad (3.1)$$

Where Δy_t is the first difference of y_t, α is a drift term, θ is defined as ρ-1 and e_t is a martingale difference sequence. The hypothesis test is H_0: θ=0 against H_1: θ<0.

For series with clear time trends, the augmented Dickey-Fuller (ADF) test is expressed as follows:

$$\Delta y_t = \alpha + \delta t + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + ... + \gamma_h \Delta y_{t-h} + e_t \quad (3.2)$$

δ is used for the control of linear time trend and the inclusion of the lagged changes of Δy_t is intended to clean up any serial correlation in Δy_t.

3.4.2 Cointegration and Error Correction Models (ECM)

When the "problem of spurious regression" exists, I(1) variables should be differenced before they are used in the linear regression models. However doing this limits the scope of the questions that can be answered because the relationship is not directly measured at the variable level but at a differenced level. The notion of cointegration can be explained as follows: Suppose $\{y_t\}$ and $\{x_t\}$ are I(1) variables. In general the linear combination of the two is still an I(1) process but it is possible that a particular combination of the two I(1) variables can produce an I(0) process. If such a linear combination exists, it says the two I(1) variables are cointegrated. The test for cointegration involves applying the DF or ADF test to the residuals, say

$$\hat{u}_t = y_t - \hat{\alpha} - \hat{\beta} x_t \quad (3.3)$$

Where $\hat{\beta}$ is an estimated cointegration parameter. If $\hat{u}_t$ is a unit root process, then y_t and x_t are not cointegrated. The above test can be easily extended including a time variable and lagged changes of x_t.

Most of time, β is unknown and needs to be estimated. In this situation there will be a problem running a spurious regression since both the variables are I(1) series. Fortunately, the asymptotic critical values of β can be estimated and are given in Davidson and Mackinnon (1993), where either the Dickey-Fuller or augmented Dickey-Fuller test is applied to the residuals.

Another popular test for cointegration is Johansen's maximum likelihood approach developed in Johansen (1991). This approach is based on the VAR in error correction model. Consider a VAR of order p:

$$y_t = \theta_1 y_{t-1} + \ldots + \theta_p y_{t-p} + \beta x_t + \varepsilon_t \qquad (3.4)$$

where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and ε_t is white noise. The above VAR can be rewritten as follows:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} T_i \Delta y_{t-i} + \beta x_t + \varepsilon_t \qquad (3.5)$$

where:

$$\Pi = \sum_{i=1}^{p} \theta_i - I, \qquad T_i = -\sum_{j=i+1}^{p} \theta_j \qquad (3.6)$$

The intention of the Johansen cointegration test is to test the rank (r) of the coefficient matrix Π in equation 3.5. Based on the Granger's representation theorem, if the matrix Π has reduced rank $r < k$, then there exist k x r matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is I(0). Therefore the rank of Π tells us how many cointegration relationships there are.

When applying the Johansen cointegration test, the user has to determine what kind of deterministic trend should be included both in the cointegration equation and VAR system since the Johansen test jointly estimates the cointegration relationships and the VAR in error correction model. EViews5 allows the following 5 assumptions:

1. no intercept or trend in cointegration equation or test VAR
2. intercept (no trend) in cointegration equation – no intercept in VAR
3. intercept (no trend) in cointegration equation and test VAR
4. intercept and trend in cointegration equation – no trend in VAR
5. intercept and trend in cointegration equation – linear trend in VAR

A practical issue which arises here is to determine which assumption should be used when carrying out the Johansen test. In general this depends on the analyst's understanding of the underlying data and how exact analysts think their theoretical model is.

The importance of carrying out the cointegration test is if there is a long-run relationship between the two I(1) variables, then users can use an error correction model to specify the dynamic between the two (Engle & Granger, 1987). In other words, the inclusion of a cointegration function (error correction term) in a dynamic regression model can improve the measurement of the short-run relationship between the two variables.

3.4.3 Granger Causality

Correlation between the two independent variables can be statistically strong but meaningless in reality. Granger (1969) defines causality as the situation where x can improve the explanation of y by adding lagged values of x in addition to the lagged values of y. Consider a vector autoregressive (VAR) model:

$$y_t = \delta_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + ... + \gamma_1 z_{t-1} + \gamma_2 z_{t-2} + ... \qquad (3.7)$$

The above equation allows users to test if past $\{z_t\}$ helps to explain y_t after controlling for past $\{y_t\}$. If it does, analysts say that z Granger causes y. In a linear VAR model, analysts will first decide the number of lags of y by using the t and F tests, then, by again using the t and F tests on any lags of z, test the null hypothesis H_0: that z does not Granger cause y. Two conditions need to be satisfied in the above VAR model. Firstly the variables need to be stationary, and secondly the model needs to be dynamic complete before adding the lagged variable of $\{y_t\}$.

3.4.4 Seasonality

Seasonality is an important feature of many economic time series. Hylleberg (1992) defines the concept of seasonality in economics as:

> "the systematic, although not necessarily regular, intra-year movement caused by the changes of the weather, the calendar, and timing of decisions, directly or indirectly through the production and consumption decisions made by the agents of the economy. These decisions are influenced by endowments, the expectations and preferences of the agents, and the production techniques available in the economy." (p.4)

Testing for seasonal effect is more complicated. From the various methods proposed, the simplest is to assume that the seasonal effect can be approximated by deterministic seasonal dummy variables and include these in the regression.

Dickey, Hasza and Fuller (1984) proposed a testing technique to test the hypothesis that a time series has a seasonal unit root. Their method was later modified by Osborn *et al.* (1988) and was referred as DHF test. For quarterly data it can be presented as follows:

$$\Delta_4 Y_t = \beta Z_{t-4} + \alpha_1 \Delta_4 Y_{t-1} + \ldots + \alpha_p \Delta_4 Y_{t-p} + \mu_t \qquad (3.8)$$

where $Z_t = \hat{\lambda}(L)Y_t = (1 - \hat{\lambda}_1 L - \ldots - \hat{\lambda}_p L^p)Y_t$ and L is the lag operator. The $\hat{\lambda}$ are the coefficient estimates obtained in the prior regression of $\Delta_4 Y_t = \lambda_1 \Delta_4 Y_{t-1} + \ldots + \lambda_p \Delta_4 Y_{t-p} + \xi_t$.

Under the DHF test, the null hypothesis (H_0) is the existence of a seasonally integrated process and the alternative hypothesis is the series is not seasonally integrated. This test however is a joint test for unit roots both for the non-seasonal and seasonal components. A similar procedure can be carried out for the monthly time series. The critical values of β for both monthly and quarterly data were given in Charemza and Deadman (1997) (Table 5 in the appendix).

To overcome the lack of flexibility in the DHF test, Hylleberg, Engle, Granger and Yoo (1990) proposed a so called HEGY test for quarterly data. The HEGY test breaks down the overall seasonal integration at different frequencies and therefore gives a richer insight into the nature of the seasonal pattern for a time series. For quarterly data, the HEGY test is based on the following regression:

$$\begin{aligned}\Delta_4 Y_t = &\sum_{i=1}^{4}\alpha_i D_{it} + \lambda T_t + \pi_1 Y_{1,t-1} + \pi_2 Y_{2,t-1} + \pi_3 Y_{3,t-2} + \pi_4 Y_{3,t-1} \\ &+ \sum_{i=1}^{k}\delta_i \Delta_4 Y_{t-i} + \varepsilon_t\end{aligned} \qquad (3.9)$$

where D_{it} are seasonal dummies, T_t is the trend, and

$$\begin{aligned}Y_{1,t} &= (1 + L + L^2 + L^3)Y_t \\ Y_{2,t} &= -(1 - L + L^2 - L^3)Y_t \\ Y_{3,t} &= -(1 - L^2)Y_t\end{aligned}$$

If π_1 =0, the series is not seasonal integrated. If π_2 =0, the series is semi-annual integrated. If π_3 =0 and π_4 =0, the seasonal unit roots are at annual frequencies. Critical values for the significance of π_i are given in Hylleberg *et al*. (1990).

Testing for unit roots in monthly time series were given in Franses (1990; 1991) as follows:

$$\begin{aligned}\varphi^*(L)y_{8,t} &= \pi_1 y_{1,t-1} + \pi_2 y_{2,t-1} + \pi_3 y_{3,t-2} + \pi_4 y_{3,t-1} \\ &+ \pi_5 y_{4,t-2} + \pi_6 y_{4,t-1} + \pi_7 y_{5,t-2} + \pi_8 y_{5,t-1} + \pi_9 y_{6,t-2} \\ &+ \pi_{10} y_{6,t-1} + \pi_{11} y_{7,t-2} + \pi_{12} y_{7,t-1} + u_t + \varepsilon_t\end{aligned} \tag{3.10}$$

where $\varphi^*(L)$ is some polynomial function of L for which the usual assumption applies, u_t is the deterministic component which might include a constant, seasonal dummies or a trend, and

$$\begin{aligned}y_{1,t} &= (1+L)(1+L^2)(1+L^4+L^8)y_t \\ y_{2,t} &= -(1-L)(1+L^2)(1+L^4+L^8)y_t \\ y_{3,t} &= -(1-L^2)(1+L^4+L^8)y_t \\ y_{4,t} &= -(1-L^4)(1-\sqrt{3}L+L^2)(1+L^2+L^4)y_t \\ y_{5,t} &= -(1-L^4)(1+\sqrt{3}L+L^2)(1+L^2+L^4)y_t \\ y_{6,t} &= -(1-L^4)(1-L^2+L^4)(1-L+L^2)y_t \\ y_{7,t} &= -(1-L^4)(1-L^2+L^4)(1+L+L^2)y_t \\ y_{8,t} &= (1-L^{12})y_t\end{aligned}$$

Applying ordinary least squares to the above equation gives estimates of the π_i. In cases where there are (seasonal) unit roots, the corresponding π_i is zero. There will be no seasonal unit roots if π_2 through π_{12} are significantly different from zero. If π_1=0, then the presence of root 1 cannot be rejected. When π_1=0, π_2 through π_{12} are unequal to zero, seasonality can be modelled with seasonal dummies. In all cases where π_i are equal to zero, it is appropriate to apply the Δ_{12} filter. Critical values for the significance of π_i were given in Franses (1990; 1991).

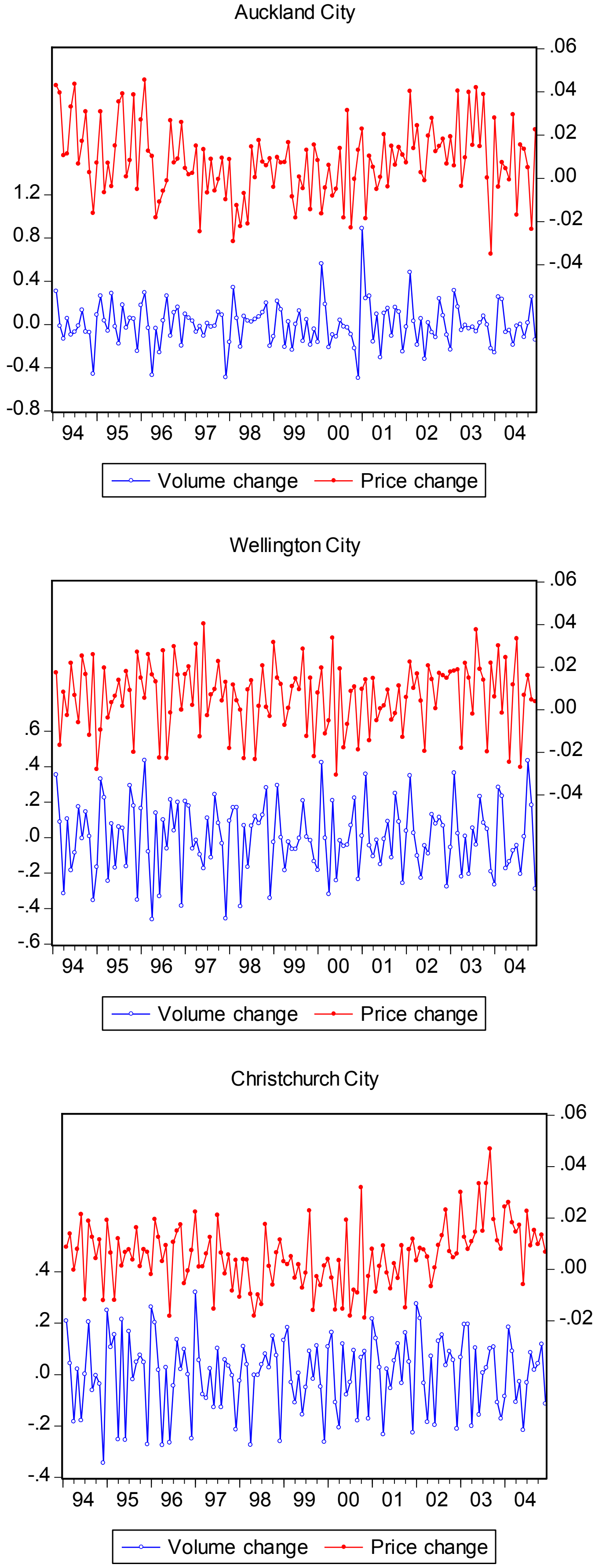
3.5 EMPIRICAL RESULTS

3.5.1 Testing for Unit Roots

It is well known in the economic literature that regression results can be spurious if the dependent variable and explanatory variables are non-stationary (Granger & Newbold, 1974). Therefore, it is a normal practice in the modern econometric research to check the time series' stationary properties before putting them in the regression.

Figure 3.2 presents a graph of monthly house price change (log price in first difference) vs. volume change (log volume in first difference) for the three largest cities in New Zealand – Auckland City, Wellington City and Christchurch City. House price movements were measured by the repeat sales index. This graph indicates that both the price and volume series appear to become stationary at the first difference, whilst volume change is much more volatile than price change.

Figure 3.2 Monthly Log Volume Change vs. Log Price Change



The results from the ADF tests are presented in Table 3.1, which shows all series are non-stationary processes in level (see the columns 1 and 2 of Table 3.1) and the majority of them become stationary after first differencing (see the column 3 of Table 3.1). Time series for Christchurch, Nelson and Palmerston North seem to be non-stationary even after first differencing. When applying second differencing to these cities, the ADF results imply possible over-differencing. Therefore, first differencing is an appropriate procedure for this data set.

Table 3.1 ADF Testing Results for Unit Roots Based on AIC Criteria

	Level (constant)	Level (constant & trend)	1st Difference (constant)	
Large Cities:				
North Shore City				
MDAN	-0.454	-1.443	-11.351	**
SPAR	-0.461	-1.391	-3.986	**
WRSQ	-0.514	-1.354	-3.679	**
NMBR	-1.902	-2.083	-3.744	**
Waitakere City				
MDAN	-1.577	-2.003	-11.124	**
SPAR	-1.909	-2.185	-4.826	**
WRSQ	-1.071	-1.711	-3.899	**
NMBR	-2.184	-2.210	-3.255	*
Auckland City				
MDAN	0.097	-1.474	-4.131	**
SPAR	-0.804	-1.601	-4.815	**
WRSQ	-0.440	-1.375	-4.776	**
NMBR	-2.115	-2.159	-4.029	**
Manukau City				
MDAN	-1.009	-3.291	-8.806	**
SPAR	-0.749	-1.759	-2.987	*
WRSQ	-0.542	-1.312	-5.382	**
NMBR	-1.670	-2.052	-3.662	**
Wellington City				
MDAN	0.190	-2.010	-3.694	**
SPAR	0.318	-1.597	-12.022	**
WRSQ	-0.156	-1.715	-5.021	**
NMBR	-2.789	-2.744	-3.875	**
Christchurch City				
MDAN	1.869	0.390	-1.113	
SPAR	-1.245	-2.492	-2.582	
WRSQ	-0.103	-2.181	-1.739	
NMBR	-1.699	-1.789	-2.653	
Small Cities:				
Papakura District				
MDAN	-1.029	-2.967	-7.801	**

SPAR	-0.975	-1.733		-17.693	**
WRSQ	-1.411	-1.774		-15.724	**
NMBR	-1.048	-1.286		-3.955	**
Porirua City					
MDAN	0.623	-2.927		-9.126	**
SPAR	1.520	-1.401		-11.927	**
WRSQ	1.492	-1.235		-9.826	**
NMBR	-2.223	-8.286	**	-4.499	**
Upper Hutt City					
MDAN	2.217	-2.372		-8.256	**
SPAR	2.938	-0.233		-18.700	**
WRSQ	2.057	-0.673		-13.166	**
NMBR	-1.584	-2.158		-4.352	**
Hutt City					
MDAN	0.756	-2.857		-9.531	**
SPAR	1.569	-1.565		-4.497	**
WRSQ	1.864	-0.682		-12.187	**
NMBR	-1.999	-2.152		-4.182	**
Palmerston North City					
MDAN	1.470	-0.549		-8.848	**
SPAR	2.856	2.711		-1.435	
WRSQ	4.826	2.389		-3.215	*
NMBR	-1.877	-3.933		-8.352	**
Nelson City					
MDAN	-0.291	-2.117		-2.104	
SPAR	-1.112	-2.024		-2.248	
WRSQ	-0.565	-1.830		-2.658	
NMBR	-1.949	-1.867		-3.801	**
Critical value at 1%	-3.482	-4.032		-3.482	
Critical value at 5%	-2.884	-3.446		-2.884	

[a] The optimum lag is determined by AIC criteria at a maximum lag of 12.

**Significant at 1% level

*Significant at 5% level

3.5.2 Seasonal Effect and Seasonal Unit Roots

The phenomenon of house prices being slightly higher or lower at certain times of year, probably caused by the changes of the weather, is defined as the seasonal effect on house price movements. This seasonal price variation has long been noticed in countries such as UK and New Zealand, where there are four distinct seasons. In this study the seasonal effect on price over a one year period is small, somewhere around ±2%. Typically, prices are higher in the spring and lower towards the end of autumn and the beginning of winter. In contrast to the seasonal effect on price the estimated seasonal effect on volume can be over ±20%. Therefore seasonality is an important feature of this New Zealand data set, particularly for volume data, and needs to be considered in the modelling.

In summary if the series is seasonally integrated, a higher order seasonal differencing rather than seasonal dummy variables will be required in the following cointegration and causality analysis through a VAR model. The DHF results for testing seasonality are presented in Table 3.2.

Table 3.2 DHF Testing Results for H_0: Seasonally Integrated

		No constant	Constant		Rejection
Large Cities:					
North Shore City					
	MDAN	0.888			no
	SPAR	0.259			no
	WRSQ	0.258			no
	NMBR	-0.543			no
Waitakere City					
	MDAN	1.289			no
	SPAR	0.539			no
	WRSQ	-0.037			no
	NMBR	-0.353			no
Auckland City					
	MDAN	0.837			no
	SPAR	0.296			no
	WRSQ	0.401			no
	NMBR	-0.671			no
Manukau City					
	MDAN	2.250			no
	SPAR	0.734			no
	WRSQ	0.486			no
	NMBR	-0.123			no
Wellington City					
	MDAN		-2.402	*	yes
	SPAR		-5.753	**	yes
	WRSQ		-3.819	**	yes
	NMBR	0.294			no
Christchurch City					
	MDAN	-0.742			no
	SPAR	0.556			no
	WRSQ	0.383			no
	NMBR	-0.566			no
Small Cities:					
Papakura District					
	MDAN		-6.060	**	yes
	SPAR	0.913			no

WRSQ	-0.092				no
NMBR	-0.441				no
Porirua City					
MDAN			0.381		no
SPAR			-0.257		no
WRSQ			-0.596		no
NMBR	1.129				no
Upper Hutt City					
MDAN			-2.977	**	yes
SPAR			-2.718	**	yes
WRSQ			-2.587	**	yes
NMBR	1.507				no
Hutt City					
MDAN			-0.155		no
SPAR			-2.543	*	yes
WRSQ			-1.403		no
NMBR	0.290				no
Palmerston North City					
MDAN	1.148				no
SPAR	-1.125				no
WRSQ	-7.131	**			yes
NMBR	1.123				no
Nelson City					
MDAN	1.114				no
SPAR	0.669				no
WRSQ	1.719				no
NMBR	-0.508				no

Notes:

1. Critical values are from Charemza and Deadman (1997) Table 5 in the Appendix.
2. The optimal lag is determined by AIC criteria at a maximum lag of 12.
3. General to specific modelling applied when carrying out the DHF test.

**Indicates significant at 1% level

*Indicates significant at 5% level

The results of DHF test suggest most time series are seasonally integrated (SI) processes rather than non-seasonally integrated processes. The null hypothesis for the existence of seasonal unit roots cannot be rejected, except for Wellington City and Hutt City. However, the DHF tests the hypothesis that all the twelve roots implied by the filter $\triangle_{12}$ are unity versus the alternative of no unit roots. Therefore a more general HEGY test as suggested by Franses (1990; 1991), which allowed for testing each of 12 unit roots in monthly time series, was designed. The results are shown in Table 3.3.

Table 3.3 HEGY Testing Results for Seasonal Integration

F-statistics	MDAN[a]		SPAR[a]		WRSQ[a]		NMBR[b]	
Large Cities:								
North Shore City								
π_3, π_4	10.302	**	13.164	**	10.159	**	10.154	**
π_5, π_6	7.673	**	6.032	**	14.249	**	12.040	**
π_7, π_8	14.913	**	7.560	**	11.483	**	8.227	**
π_9, π_{10}	11.823	**	9.607	**	9.988	**	9.816	**
π_{11}, π_{12}	18.125	**	13.467	**	10.500	**	9.091	**
$\pi_3 ...... \pi_{12}$	35.413	**	145.003	**	108.218	**	30.733	**
Waitakere City								
π_3, π_4	9.977	**	6.961	**	5.852	**	7.340	**
π_5, π_6	12.532	**	8.725	**	11.193	**	9.706	**
π_7, π_8	11.294	**	9.250	**	10.720	**	10.268	**
π_9, π_{10}	10.615	**	9.230	**	11.223	**	11.281	**
π_{11}, π_{12}	17.707	**	11.823	**	14.422	**	11.582	**
$\pi_3 ...... \pi_{12}$	51.900	**	88.435	**	61.069	**	28.232	**
Auckland City								
π_3, π_4	17.006	**	6.551	**	9.440	**	10.365	**
π_5, π_6	10.406	**	15.813	**	7.610	**	10.248	**
π_7, π_8	21.561	**	8.997	**	11.425	**	7.720	**
π_9, π_{10}	7.271	**	14.159	**	11.168	**	9.816	**
π_{11}, π_{12}	7.747	**	13.723	**	12.225	**	7.634	**
$\pi_3 ...... \pi_{12}$	49.876	**	195.898	**	78.568	**	28.623	**
Manukau City								
π_3, π_4	10.509	**	6.921	**	6.664	**	10.433	**
π_5, π_6	8.856	**	9.378	**	8.287	**	12.245	**
π_7, π_8	10.662	**	11.449	**	15.558	**	8.251	**
π_9, π_{10}	12.391	**	14.047	**	8.058	**	7.304	**
π_{11}, π_{12}	12.644	**	9.851	**	12.565	**	9.935	**
$\pi_3 ...... \pi_{12}$	21.630	**	130.590	**	69.499	**	41.119	**
Wellington City								
π_3, π_4	14.870	**	9.810	**	12.187	**	9.897	**
π_5, π_6	12.909	**	12.000	**	11.383	**	14.646	**
π_7, π_8	15.511	**	9.037	**	13.742	**	11.409	**
π_9, π_{10}	15.362	**	12.182	**	7.631	**	9.902	**
π_{11}, π_{12}	12.853	**	7.545	**	11.530	**	8.712	**
$\pi_3 ...... \pi_{12}$	29.560	**	85.546	**	75.221	**	20.768	**
Christchurch City								
π_3, π_4	10.358	**	9.774	**	10.184	**	8.467	**
π_5, π_6	11.504	**	7.487	**	14.024	**	12.682	**
π_7, π_8	12.464	**	6.696	**	11.912	**	13.640	**
π_9, π_{10}	10.829	**	8.512	**	13.094	**	8.689	**
π_{11}, π_{12}	6.388	**	8.729	**	11.329	**	8.137	**
$\pi_3 ...... \pi_{12}$	37.223	**	136.800	**	141.044	**	60.583	**
Small cities:								
Papakura District								
π_3, π_4	19.969	**	11.772	**	7.654	**	11.134	**
π_5, π_6	8.919	**	10.812	**	9.110	**	9.471	**
π_7, π_8	15.463	**	16.804	**	21.058	**	9.328	**
π_9, π_{10}	12.977	**	12.019	**	10.788	**	11.529	**

π_{11}, π_{12}	18.688	**	9.827	**	10.704	**	8.172	**
$\pi_{3}......\pi_{12}$	17.654	**	77.332	**	67.875	**	19.624	**
Porirua City								
π_{3}, π_{4}	10.955	**	9.988	**	8.703	**	6.802	**
π_{5}, π_{6}	13.185	**	6.955	**	8.565	**	9.697	**
π_{7}, π_{8}	11.253	**	16.363	**	18.042	**	9.839	**
π_{9}, π_{10}	9.173	**	9.135	**	12.806	**	8.247	**
π_{11}, π_{12}	7.845	**	10.352	**	8.021	**	9.371	**
$\pi_{3}......\pi_{12}$	12.455	**	18.811	**	23.517	**	11.887	**
Upper Hutt City								
π_{3}, π_{4}	10.295	**	16.299	**	9.447	**	7.655	**
π_{5}, π_{6}	5.645	*	9.694	**	11.066	**	13.363	**
π_{7}, π_{8}	6.507	**	14.080	**	19.612	**	10.075	**
π_{9}, π_{10}	8.977	**	19.160	**	16.070	**	10.315	**
π_{11}, π_{12}	12.841	**	10.304	**	15.094	**	12.941	**
$\pi_{3}......\pi_{12}$	10.922	**	68.604	**	28.233	**	19.176	**
Hutt City								
π_{3}, π_{4}	9.951	**	9.940	**	12.156	**	6.961	**
π_{5}, π_{6}	13.025	**	8.996	**	11.804	**	7.410	**
π_{7}, π_{8}	6.412	**	28.565	**	13.339	**	10.656	**
π_{9}, π_{10}	12.870	**	10.138	**	11.144	**	6.578	**
π_{11}, π_{12}	11.130	**	6.748	**	18.612	**	10.629	**
$\pi_{3}......\pi_{12}$	13.044	**	61.297	**	40.816	**	17.624	**
Palmerston North City								
π_{3}, π_{4}	8.992	**	9.360	**	7.780	**	12.128	**
π_{5}, π_{6}	5.528	*	6.067	**	6.681	**	8.035	**
π_{7}, π_{8}	9.010	**	12.713	**	12.127	**	13.219	**
π_{9}, π_{10}	8.765	**	10.043	**	7.931	**	11.423	**
π_{11}, π_{12}	9.321	**	11.495	**	12.622	**	15.886	**
$\pi_{3}......\pi_{12}$	9.789	**	52.486	**	30.609	**	18.964	**
Nelson City								
π_{3}, π_{4}	21.573	**	15.284	**	15.716	**	8.008	**
π_{5}, π_{6}	15.093	**	9.965	**	10.933	**	14.986	**
π_{7}, π_{8}	19.330	**	8.360	**	9.762	**	18.943	**
π_{9}, π_{10}	13.082	**	9.420	**	11.246	**	8.262	**
π_{11}, π_{12}	25.188	**	13.162	**	16.800	**	11.868	**
$\pi_{3}......\pi_{12}$	32.187	**	123.616	**	303.673	**	32.332	**

Notes:

1. The auxiliary regression contains constant, trend and seasonal dummies.
2. The auxiliary regression contains constant and seasonal dummies.
3. Critical values are given in Franses (1991) Exhibit 3.

* Significant at 10% level

** Significant at 5% level

A summarised result from the above test indicated very strong evidence against seasonal integration at all seasonal frequencies in each data series as the joint F tests for pairs of π's as well as a joint F test for all π_i, i=3,…,12 were significantly different from zero. Moreover, the t tests for π_1 for all series were not significant at the 10% level, which indicated that a unit root appeared to exist only at the long run frequency zero. Thereby, the seasonal effect can be appropriately modelled by using seasonal dummy variables in the regression analysis for causality. This corresponded to the results in Alexander and Barrow (1994) where similar findings for monthly UK house price series are reported.

3.5.3 Empirical Results of House Price-Volume Dynamics

3.5.3.1 Granger Causality Test

A VAR(12) model was used in this section, incorporating up to 12 lags for each of the variables in the first difference. This is because the Granger test is only appropriate where the variables are stationary and using more lags rather than fewer lags since the model needs to be dynamically complete. Furthermore, price and volume both tend to have long memories (Zhou, 1997). Results from the optimum lags test using AIC criteria of up to 20 lags showed the optimum lag length for various price series in first differences was between 4 to 12 lags and around 12 lags for volume data. Spatial lags were also incorporated in the above VAR model. The research found house price comovements are constrained within the region (metropolitan area) and there was little evidence to suggest that this spatial relationship spreads out nationally. Therefore, no spatial relationships were considered apart from the Auckland and Wellington regions. For the Auckland region, price changes in Auckland Granger-caused price changes of other cities in the region but not vice versa. For the Wellington region, the identified leading area was Wellington City. The length of spatial lags was determined at 3 lags as spatial effects were mostly captured by the first 3 lags in price changes from the leading city in this New Zealand data set. Accordingly, the VAR equation used in the causality test was formulated as follows:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + \sum_{i=1}^{3} \lambda_i \Delta p_{t-i} + 11\, seasonal\ dummies + \varepsilon_t \quad (3.11)$$

where x and y are log prices and log volumes and vice versa, a_0 is constant and ε is white noise. p is the spatial lag. For the Auckland region, p is the log price for Auckland City. For the Wellington region, p is the log price for Wellington City. For other cities, no spatial lags are incorporated into the above model. The hypothesis test is H_0: past Δy does not Granger-cause current Δx.

The test results are summarised in Table 3.4 (see Table B.1, in Appendix B2 for detail). Table 3.4 shows there was a strong causality between price and volume for large cities, where the causal relationship ran from volume to price. These findings are in line with the prediction of the Berkovec and Goodman (1996) search model. In contrast, the results for small cities indicated there was either no causal relationship between price and volume or the direction of causality was from volume to price. One explanation for the results of small cities may be due to the problem of small sample sizes. Both the price and volume series become volatile, particularly for trading volumes in small cities.

Table 3.4 Standard Granger Causality Tests of Price and Volume

	MDAN			SPAR			WRSQ		
Null hypothesis	*P* → *Vol*	*Vol* → *P*	*Neither*	*P* → *Vol*	*Vol* → *P*	*Neither*	*P* → *Vol*	*Vol* → *P*	*Neither*
Large Cities:									
North Shore City			√	x	√		x	√	
Waitakere City	x	√		x	√		x	√	
Auckland City			√	x	√		x	√	
Manukau City			√	x	√		x	√	
Wellington City			√	√	√		x	√	
Christchurch City			√			√	x	√	
Small Cities:									
Papakura District			√	√	√				√
Porirua City			√			√			√
Upper Hutt City			√			√			√
Hutt City			√			√			√
Palmerston North City	x	√		x	√		x	√	
Nelson City			√			√			√

Notes: *P* denotes price change, *Vol* denotes volume change and → denotes the direction of Granger causality. x denotes no causality and √ denotes causality, both at 10% significance level

For index comparisons, it seemed that the WRSQ index and SPAR index both performed well in the standard causality test for large cities. Often the WRSQ index indicated an even stronger one-way causal relationship running from volume to price. Among the three indices, the median price index indicated no causal relationship between price and volume for large cities. It is hypothesized that since the median price index was vulnerable to change in the mix of properties being sold, the price "noise" in the estimated median index may have prevented it revealing any meaningful short-run dynamics in the analysis.

3.5.3.2 Cointegration

The results of the unit root test suggested that because both the price and volume data were I(1) series, it was possible to investigate a cointegration relationship between the two I(1) variables. It used the Johansen approach in this section. Since the seasonal effect can be modelled by seasonal dummy variables, it adopted a VAR model including a constant in the cointegration equation and 11 seasonal dummy variables. Including a constant in the model enabled possible deterministic trends in the series to be accounted for. This followed the method suggested by Vahid and Engle (1993) in choosing the order of the VAR system by estimating different lengths in levels and selecting the one with the smallest AIC. Since the lags are specified in the first differences in the Johansen cointegration regression, it used the lag length in levels found in the above less one more lag in the Johansen cointegration test. For example, an unrestricted VAR of order 2 in levels implied a VAR of order 1 in the Johansen cointegration test. The result of the Johansen cointegration test is summarised in Table 3.5 (see Table B.2, in Appendix B2 for detail).

Table 3.5 Johansen Cointegration Tests of Price and Volume

	MDAN		SPAR		WRSQ	
Null hypothesis	*r=0*	*r=1*	*r=0*	*r=1*	*r=0*	*r=1*
Large Cities:						
North Shore City	x	√	x	√	x	√
Waitakere City	x	√	x	√	x	√
Auckland City	x	√	x	√	x	√
Manukau City	x	√	x	√	x	√
Wellington City	x	√	x	√	x	√
Christchurch City	x	√	x	√	x	√
Small Cities:						
Papakura District	√	√	x	√	x	√
Porirua City	√	√	x	√	x	√
Upper Hutt City	x	√	x	√	x	x
Hutt City	√	√	x	√	x	√
Palmerston North City	x	x	x	x	x	x
Nelson City	x	√	x	√	x	√

Notes: r denotes number of cointegrating relations. x denotes rejection of the hypothesis and √ denotes it fail to reject the hypothesis, both at the 0.05 level by trace statistics.

These results supported the existence of a cointegration relationship between price and volume for both large and small cities. For large cities all three indices indicated that there was one cointegration. The results from the SPAR index and the WRSQ index in this cointegration test are highly consistent, whilst the MDAN index showed some differing results in the small cities' analysis.

3.5.3.3 Causality Test Based on the Vector Error Correction Model (VECM)

Since price and volume are cointegrated in the long run, the causality test used a VECM model to re-estimate the causal relationship between price and volume. This was achieved by adding the error correction terms calculated from the above cointegration analysis to the VAR(12) system. The VECM model is arranged as follows:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + \alpha_1 \mu_{t-1} + \sum_{i=1}^{3} \lambda_i \Delta p_{t-i} + 11 seasonaldummies + \varepsilon_t \quad (3.12)$$

where μ is the error correction term from the cointegration regression and all other terms are as defined for Equation (3.11).

One feature of the above VECM approach is the model incorporates both the long-run relationship and short-run dynamics between variables. The long-run relationship is represented by the error correction terms and short-run dynamics are represented by the both lagged variables x and y in the model. The VECM approach provides an insight into the sources of causality. The causality testing results are summarised in Table 3.6 (see Table B.3, in Appendix B2 for detail).

Table 3.6 Granger Causality Test of Price and Volume Based on the VECM Model

	MDAN				SPAR				WRSQ			
	P → *Vol*		*Vol* → *P*		*P* → *Vol*		*Vol* → *P*		*P* → *Vol*		*Vol* → *P*	
Null hypothesis	F-statistic	Error-corr.	F-statistic	Error-corr.	F-statistic	Error-corr.	F-statistic	Error-corr.	F-statistic	Error-corr.	F-statistic	Error-corr.
Large Cities:												
North Shore City				√				√				√
Waitakere City				√				√				√
Auckland City				√				√				√
Manukau City				√		√		√		√		√
Wellington City		√				√				√	x	√
Christchurch City				√				√				√
Small Cities:												
Papakura District				√		√		√				
Porirua City		√				√				√		
Upper Hutt City								√				√
Hutt City		√		√		√				√		
Palmerston North City		√	x									√
Nelson City		√		√		√		√		√		√

Notes: *P* denotes price change, *Vol* denotes volume change and → denotes the direction of Granger causality. x denotes F-statistic of lagged price or volume changes and √ denotes the error-correction term, both at 5% significance level.

The results demonstrated that causality is often achieved via a long-run relationship between price and volume as represented by the statistical significance of the error correction term in the VECM model. Short run dynamics, as represented by the joint F-statistics of lagged variables in the model, can have an effect on the causal relationship but are often less important. For large cities, the direction of causality under the VECM approach was often from volume to price. For small cities there was evidence the direction can be from price to volume. The finding of causality from price to volume, or bi-directional in some local housing markets, suggested that price was influencing volume as well, which was predicted by both the down-payment model and loss aversion model.

The inconsistent results between the VECM approach and the previous VAR approach, particularly for small cities, are interesting. Under the VECM approach there was a causal relationship between price and volume for small cities, which was in sharp contrast to no causality under the VAR model. One explanation is that both the price and the volume series become "noisy" at a monthly level for small cities. This is due to the problem of small sample sizes. Short-run dynamics in this instance are difficult to estimate when compared to the long-run relationship between price and volume. Therefore the result from the VECM approach should carry more weight over the result from the standard VAR model, particularly for small cities in this study.

It is also interesting to note the median house price index performed reasonably well under the VECM model. It can be said that the median price index is still useful in the long-run analysis but may not be good in the short-run dynamics analysis. Since house price and trading volume are cointegrated in the long run, the median price index has revealed similar results to the SPAR and WRSQ indices under the VECM model.

3.5.4 Empirical Results of Local House Price Comovements

3.5.4.1 Granger Causality Test

A cross-correlation analysis of house price movements for all local markets was tested before carrying out the standard Granger causality test. The result of the cross-correlation test is presented in Table 3.7 and the graphed house price comovements are featured in Figure 3.3. The table and figure provide an initial indication that local market house prices are closely interrelated and move together in the same direction in the long run.

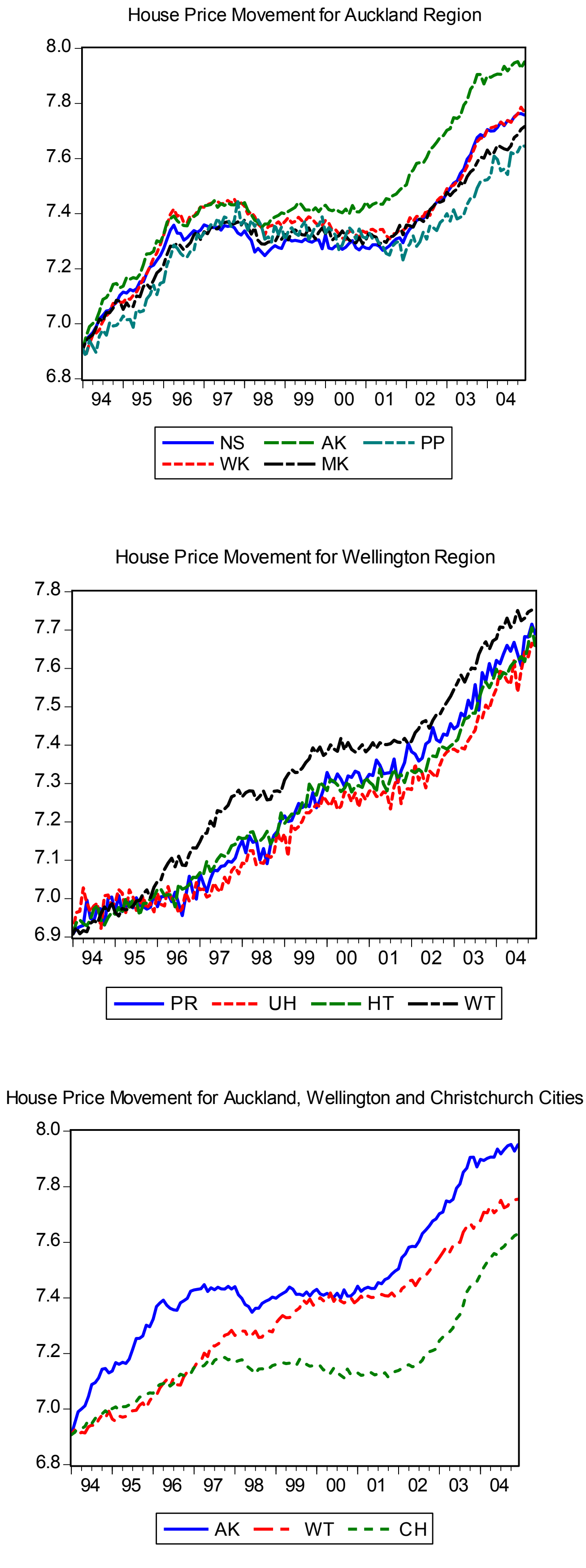
Table 3.7 Cross Correlation of Local Market Price Movements

	NS	WK	AK	MK	PP	WT	PR	UH	HT
WK	0.975								
AK	0.983	0.951							
MK	0.976	0.982	0.978						
PP	0.909	0.962	0.902	0.962					
WT	0.878	0.858	0.936	0.926	0.881				
PR	0.845	0.788	0.910	0.871	0.791	0.976			
UH	0.842	0.776	0.901	0.857	0.774	0.961	0.987		
HT	0.869	0.825	0.927	0.900	0.834	0.988	0.990	0.984	
CH	0.965	0.937	0.944	0.947	0.893	0.880	0.858	0.869	0.886

Notes:

1. Price movements are measured by the weighted repeat sales index in log form.

Figure 3.3 Regional House Price Comovements Measured by the Repeat Sales Index



Most empirical work in this area uses all local market price indices for the causality and cointegration analysis. However, a more meaningful approach is to design the research based on regions, firstly by identifying any ripple effect in the region, and secondly by analysing it between regional centres. The benefits of this approach are to:

1. Provide results that are more logical and consistent with the "ripple effect" theory. Local real estate markets are believed to exhibit some degree of structural differences and such differences can be very dependent on spatial distance. Therefore if a ripple effect does exist, it will first affect the local real estate market in the region and then spread outside the region.
2. Substantially reduce the amount of calculations required. This occurs by limiting causality and cointegration analysis to local markets in the region or between the identified regional centres.
3. Identify and observe the "ripple effect". The ripple effect will first be observed at the regional level, and then be studied at the national level between regional centres. The results will clearly show a pattern of ripple effect if it does exist.

The VAR equation for the Granger causality test is formulated as following:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + 11\ seasonal\ dummies + \varepsilon_t \qquad (3.13)$$

Where x and y are log prices in two different cities, a_0 is a constant and ε is white noise. The hypothesis test is H_0: past Δy does not Granger cause current Δx.

Table 3.8 shows the results of the standard Granger causality test. For the Auckland region, it became very clear the ripple effect commence at Auckland City and then spreads out over the surrounding cities within the region. This is evidenced by both the SPAR index and WRSQ index where price changes in Auckland Granger cause price changes of other cities in the region but not vice versa. The identified regional centre therefore is Auckland City. One feature of this ripple effect is that the pattern is related to distance. This is particularly illustrated by the SPAR index; for example price changes of Papakura (PP) are mostly influenced by the nearest city – Manukau (MK), then by the next nearest city – Auckland (AK), Waitakere (WK) and finally by the furthest city – North Shore (NS). It was also noticed the results from the MDAN index are not very informative. This may be due to the fact that the median price index itself is not a constant quality index and as such the results of applying a monthly median house price to research of local real estate markets in New Zealand may be questionable.

Table 3.8 Granger Causality Tests of Price Comovements

Auckland Region

	NS	WK	AK	MK	PP
MDAN:					
NS		1.234	1.065	0.925	1.285
WK	1.213		0.939	1.893 *	1.366
AK	2.257 *	1.617		1.154	1.851
MK	0.955	1.470	0.403		1.271
PP	0.989	1.934 *	1.025	0.668	
SPAR:					
NS		1.783	1.549	3.178 **	3.093 **
WK	0.803		1.134	2.002 *	3.327 **
AK	2.675 **	2.000 *		4.040 **	3.423 **
MK	1.441	1.911 *	0.910		3.953 **
PP	1.450	0.987	1.169	1.592	
WRSQ:					
NS		1.622	1.845	5.476 **	2.672 **
WK	1.007		2.612 **	2.293 **	2.956 **
AK	3.143 **	1.721		2.771 **	2.765 **
MK	2.689 **	1.492	1.166		2.470 **
PP	1.638	1.182	1.475	1.294	

Wellington Region

	PR	UH	HT	WT
MDAN:				
PR		0.907	0.861	0.722
UH	0.970		0.744	1.332
HT	0.663	0.849		1.263
WT	1.232	1.342	0.733	
SPAR:				
PR		1.835	2.430 **	1.085
UH	1.163		1.666	0.677
HT	1.092	2.212 *		1.386
WT	1.039	1.392	2.221 *	
WRSQ:				
PR		2.078 *	0.942	2.795 **
UH	1.251		0.563	0.784
HT	1.685	3.185 **		1.678
WT	1.360	1.625	1.017	

Main Centres

	AK	WT	CH
MDAN:			
AK		1.237	0.970
WT	1.069		0.674
CH	1.669	0.719	
SPAR:			
AK		1.512	1.461
WT	3.101 **		1.563
CH	0.624	0.947	
WRSQ:			
AK		1.443	1.722
WT	1.656		1.093
CH	1.391	1.506	

Notes:

1. Test includes intercept and 11 seasonal dummies based on the following VAR:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + 11\ seasonal\ \ dummies + \varepsilon_t$$

2. The causality is tabulated by row to column and Granger caused by column to row. For example in Auckland region under the SPAR index, North Shore (NS) (row) Granger cause Manukau (MK) and Papakura (PP) and is Granger caused by Auckland (AK). In the Wellington region under the SPAR index, Porirua (PR) (row) Granger causes Hutt (HT) and is Granger caused by none.

**indicates significant at 1% level

*indicates significant at 5% level

Within the Wellington region, the ripple effect was not obvious for any of the three indices. It appeared price changes for Upper Hutt (UH) were influenced by the price changes for Hutt (HT). The latter was slightly affected by the price changes for Wellington (WT) as indicated by the SPAR index. Therefore the regional centre was assumed to be Wellington City in this study. Several factors may help to explain these observed features: 1) Structure differences (such as the geographical and economic differences) in each local housing market are important. Wellington City is the capital of New Zealand and households in Wellington may differ in both behaviour and composition. For example, workers in Wellington City have the highest average wage in the country and a large proportion of the government workforce is well educated. This is in sharp contrast to the surrounding areas within the region, where most areas are industrial or rural. 2) The problem of small samples size for producing the indices. Except for Wellington City, Upper Hutt, Hutt and Porirua Cities were regarded as small cities which may lack the required sales for index reporting at least at the monthly frequency.

Following the application of the causality tests to identify ripple effects by regions, the causality tests between regional centres were next examined. The regional centres comprised Auckland City for the Auckland region, Wellington City for the Wellington region and Christchurch City for the Christchurch region. Based on the VAR(12) model, it was quite clear that there was a weak causal relation between them. Each main centre's price movements seemed to be fairly independent. Although the SPAR index showed causality between Wellington and Auckland Cities, it should be interpreted with caution as the assessed values were reassessed annually in

Wellington City in contrast to the more typical 3 yearly basis elsewhere in New Zealand[12]. These results implied the geographic and economic differences in each regional centre prevented the ripple effect being distributed between them at the national level. This supports the findings in Meen (1999) where his research suggested that the ripple effect was likely to be caused by a region's internal economic factors rather than migration and spatial arbitrage.

3.5.4.2 Bivariate Johansen Cointegration Test

A bivariate cointegration test was designed to test whether local market house prices were interlinked in the long run. In this Johansen cointegration testing process, the optimal lags in levels were first determined by the AIC criteria at a maximum lag of 12 in an unrestricted VAR system including a constant and 11 seasonal dummy variables. Using the lag length chosen in levels less one more lag[13], the author tested the Johansen cointegration rank of r in a vector error correction model (VECM). The VECM included a constant in the cointegration equation, and a constant and 11 seasonal dummy variables in the VAR system.

The results of the Johansen cointegration trace test are reported in Table 3.9. It shows that house prices within regions are interconnected in the long run. For the Auckland region under the SPAR index, it shows that the price changes of North Shore (NS) and Waitakere (WK) are cointegrated, and also for Auckland (AK) and Waitakere

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[12] The inconsistency (uniformity) problem between reassessments will cause the SPAR index to be biased. The more frequent the reassessment, the more likely the SPAR index is to be biased. This has been seen in the SPAR index for Wellington. More detailed discussion on this has been presented in the first essay. Therefore, readers need to exercise caution here when interpreting the results for Wellington.

[13] For example, if the optimal lag obtained in levels is 4, the lag length used in the Johansen cointegration test is to be 3. This is because the lags are specified as lags of the first differenced terms in the Johansen test, not in terms of the levels.

(WK) and Auckland (AK) and Manukau (MK). Similar results are found for the Wellington region under the WRSQ index. On the other hand, there is weak long run house price comovement between regional centres. The WRSQ index shows a long run relationship of house price comovements between Auckland and Christchurch Cities at the 5% significance level, however the trace test statistic itself is not high and not supported by the results based on the other two indexing methods. It appears that the price comovement between Auckland and Christchurch seems to have a higher statistical significance than the price comovement between Wellington and Christchurch. Again the bivariate cointegration test supports the previous finding in the causality analysis.

Table 3.9 Bivariate Johansen Cointegration Trace Test of Price Comovements

Auckland Region

	NS	WK	AK	MK
MDAN index:				
WK	16.922 *			
AK	24.357 *	15.365		
MK	7.515	12.369	16.088 *	
PP	18.173 *	17.949 *	22.420 *	31.507 *
SPAR index:				
WK	25.742 *			
AK	8.510	17.030 *		
MK	9.821	14.592	19.184 *	
PP	33.993 *	29.132 *	23.674 *	11.851
WRSQ index:				
WK	13.274			
AK	6.437	12.946		
MK	17.278 *	6.059	35.939 *	
PP	24.899 *	22.791 *	39.451 *	15.592 *

Wellington Region

	PR	UH	HT
MDAN index:			
UH	23.140 *		
HT	49.184 *	21.123 *	
WT	7.106	9.926	14.017
SPAR index:			
UH	14.392		
HT	14.085	15.056	
WT	8.490	7.064	12.637
WRSQ index:			
UH	21.638 *		
HT	8.792	19.171 *	
WT	6.962	16.643 *	8.577

Main Centres

	AK	WT
MDAN index:		
WT	9.950	
CH	14.200	7.526
SPAR index:		
WT	8.676	
CH	13.398	2.181
WRSQ index:		
WT	14.786	
CH	17.290 *	4.605

Notes:

1. The optimal lag is determined by AIC criteria at a maximum lag of 12 with seasonal dummy variables.
2. Test includes a constant in CE and a constant and 11 seasonal dummy variables in the VAR. The optimal lag number for the cointegration in the VAR system is the optimum lags in levels less one lag.

* Significant at 5% level

3.5.4.3 Multivariate Cointegration Test and VECM for Causality Testing

Despite the bivariate cointegration test carried out in the above, in this instance a more meaningful approach to cointegration is the multivariate cointegration test, simply because there were more than two price series in regions for cointegration analysis. In this section the Johansen cointegration trace test is again used to obtain the cointegration rank. The trace test statistics for Auckland and Wellington regions are presented in Table 3.10.

The primary finding obtained from the multivariate cointegration test is that a stationary long run relationship exists among local real estate markets in the region. The cointegration rank may vary according to the house price indices adopted. In the Auckland region, the MDAN index indicates a cointegration rank of 3, whilst the SPAR index shows a rank of 2 and the WRSQ index reports a rank of 4. Similar results are shown for the Wellington Region. Nevertheless, the cointegration relationship implies that, in the long run, house prices for various local markets in the region do not diverge.

Table 3.10 Multivariate Cointegration Test of Price Comovements – Regions

	Auckland Region						Wellington Region				
No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**	rank	No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**	rank
MDAN index:						MDAN index:					
None *	0.332	105.883	69.819	0.000		None *	0.247	70.123	47.856	0.000	
At most 1 *	0.158	53.827	47.856	0.012		At most 1 *	0.177	33.495	29.797	0.018	
At most 2 *	0.148	31.596	29.797	0.031	3	At most 2	0.061	8.386	15.495	0.425	2
At most 3	0.080	10.881	15.495	0.219		At most 3	0.002	0.295	3.841	0.587	
At most 4	0.001	0.111	3.841	0.739							
SPAR index:						SPAR index:					
None *	0.377	124.560	69.819	0.000		None *	0.215	58.909	47.856	0.003	
At most 1 *	0.235	63.909	47.856	0.001	2	At most 1	0.124	27.712	29.797	0.085	1
At most 2	0.162	29.633	29.797	0.052		At most 2	0.079	10.618	15.495	0.236	
At most 3	0.049	7.031	15.495	0.574		At most 3	0.001	0.066	3.841	0.798	
At most 4	0.005	0.647	3.841	0.421							
WRSQ index:						WRSQ index:					
None *	0.343	137.566	69.819	0.000		None *	0.324	80.230	47.856	0.000	
At most 1 *	0.282	82.883	47.856	0.000		At most 1 *	0.130	30.103	29.797	0.046	2
At most 2 *	0.156	39.785	29.797	0.003		At most 2	0.091	12.302	15.495	0.143	
At most 3 *	0.120	17.714	15.495	0.023	4	At most 3	0.000	0.025	3.841	0.873	
At most 4	0.008	1.106	3.841	0.293							

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Therefore the Granger causality test based on a VECM model is designed as follows:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + A\mu_{t-1} + 11\, seasonal\ dummies + \varepsilon_t \qquad (3.14)$$

Where μ is a k-vector of the error correction terms from the cointegration regression[14] and the other terms are as defined in equation (3.13).

The procedure for testing the F-statistics for Granger causality is set out as follows. Firstly, a regression is run of the first-order difference of the variable (Δx) against a constant, 11 seasonal dummy variables and 12 lags of Δx itself. Secondly, error terms (cointegration vectors) are added via the Johansen procedure to the above regression in step 1 and an F-statistic is calculated to test the joint significance of the error terms. If the error terms are jointly significant, they will be left in the regression model. If the error terms are not jointly significant they will be left out of the regression. Finally, 12 lags of Δy are added to the regression in step 2. An F-statistic of Δy will indicate whether or not the past Δy will help to explain the current Δx.

[14] There could be more than one cointegration relationship within a region. The maximum number of cointegration relationships *k* shall equal to the number of local markets in the region less one. For example, there are a total of 5 submarkets in the Auckland region and hence the maximum number of cointegration relationships is 4.

Table 3.11 F-statistics for Granger Causality Test of Price Comovements Based on VECM Model

	Auckland Region							Wellington Region				
	Error	NS	WK	AK	MK	PP		Error	PR	UH	HT	WT
MDAN:							MDAN:					
NS	8.069 **		0.776	1.630	0.929	1.048	PR	1.383		1.482	0.960	1.430
WK	6.489 **	1.146		1.208	1.727	1.889	UH	2.513	0.866		0.799	1.170
AK	1.838	0.851	1.544		0.377	0.976	HT	3.845 *	0.738	0.999		0.617
MK	4.241 **	1.082	1.250	0.632		0.760	WT	0.210	0.725	1.335	1.229	
PP	5.045 **	0.856	0.977	0.867	1.040							
SPAR:							SPAR:					
NS	4.003 *		1.303	2.965 **	1.191	0.832	PR	0.029		1.317	1.092	1.025
WK	8.422 **	1.016		1.012	1.193	1.280	UH	2.709	1.744		2.134 *	1.381
AK	3.282 *	1.588	1.186		0.840	1.143	HT	14.479 **	2.598 **	0.833		1.679
MK	8.779 **	2.904 **	1.830	3.028 **		1.262	WT	9.992 **	1.275	1.153	0.977	
PP	15.245 **	1.454	1.469	1.514	1.520							
WRSQ:							WRSQ:					
NS	4.697 **		1.287	2.294 *	3.019 **	3.110 **	PR	1.510		1.485	1.880 *	1.534
WK	6.516 **	0.775		1.331	2.537 **	2.146 *	UH	11.743 **	1.067		1.832	1.731
AK	3.645 **	1.968 *	2.340 *		1.249	2.353 *	HT	5.152 **	1.003	0.777		0.931
MK	11.920 **	3.347 **	1.130	1.334		1.194	WT	1.188	2.524 **	0.905	1.533	
PP	12.855 **	1.392	0.754	1.184	0.607							

Notes:

1. the VECM model is defined as follows:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-1} + \sum_{i=1}^{12} \beta_i \Delta y_{t-1} + A\mu_{t-1} + 11\, seasonal\ dummies + \varepsilon_t$$

where x and y are Log prices in two different cities, μ is a *k*-vector of the error correction terms from the cointegration regression and ε is white noise.

**indicates significant at 5% level

*indicates significant at 10% level

Table 3.11 reports the findings for causality, based on error-correction models instead of the standard Granger causality test based on equation (3.14). Causality was most likely through a long-run relationship among local housing markets in the region, rather than short-run dynamics between them, based on the significance of the error-correction terms[15]. Since the significance of the error terms represents the long run relationship in the regression, the more significant the error term, the more dependent the explained variable is on other variables in the regression. This can be illustrated in Table 3.11 by both the SPAR index and WRSQ index for the Auckland region. The significance of the error terms clearly indicated house price in the Auckland City (AK) was the least dependent upon other local market's house price movements in the region. This was followed by the North Shore City (NS), Waitakere City (WK) and Manukau City (MK). The house price in the Papakura district (PP) was the most dependent upon others in the Auckland region. For the Wellington region under the WRSQ index, it revealed that house price in Wellington City (WT) was the least dependent and Upper Hutt (UH) was the most dependent upon others. However the result under the SPAR index for the Wellington region was not so clear. Interestingly, the MDAN indices for both Auckland and Wellington regions have neither shown the correct sequence of inter-dependence of each local market house price movements in the region based on the significance of the error terms, nor revealed any impact of short run dynamics on price comovements between local markets.

[15] The estimates of the coefficients for the error-correction terms in equation (3.14) are presented in Table B.4, in Appendix B2. In general, they are more than 0.10, i.e. the long run relationships as measured by the error-correction terms are economically meaningful.

3.6 CONCLUSIONS

This essay firstly investigated the causal relationship between sale prices and trading volumes and secondly the ripple effect of house price movements across local real estate markets.

The study of the price-volume dynamics found that sale price and trading volume are cointegrated and causality was caused by the long-run relationship rather than the short-run dynamics. The direction of causality was from volume to price for most cities in this study, which supported the frictional search model proposed by Berkovec and Goodman (1996). However, the finding of causality being from price to volume in Wellington City and in some small cities suggested that the down payment model by Stein (1995) and the loss aversion model suggested by Genesove and Mayer (2001) still seem to be applicable in some local housing markets.

The results are likely to be useful for housing market participants. They showed volume changes lead price changes for most large cities in this New Zealand data set. For short term forecasting, if the volume is down substantially, then price will soon follow. In the long run, if the volume level is low, the price level is expected to be low as well and vice versa. Since the periodical volume data is reported in a more timely manner than the quality controlled price information, housing market participants could use the results from this research in forecasting housing market price movements in general.

In terms of the study of the local house price comovements, the observed ripple effect between local housing markets was most likely constrained within the region and there was little evidence to suggest that the ripple effect would spread out nationally between regional centres. For example, local house price movements within the Auckland region were interrelated, but no evidence suggested that the house price movements in Auckland affected price changes in Wellington and Christchurch. Results indicated the geographic and economic structural differences in local housing markets for this New Zealand data set played an important role in determining how far the ripple effect spread. As implied by the economic theory that house price movements are dependent on the local housing market supply and demand factors, the results further supported the findings in Meen (1999) where his research suggested the ripple effect was likely caused by a region's internal economic factors rather than migration and spatial arbitrage. Meanwhile, through a multivariate VECM model this research found the ripple effect was often achieved through the long run relationship among local markets in a region rather than the short run dynamics between them.

For index comparisons, the research demonstrated all three indices had the same conclusion on unit roots tests, but could be very different on the causality tests. The median price index tended to reject a causality relationship in a short-run dynamic analysis but improved in a long-run analysis. Research further showed the median price index was much more volatile at a monthly level when compared to the SPAR and repeat sales indices. It suggested that the noise in the monthly median price changes may have caused the median price index failure to reveal the expected short run price dynamics across local markets. When comparing between the quality-controlled price indices, it was found that other than for the Wellington region, the SPAR index generally gave a similar result to the weighted repeat sales index, at least for large cities. The results supported in general the literature on the use of quality-controlled price indices in the study of local house price dynamics. The results for small cities may vary according to the indices adopted, even based on the quality controlled price indices.

CHAPTER 4

ESSAY THREE

Predictability of Local House Price Movements

4.1 INTRODUCTION

There is extensive coverage of the price formation process within the finance literature. One of the most debatable concepts is the efficient market hypothesis (EMH), which in its simplest form states that security prices reflect all available information. The EMH theory implies that information formulates price and abnormal security returns are unpredictable[16].

Although the EMH originated in finance, similar tests of the EMH have been carried out for the housing market. In general, the empirical evidence shows that price movements in housing markets do not conform to the EMH. This is evidenced by the fact house price changes are positively correlated and a number of different types of public information can help to predict price changes (K. E. Case & Shiller, 1989; K. E. Case & Shiller, 1990). There are several likely reasons for this. First are the high transaction costs experienced in the real estate market. In New Zealand, selling real estate typically involves a transaction cost between 4% - 6% of the total sale price. This normally includes real estate agency fees, advertising costs, administration and legal fees. High transaction costs will have a "sticky" effect on price adjustment to new information unless the marginal benefit exceeds the marginal cost of transacting. Second, in comparison to the stock market real estate is seldom traded. Therefore it is almost impossible to study the EMH by observing individual house price changes in relation to information. Third, real estate is heterogeneous product. This represents a significant challenge when studying the EMH by observing market price movements in relation to information on an aggregation basis. Also, the problem of measurement

[16] The stock dividend change is believed to be stable, therefore the difference between return and price change is small. In practice, forecasts of returns and forecasts of price changes are very similar (Campbell & Shiller, 2001).

error in price indices may distort the results of an EMH study in the real estate market (Richard Meese & Wallace, 1994). Cho (1996) further summarised that any results from an EMH study in real estate markets might be “an artefact of the price index used rather than a real feature of the market”.

This study used three high frequency house price indices to investigate the house price dynamics in 12 local housing markets in New Zealand between 1994 and 2004. Firstly, it examined the weak-form market efficiency, particularly the random walk hypothesis. The random walk hypothesis implies that house price changes should be unpredictable based on historical price information. Secondly, the study tested the semi-strong form market efficiency with additional public information. This includes local market rents and nationwide mortgage lending rates. The rationale for studying rents and mortgage rates in the analysis is that they are proxies for dividends and discount rates (the opportunity cost of capital) for holding shares in the stock market. Under the present value model, a stock price should equal the expected discounted value of all future dividends (fundamental value). The hypothesis here is that if the property market is subject to mean reversion, the long-run relationship between house prices, rents and mortgage rates should help to predict future house price changes. If this is the case, it will provide further evidence against the efficient market hypothesis for housing markets.

This study was unique as it not only used high frequency data for the analysis, but also three different house price indices for comparisons at local housing market levels. All price indices were directly calculated from the market transaction data used in the first essay. The indexing method included the median house price, the sale price appraisal ratio (SPAR) method and the weighted repeat sales (WRS) method. One objective was to compare results between indices adopted. Therefore, the problem of the choice for house price indices on the EMH study as questioned by Meese and Wallace (1994) and Cho (1996) was minimised.

The remainder of the chapter is organised as follows: Section 4.2 reviews the literature. Section 4.3 describes the data utilised. Section 4.4 reviews the econometric tools used in this research. Section 4.5 reports the empirical results. Section 4.6 provides a conclusion.

4.2 LITERATURE

4.2.1 Efficient Market Hypothesis

An efficient market is defined by Fama (1965) as "a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants". Fama further points out the sufficient conditions for capital market efficiency which include: (i) there are no transactions costs in trading securities, (ii) all available information is costlessly available to all market participants, and (iii) all agree on the implications of current information for the current price and distributions of future prices of each security (Fama, 1970). The first two conditions are about the market itself and last one is about the market participants. Among all these conditions, the behaviour of market participants is extremely important and inevitably the EMH does not hold.

Fama (1970) describes three forms of the EMH:

- Weak-form efficiency: current securities prices reflect all information set in historical prices.
- Semi-strong form efficiency: current securities prices reflect all public information.
- Strong-form efficiency: current securities prices reflect all public and private information.

Under weak-form efficiency, the future stock price should follow a random walk model as showed by Granger and Morgenstern (1970), which means that the future stock price is based purely on the arrival of new information which cannot be predicted at the present time. Therefore any technical analysis based on past stock movements is worthless as a tool for determining an investment strategy. In a semi-strong efficient market, stock prices instantly adjust to new public information, meaning investors cannot consistently make excess returns from trading on the analysis of available public information. If this is true, any fundamental analysis of market research is worthless. The underlying principle behind the strong-form efficiency concept is that access to insider/private information cannot consistently allow for the making of excess returns to investors, bearing in mind trading on insider information is illegal in most stock markets.

In reality markets are neither perfectly efficient nor completely inefficient. One extreme example of an efficient market is the concept of the perfect market, in which case the following conditions hold:

- “Markets must be frictionless, i.e. there should be no transaction costs or taxes, and all assets must be perfectly divisible and marketable (operational efficiency)
- Information should be costless and received simultaneously by all individuals (informational efficiency).
- All investors should be rational and depending on their risk preferences prefer more return to less (allocational efficiency).”

(Brown & Matysiak, 2000)

In a perfect market, the market is efficient. However, it is important to note that the above perfect market conditions are sufficient but not necessary for an efficient market. Operational and allocational inefficiency do not mean that the market is informationally inefficient. Thus, the transactional cost and allocational cost will have a “sticky” effect on price adjustment to new information unless the marginal benefit exceeds the marginal cost to do so. In general, capital markets with intensive competition are considered more “efficient” than real estate markets. This is evidenced by comparing the operational, allocational and informational efficiency between the two. First, buying or selling real estate often has a high transactional cost including searching costs, lawyer fees, valuation fees, financing costs, building inspection, land information memorandum (LIM) reports and real estate agent’s commissions. Second, real estate is seldom sold in small units because it requires a large amount of capital and a long marketing time to sell. Third, real estate is a heterogeneous product. It is difficult and costly to ensure that all property related information is properly recorded and analysed. There has been a lack of a reliable and timely reported price index in the real estate market for a long time.

In the finance literature, the EMH test is primarily about informational efficiency as the operational and allocational costs are relatively low compared to asset markets. However, empirical tests of the EMH can prove to be difficult since they are a joint test of market efficiency and asset pricing models. Another obstacle to test the EMH is the dynamic nature of the market analysed. Therefore, tests of the EMH are largely dependent on the asset pricing model adopted and period of time studied. There is a considerable debate on whether the controversial results for the tests of the EMH are due to the failure of the EMH or that there is simply a lack of an appropriate asset pricing model. So far the majority of academic work supports the EMH in general, but there is increasing evidence against the EMH (Jensen, 1978). Results include certain market anomalies, fads and noise trading, and behavioural aspects. The growing criticism of the EMH suggests that the stock market may not always trade on rational expectations but on a mixture of rational expected returns based on fundamentals and irrational aspects based on speculation (Russel & Torbey, 2002).

The literature on housing market efficiency is in its infancy when compared to the finance literature. Gau (1984) carried out the empirical test of weak-form market efficiency for the apartment and commercial real estate investment market in the city of Vancouver for the time period 1971 to 1980. He concluded real estate prices in his study were approximately random and thus supported the real estate investment market as being weak-form efficient. However, his conclusion was subject to the credibility of his price index methodology. Based on the weighted repeat sales (WRS) method introduced by Case and Shiller (1987), Case and Shiller re-examined housing market efficiency as a whole. Their conclusions were that house prices exhibited substantial persistence over short (1 or 1.5 quarters) to intermediate (1 year) timeframes and citywide excess returns were forecastable.

Although Case and Shiller's research places some doubts on the belief that the real estate market is weak-form efficient, one possible explanation for this variation is due to the real estate market imperfections as discussed above. Information may still be instantly reflected into price but it cannot be measured in a timely way. During the time period taken to observe price adjustments, individual information may be devalued or enhanced when it simultaneously enters into the price formation process. Some information may even get lost or the high transactional and searching costs in real estate may prevent the information from being reflected in price changes. Therefore real estate prices may exhibit some inertia or "sticky" effects during this information absorption process. Whether investors can take advantage of this to make excess returns is debateable and needs to be subjected to further empirical studies.

Some researchers test the semi-strong form of the EMH in real estate markets by using a number of macro and local economic public information. Case and Shiller (1990) showed certain public information such as the ratio of construction cost to price, real per capita income growth and increases in the adult population were positively correlated to house price changes, indicating that prices did not fully reflect all public information. Their research added weight to the argument real estate markets were inefficient as developed by the EMH in financial markets. Clapp and Giaccotto (1994) found house prices were correlated to local unemployment and expected and unexpected inflation. Again their research supported the argument that the housing market was not semi-strong form efficient.

Clayton (1998) tested the EMH for condominium apartment prices in Vancouver. His study on the weak-form of the EMH indicated past excess housing returns could be used to predict future housing returns but the coefficient estimates were small in magnitude and only reported on an annual level. By taking into account additional information such as the rent-price ratio, one of Clayton's conclusions on the semi-strong form of the EMH was future house prices were partly predictable based on currently available information. This provided additional evidence to suggest housing markets are semi-strong form inefficient.

More recently there has been considerable interest in both the finance and the real estate literature about using valuation ratios to predict future price movements in long-horizons. This was seen as being the case prior to the global credit crunch which hit in 2007. By examining the price-earning ratios and dividend-price ratios for the US stock market from 1871 to 2000, Campbell and Shiller (2001) found these valuation ratios were useful in forecasting future stock price changes in the longer term. Moreover, based on the fact the estimated valuation ratios in 2001 were significantly different from their historical averages, they forecasted a poor outlook for the stock market over the next ten years. Similarly Gallin (2004) used quarterly rent-price ratios to predict house price changes for the US over three-year periods from 1970 to 2003. He found rent and price were cointegrated and the rent-price ratio was an indicator for future house price movements. Himmelberg, Mayer and Sinai (2005) further pointed out that instead of using the direct market rent, the "user cost" of housing should be used in calculating the rent-price ratio.

There are few published works by real estate academics on the study of the strong-form of the EMH. Most academics believe that real estate markets are not strong-form efficient due to the market imperfections discussed previously. Real estate is generally regarded as a heterogonous product and information is closely held within the related parties. To some extent most real estate transactions are made with some degree of inside information/knowledge. For example, even though the final transaction price is known to the public, perhaps only the buyer and seller know exactly what the physical characteristics of the property are and what are the financial terms associated with the deal. Outsiders can access only limited information from published data sources.

4.2.2 Random Walk Theory

A simple explanation of the random walk theory is that price changes cannot be predicted from previous prices (Granger & Morgenstern, 1970). The model is written as follows:

$$P_t = R + P_{t-1} + e_t \tag{4.1}$$

where *P* is the stock price, *R* is the expected price change or drift, *e* is independently and identically distributed with mean zero and variance σ^2.

Using repeated substitution the expected value and variance at time *t* can be derived as follows:

$$E(P_t) = P_0 + R_t \tag{4.2}$$

$$Var(P_t) = \sigma^2 t$$

Despite the simplicity of the above model, the assumption of identically distributed innovation *e* is too strong to apply in empirical research. Sometimes, a random walk model is defined differently by relaxing the assumptions of *e* in the above model. A more general version of the random walk model, which is often tested in the empirical literature, is to assume the innovation *e* being dependent but uncorrelated (Campbell et al., 1997).

The random walk theory is a special case of the efficient market hypothesis, where investors' expected price change is constant (Campbell & Shiller, 2001). This may be true for financial asset prices over short time spans, but it is unlikely to hold over a longer time period. Nevertheless, the theory is widely used in the finance literature for testing weak-form market efficiency, but normally for very high frequency data such as daily data or intraday data.

4.2.3 Present Value Model

The present value model focuses on the prices themselves. The model relates the price of an asset to its expected future cash flows discounted to the present by using an expected discount rate. If it is assumed the discount rate is constant, the current asset price at time *t* is written as follows:

$$P_t = E_t\left[\sum_{i=1}^{n} \frac{D_{t+i}}{(1+R)^i}\right] + E_t\left[\frac{P_{t+n}}{(1+R)^n}\right] \qquad (4.3)$$

where D_t is the dividend or cash flow at time t and R is the expected discount rate.

In finance literature the first term is often called the fundamental value and the second term is the price bubble. When n is sufficiently large, the second term will converge to zero. The model implies that the current asset price is simply the sum of all expected present values of future cash flows, discounted at a constant rate.

The well-known Gordon growth model is accordingly set as follows:

$$P_t = \frac{(1+G)D_t}{R-G} \tag{4.4}$$

where G is the constant growth rate of cash flows and is less than R.

When G is zero, the above formula becomes:

$$P_t = \frac{D_t}{R} \tag{4.5}$$

This formula is widely used in the valuation of income producing properties. Here R is referred as the capitalisation rate in commercial real estate investment. Also, residential property investors refer R as the "yield", but usually in gross terms.

The assumption of a constant expected discount rate R is analytically convenient, but it contradicts the evidence that the investor's expected rate of returns will vary over time. Campbell and Shiller (1988a; 1988b) suggest a log linear present value model with time-varying expected returns, where a log stock price at time t is written as follows:

$$p_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{n} \rho^j \left[(1-\rho)d_{t+1+j} - r_{t+1+j}\right]\right] + E_t\left[\rho^j p_{t+j}\right] \quad (4.6)$$

where $\rho = 1/\left(1+\exp\left(\overline{d-p}\right)\right)$, $\overline{(d-p)}$ is the average log dividend-price ratio, $k = -\log(\rho) - (1-\rho)\log\left(\frac{1}{\rho} - 1\right)$ and $r_{t+1} = \log(P_{t+1} + D_{t+1}) - \log(P_t)$.

When the time horizon n increases to infinity, the third term, which is the discounted expected value of the stock price, will shrink to zero. Accordingly, the current stock price will be presented as follows:

$$p_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j \left[(1-\rho)d_{t+1+j} - r_{t+1+j}\right]\right] \quad (4.7)$$

This equation can be rewritten in terms of the log dividend-price ratio, which is:

$$d_t - p_t = -\frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j \left[\Delta d_{t+1+j} + r_{t+1+j}\right]\right] \quad (4.8)$$

The above equation (4.8) is called the dividend-ratio model by Campbell and Shiller (1988a; 1988b). Equation (4.8) implies that the log dividend-price ratio should be stationary provided the changes in log dividends and the expected stock return are stationary. In the case where the log dividend-price ratio is nonstationary, it is very likely the expected stock return is nonstationary (high persistent), even when the above present value model is valid. The question of whether this persistent expected return is supportable by market fundamentals, leads to an interesting research topic: testing for price bubbles.

In empirical tests, cointegration and unit root tests between stock prices and dividends give mixed findings depending on the time period studied. Through using the annual US stocks market data from 1871 to 1986 Campbell and Shiller (1987) found stock prices and dividends were not cointegrated. The deviation from prices and dividends was quite persistent. On the other hand, Diba and Grossman (1988) indicated a possible cointegration relationship between stock prices and dividends for the US stock market. In terms of the housing market, Gallin (2004) found by using aggregated quarterly data for the US housing market that the log rent-price ratio was stationary. Brooks, Katsaris, McGough and Tsolacos (2001) examined the monthly prices of UK equity-traded property stocks from 1986 to 1998. They found that prices and rents were not cointegrated over the sample period.

4.2.4 Price Bubbles

Price bubbles are phenomena that occur when people buy houses for prices that reflect unrealistic expectations about future capital gains. One characteristic of an asset bubble is its self-fulfilling nature. High asset prices which are not justified by various simple efficient-market models can become persistent over a long period of time. Under the present value model, if a self-fulfilling price bubble does exist, stock prices and dividends will not be cointegrated or the dividend-price ratio will not be stationary. However, a finding of non-cointegration between stock prices and dividends does not necessarily imply a price bubble exists. This is because there may be unobserved factors in market fundamentals causing this nonstationarity. The key question is: how we define fundamental values. By taking account of the change of market fundamentals, such as the changes in real interest rates, expected inflation, house price appreciation and taxes, Himmelberg, Mayer and Sinai (2005) found US housing markets are relatively efficient (not systematically mispriced) in general and there is little evidence of housing bubbles for most US housing markets. On the other hand, Shiller (2006) argued that in theory home prices should be the present value of future rents. By using a long-term series of real home prices, he found there was huge divergence between real interest rates and real rental-price ratios in the US housing market since 1995. He further concluded that there was an irrational overpricing (bubble) for house prices in general and even suggested that there might be a huge fall in home prices in the near future.

Another characteristic of price bubbles is the increased volatility of asset returns. Speculation activities will cause prices to change by more than the fundamental value based on new information. By using the present value model for calculating market fundamentals, Brooks, Katsaris, McGough and Tsolacos (2001) compared the variance of actual UK traded property stocks with those of their implied market fundamentals. They found evidence of the existence of bubbles.

4.3 METHODOLOGY

4.3.1 Serial Correlation

Serial correlation is the most direct and intuitive test for testing price behaviour under the weak-form of the EMH. If prices follow a random walk, the price changes shall not be serially correlated, i.e. the autocorrelation coefficients of the first-differences (price changes) at various lags are all zero. The autocorrelation of a series X at lag *k* is estimated as follows:

$$\psi_k = \frac{\sum_{t=k+1}^{T}\left(X_t - \overline{X}\right)\left(X_{t-k} - \overline{X}\right)}{\sum_{t=1}^{T}\left(X_t - \overline{X}\right)^2} \qquad (4.9)$$

where $\overline{X}$ is the sample mean of X and T is the number of observations. If ψ_1 is nonzero, it means that the series is first order serially correlated.

For testing of high-order serial correlation, the study uses the Ljung-Box Q-statistics. The null hypothesis of Q-statistics is there is no autocorrelation (all Q statistics should be insignificant) up to order *k* and is computed as follows:

$$Q = T(T+2)\sum_{j=1}^{k}\frac{\psi_j^{\,2}}{T-j} \qquad (4.10)$$

where ψ_j is the j^{th} autocorrelation.

4.3.2 Variance Ratios

The study followed the method proposed by Lo and MacKinlay (1988). If a price series follows a random walk, the variance ratio of its price changes should be equal to one. For example, if we define the continuously compounded return $r_t = \log(P_t) - \log(P_{t-1})$, under the random walk theory, r_t are independently and identically distributed. Then the variance ratio of $r_t + r_{t-1}$ to r_t is calculated as follows:

$$VR(2) = \frac{Var[r_t + r_{t-1}]}{2\,Var[r_t]} = \frac{2\,Var[r_t] + 2\,Cov[r_t + r_{t-1}]}{2\,Var[r_t]} \tag{4.11}$$

Since the covariance between r_t and r_{t-1} is zero, the *VR(2)* is equal to one. In general, assuming the sample consists of $nq+1$ observations, the variance ratio *VR(q)* can be derived as:

$$VR(q) = \frac{Var[r_t(q)]}{q \times Var[r_t]} \tag{4.12}$$

$$Var[r_t(q)] = \frac{1}{m}\sum_{t=q}^{nq}(p_t - p_{t-q} - q\hat{\mu})^2$$

and

$$Var[r_t] = \frac{1}{(nq-1)}\sum_{t=1}^{nq}(p_t - p_{t-1} - \hat{\mu})^2$$

where

$$m = q(nq - q + 1)\left(1 - \frac{q}{nq}\right)$$

$$\hat{\mu} = \frac{1}{nq}(p_{nq} - p_0)$$

$$p_t = \log(P_t)$$

The asymptotic standard normal test statistics of the variance ratio under the assumption of homoskedasticity in the r_t's is given:

$$z(q) = \frac{\sqrt{nq}\,\left(VR(q)-1\right)}{\sqrt{2(2q-1)(q-1)/3q}} \tag{4.13}$$

The asymptotic standard normal test statistic for the heteroskedasticity-consistent estimator is:

$$z^*(q) = \frac{\sqrt{nq}\,\left(VR(q)-1\right)}{\sqrt{\theta(q)}} \tag{4.14}$$

where

$$\theta(q) = 4\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2 \zeta(k)$$

$$\zeta(k) = \frac{nq\sum_{j=k+1}^{nq}(p_j - p_{j-1} - \hat{\mu})^2 (p_{j-k} - p_{j-k-1} - \hat{\mu})^2}{\left[\sum_{j=1}^{nq}(p_j - p_{j-1} - \hat{\mu})^2\right]^2}$$

When using this variance ratios method for testing the random walk hypothesis in the weekly stock returns in the US between 1962 and 1985, Lo and MacKinlay (1988) found the weekly stock returns for that specific period did not follow the random walk. Darrat and Zhong (2000) applied the similar variance based test to the Chinese stock markets. In the weekly returns from 1990 to 1998, they found similar conclusions to Lo and MacKinlay (1988). Gu (2002) studied the quarterly house price changes across the entire United States from 1975 to 1999. By analysing the variance ratios in returns, he found the returns are partly predictable but the patterns differ across local markets.

4.3.3 Cointegration and Error Correction Models

Cointegration tests are widely used in empirical economic studies. Regressions involve I(1) variables. If x and y are two I(1) processes, then in general, $y_t - \beta x_t$ is an I(1) process as well. However, if $y_t - \beta x_t$ is an I(0) process for some β, then x and y are cointegrated. In this study, the Johansen maximum likelihood approach is used to test for the number of cointegration relationships. If it turns out that time series in the study are cointegrated, an error correction model can be applied to specify the dynamic between them.

4.4 DATA AND PREPARATION

House price movements for the twelve selected cities are estimated directly from the transaction data in the first essay. For each city, house price movement is measured by the median, SPAR and WRS methods. Hereafter denoted as MDAN for the median price index, SPAR for the sale price appraisal ratio index and WRSQ for the weighted repeat sales index.

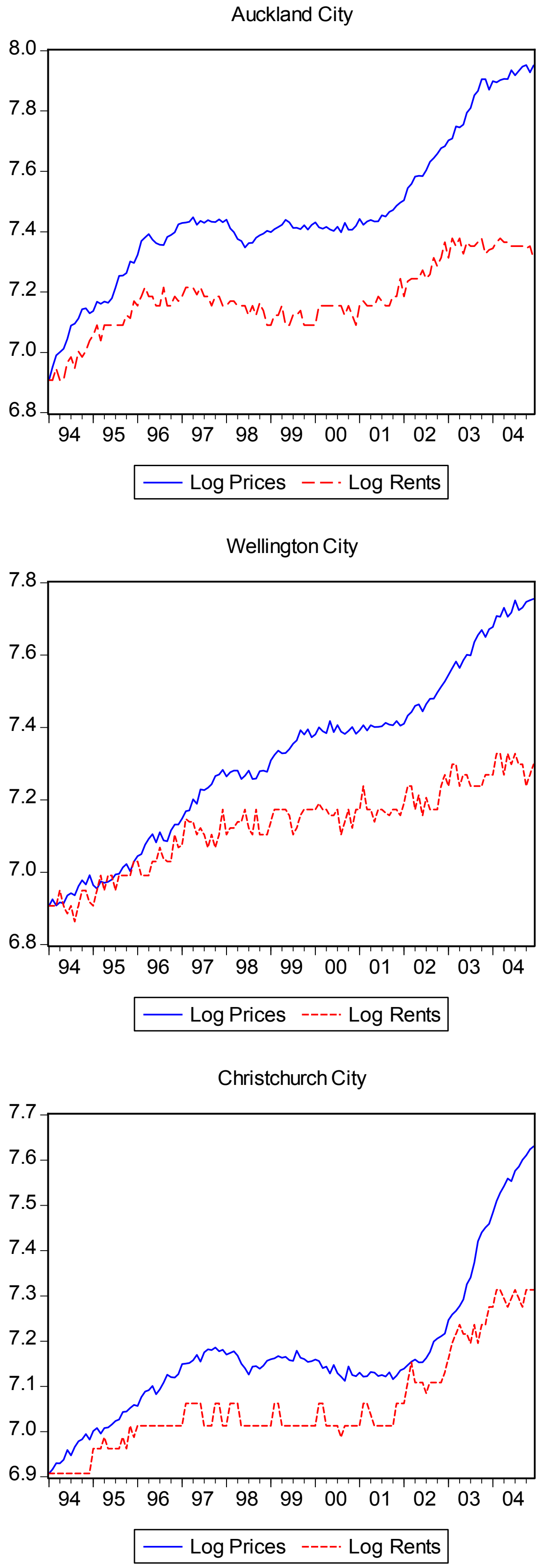
Monthly rental data for single family homes was obtained from the Tenancy Services Division of Department of Building and Housing (DBH) in New Zealand. Under the Residential Tenancies Act, all tenancy bonds must be lodged with the DBH within 23 working days from the start of the tenancy. The bonds usually amount to two or three weeks rent payable under the new tenancy. Therefore, the DBH rental data is transaction based and very comprehensive in terms of market rent settings for all new tenancies in New Zealand.

The monthly median rent is used to measure the rental movements for each local housing market. The calculated median rents are often equal to the median rent of a 3-bedroom single family home across all areas studied during the time period from 1994 to 2004. Rental data of rental houses is used as a proxy for the user cost or "imputed rent" of owning. There are several reasons for this. Firstly, the true user cost of owning a house is unobserved. Although it could be estimated (P.H. Hendershott & Slemrod, 1983; Himmelberg et al., 2005), it will inevitably introduce measurement errors in the calculated "imputed rent". Secondly, the total percentage of rental housing in the New Zealand housing stock is large and increasing. By 2004 rental housing comprised around 30 percent of the national housing stock[17]. Thirdly, rental house prices are not substantially different from owner-occupied house prices in New Zealand. The survey by Hargreaves and Shi (2005) showed that, on average, rental house prices fall between the open-market median and lower quartile house prices[18]. The historical house price movements and rental levels for selected cities are presented in Figure 4.1.

[17] Although New Zealand has traditionally had a high rate of home ownership, this rate has gradually declined between 1996 and 2006. Analysis of census data from Statistics New Zealand shows that in 1996, 70.7 percent of households owned their dwellings but this proportion fell to 67.8 percent in 2001 and then to 66.8 percent in 2006.

[18] Where the percentage of rental properties is high, rental houses are not confined to the less expensive suburbs. In fact, rental housing increases across all established suburbs across all cities in New Zealand.

Figure 4.1 House Price Movements and Rental Levels



Note: House prices are measured by the weighted repeat sales method. Rents are the median rents for the cities.

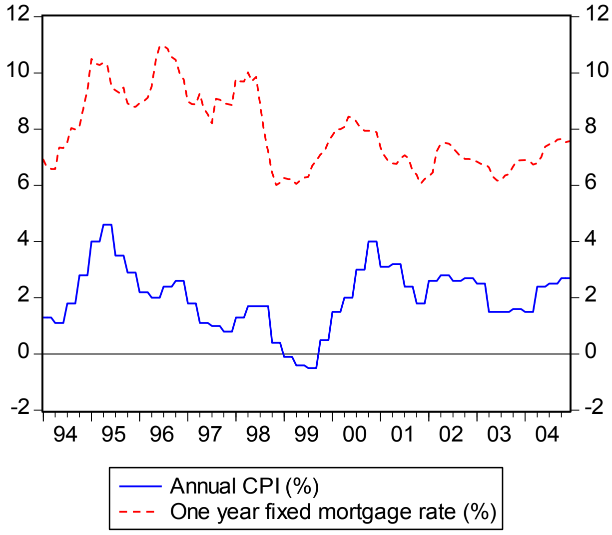
Interest rates were obtained from the New Zealand's central bank, the Reserve Bank of New Zealand (RBNZ). Monthly one year fixed term mortgage rates were used in this study for measuring the holding cost of single family homes[19]. Households have the choice to either use the money to retire part of their home loan or invest the money somewhere else. The main reason for using the fixed term mortgage rate rather than variable interest rate was due to the consideration of housing market imperfections. Housing is generally viewed as an illiquid asset being held for a long period. Therefore, its true holding cost is more likely to be a longer term interest rate rather than a shorter term rate. Moreover, most New Zealand households are on "fixed" term mortgages[20], i.e. the interest rate is fixed for a period of time between 6 months and 5 years but the mortgage is for 10 -25 years.

Finally, all data are nominal data in log form. Monthly returns were calculated as the log difference between two consecutive monthly prices. Since the volatility of monthly nominal returns is much larger than that of inflation, the use of nominal data in volatility-based tests has similar results to those achieved using the real data. Furthermore, inflation, as measured by the consumer price index (CPI), is reported quarterly in New Zealand. Although it is possible to convert quarterly CPI to a monthly interval, it was considered this introduced unnecessary errors into the data set. The annual CPI and the one year fixed mortgage rates from 1994 to 2004 are presented in Figure 4.2.

[19] In the standard calculation of the real homeowner cost of capital, analysts will not only consider the mortgage rates, but will also include variables for income taxes, property taxes, depreciation rates. In New Zealand, there is no tax benefit of owning a house as opposed to in the US. Interest payments for owner-occupied homes are not tax deductable items unless they are investment properties. Therefore, homeowners' marginal tax rates should not have much impact here. In addition, property taxes in New Zealand (i.e. local council rates and property depreciation are very stable at local market levels over the studied time period.

[20] According to the 2004 statistics from the Reserve Bank of New Zealand, about 70% of the total value of residential mortgage loans in New Zealand is in fixed term mortgages between 6 months to 5 years. Among all those fixed mortgage loans, about 55% was fixed in a term less than two years.

Figure 4.2 The Annual Consumer Price Index vs. the One Year Fixed Mortgage Rates



4.5 EMPIRICAL RESULTS

4.5.1 Random Walk Tests

The results of testing autocorrelations of price changes are presented in Table 4.1. It shows monthly house price movements are highly correlated over a 12 month period. The autocorrelation coefficients at various lags are large and the p-values associated with the Q-statistics are significant at a 5% level. Thus the hypothesis of random walk series for housing market price movements on monthly data can be easily rejected.

Table 4.1 Autocorrelations of monthly returns

City	Autocorrelation at lag 1	2	3	4	5	6	12	p-values Q6	Q12
					Panel A: Median Index				
Large Cities:									
North Shore	-0.233	-0.182	-0.021	0.086	0.021	-0.026	-0.049	(0.043)	(0.245)
Waitakere	-0.312	-0.087	0.075	0.146	-0.055	-0.152	-0.05	(0.002)	(0.001)
Auckland	-0.377	-0.013	-0.028	-0.054	0.139	0.02	0.181	(0.001)	(0.004)
Manukau	-0.418	0.065	-0.124	-0.043	0.107	-0.022	0.011	(0.000)	(0.004)
Wellington	-0.494	0.073	-0.051	-0.049	0.049	0.009	-0.129	(0.000)	(0.000)
Christchurch	-0.329	0.06	0.025	-0.01	-0.021	0.169	0.129	(0.004)	(0.015)
Small Cities:									
Hutt	-0.539	0.144	-0.084	-0.085	0.17	-0.101	0.145	(0.000)	(0.000)
Palmerston North	-0.47	0.001	-0.052	0.067	0.057	-0.089	0.074	(0.000)	(0.000)
Nelson	-0.396	-0.03	-0.071	0.117	-0.049	0.093	-0.138	(0.000)	(0.000)
Papakura	-0.759	0.328	-0.045	-0.069	0.095	-0.072	-0.066	(0.000)	(0.000)
Porirua	-0.454	0.009	-0.063	-0.044	0.05	0.147	0.074	(0.000)	(0.000)
Upper Hutt	-0.43	-0.088	0.073	-0.012	0.052	-0.135	0.256	(0.000)	(0.000)
					Panel B: SPAR Index				
Large Cities:									
North Shore	0.108	0.345	0.219	0.228	0.203	0.138	0.267	(0.000)	(0.000)
Waitakere	0.309	0.372	0.223	0.159	0.17	0.088	0.149	(0.000)	(0.000)
Auckland	0.197	0.413	0.18	0.202	0.096	0.176	0.107	(0.000)	(0.000)
Manukau	-0.099	0.278	0.145	0.13	0.212	0.035	0.14	(0.001)	(0.001)
Wellington	-0.06	0.111	0.044	0.062	-0.007	0.052	-0.027	(0.768)	(0.768)
Christchurch	0.084	0.372	0.245	0.198	0.273	0.235	0.105	(0.000)	(0.000)
Small Cities:									
Hutt	-0.24	-0.188	0.314	0.061	-0.12	0.037	0.04	(0.000)	(0.000)
Palmerston North	-0.256	0.066	0.225	0.113	0.058	0.108	0.22	(0.003)	(0.000)
Nelson	0.019	0.248	0.244	0.234	0.102	0.293	0.025	(0.000)	(0.000)
Papakura	-0.415	0.099	0.03	0.039	0.088	-0.013	-0.053	(0.000)	(0.000)
Porirua	-0.507	0.115	-0.019	-0.026	0.025	-0.076	-0.015	(0.000)	(0.000)
Upper Hutt	-0.452	0.226	-0.019	0.018	0.017	0.004	0.106	(0.000)	(0.000)
					Panel C: WRSQ Index				
Large Cities:									
North Shore	0.079	0.197	0.207	0.187	0.085	0.242	0.18	(0.000)	(0.000)
Waitakere	0.188	0.224	0.323	0.114	0.179	0.12	0.099	(0.000)	(0.000)
Auckland	0.072	0.177	0.192	0.143	0.079	0.027	0.096	(0.033)	(0.018)
Manukau	-0.179	0.073	0.179	-0.04	0.154	0.027	0.179	(0.043)	(0.023)
Wellington	-0.327	0.01	0.164	-0.014	-0.098	0.162	-0.042	(0.001)	(0.019)
Christchurch	0.13	0.245	0.259	0.285	0.339	0.264	0.14	(0.000)	(0.000)
Small Cities:									
Hutt	-0.328	-0.136	0.066	0.078	0.017	0.024	-0.066	(0.005)	(0.003)
Palmerston North	-0.322	-0.004	0.154	0.147	-0.052	0.071	0.089	(0.002)	(0.017)
Nelson	-0.192	0.22	0.196	0.092	0.187	0.077	0.025	(0.001)	(0.002)
Papakura	-0.314	0.051	-0.103	0.1	0.062	-0.044	0.024	(0.009)	(0.008)
Porirua	-0.466	0.059	-0.085	0.127	-0.161	0.073	0.105	(0.000)	(0.000)
Upper Hutt	-0.448	-0.034	0.139	-0.036	-0.049	-0.045	-0.097	(0.000)	(0.000)

Notes:

1. The figures presented are the autocorrelations up to and including that lag. P-values associated with the Q-statistics are presented in parentheses.
2. The monthly return is calculated as the log difference between two consecutive monthly prices. Sample period is from January, 1994 to December, 2004. Total sample size is 132.

For large cities, house prices are often positively correlated as indicated by both the SPAR and WRSQ indices. This implies price appreciation in large cities can be very persistent over a long period of time. For small cities, the correlation can be either positive or negative. This is also seen in some large cities as indicated by the MDAN index. One possible explanation could be the problem of small sample sizes in small cities when constructing the price indices[21]. Another possible explanation is the median price index is not quality controlled and as such the index itself tends to be noisy when compared to the quality controlled SPAR and WRS indices.

In order to confirm the serial correlations found in the above, the variance ratios of monthly returns were tested by using various price indices. The ratios are calculated by using overlapping periods of monthly returns and the results are presented in Table 4.2. Panel A contains results for the median price index. It shows that the random walk hypothesis is mostly rejected at the 5% significance level. The estimates of the variance ratio is smaller than 1 for all cases, indicating monthly returns are negatively correlated. This negative correlation in monthly returns is generally consistent with the findings in Table 4.1 under panel A, showing negative autocorrelations in monthly median price returns.

[21] The results of autocorrelations of price changes on quarterly data for small cities are available in Table C.1, in Appendix C1. The results show a positive autocorrelation of price changes for most small cities.

Table 4.2 Variance ratios of monthly returns

	Monthly Returns											
City	m=2	Z*(q)		m=4	Z*(q)		m=8	Z*(q)		m=16	Z*(q)	
					Panel A: Median Index							
Large Cities:												
North Shore	0.76	-2.47	**	0.47	-3.17	**	0.42	-2.27	**	0.48	-1.43	
Waitakere	0.67	-3.22	**	0.49	-2.82	**	0.53	-1.73	*	0.73	-0.68	
Auckland	0.62	-3.33	**	0.40	-3.01	**	0.34	-2.34	**	0.39	-1.53	
Manukau	0.59	-2.77	**	0.39	-2.53	**	0.27	-2.27	**	0.19	-1.94	*
Wellington	0.49	-4.77	**	0.30	-3.81	**	0.21	-2.83	**	0.18	-2.08	**
Christchurch	0.67	-3.58	**	0.57	-2.61	**	0.59	-1.63		0.76	-0.64	
Small Cities:												
Hutt	0.46	-4.85	**	0.29	-3.64	**	0.16	-2.85	**	0.12	-2.11	**
Palmerston North	0.54	-4.01	**	0.27	-3.69	**	0.20	-2.80	**	0.16	-2.13	**
Nelson	0.61	-3.66	**	0.35	-3.43	**	0.29	-2.49	**	0.34	-1.59	
Papakura	0.49	-4.36	**	0.31	-3.33	**	0.16	-2.73	**	0.11	-2.11	**
Porirua	0.54	-4.14	**	0.30	-3.75	**	0.16	-3.16	**	0.10	-2.34	**
Upper Hutt	0.57	-4.77	**	0.31	-4.16	**	0.20	-2.98	**	0.15	-2.14	**
					Panel B: SPAR Index							
Large Cities:												
North Shore	1.12	1.64		1.68	4.42	**	2.71	6.63	**	4.58	9.23	**
Waitakere	1.33	3.47	**	2.03	5.62	**	2.87	6.66	**	4.18	8.09	**
Auckland	1.20	2.23	**	1.82	4.86	**	2.68	6.34	**	4.11	8.01	**
Manukau	0.91	-0.75		1.25	1.25		1.93	3.17	**	3.25	5.32	**
Wellington	0.95	-0.56		1.09	0.55		1.34	1.32		1.59	1.51	
Christchurch	1.10	0.83		1.69	3.24	**	2.81	5.68	**	4.90	8.57	**
Small Cities:												
Hutt	0.77	-2.36	**	0.61	-2.13	**	0.76	-0.86		1.10	0.25	
Palmerston North	0.76	-2.15	**	0.82	-0.95		1.26	0.93		2.08	2.82	**
Nelson	1.03	0.29		1.44	2.35	**	2.40	4.66	**	3.93	6.79	**
Papakura	0.59	-3.97	**	0.51	-2.67	**	0.64	-1.28		1.01	0.03	
Porirua	0.50	-4.55	**	0.36	-3.47	**	0.27	-2.68	**	0.28	-1.84	*
Upper Hutt	0.54	-4.15	**	0.53	-2.43	**	0.59	-1.44		0.88	-0.29	
					Panel C: WRSQ Index							
Large Cities:												
North Shore	1.08	0.69		1.45	2.17	**	2.21	4.05	**	3.67	6.61	**
Waitakere	1.19	2.03	**	1.73	4.16	**	2.62	5.92	**	4.24	8.32	**
Auckland	1.07	0.85		1.37	2.35	**	1.89	3.52	**	2.86	5.01	**
Manukau	0.83	-2.02	**	0.92	-0.51		1.15	0.58		1.81	2.16	**
Wellington	0.68	-3.67	**	0.63	-2.28	**	0.70	-1.15		0.91	-0.25	
Christchurch	1.15	1.35		1.64	3.30	**	2.91	6.48	**	5.31	10.33	**
Small Cities:												
Hutt	0.65	-3.28	**	0.40	-3.27	**	0.40	-2.25	**	0.52	-1.29	
Palmerston North	0.67	-3.32	**	0.59	-2.35	**	0.79	-0.75		1.29	0.73	
Nelson	0.81	-2.17	**	1.06	0.38		1.67	2.55	**	2.73	4.45	**
Papakura	0.69	-3.73	**	0.55	-2.93	**	0.60	-1.62		0.89	-0.30	
Porirua	0.54	-4.19	**	0.33	-3.38	**	0.25	-2.55	**	0.25	-1.87	*
Upper Hutt	0.55	-4.21	**	0.35	-3.47	**	0.25	-2.67	**	0.34	-1.68	*

Notes:

1. Column m represents the variance ratios of that overlapping q-period returns, z(q) represents the standardized heteroskedasticity-consistent test for that variance ratios. Under the random walk hypothesis, the value of the variance ratio should be equal to one. The monthly return is calculated as the log difference between two consecutive monthly prices. Sample period is from January, 1994 to December, 2004. Total sample size is 132.

** indicates statistical significance at the 0.05 level

* indicates statistical significance at the 0.10 level

Panel B shows the results for the SPAR index. In contrast to Panel A, returns for large cities are positively correlated. The variance ratios are generally around one for a two-month return (m=2) and increase for larger Z*(q). For example, the variance ratio of North Shore City in panel B climbs from 1.12 (for m=2) to 4.58 (for m=16) with a Z*(q) of 9.23. For small cities, the variance ratios are normally smaller than one and become insignificant when the estimated number of months increases. The findings imply that the predictability in housing returns increase through time for large cities but decrease for small cities. The problem of small sample sizes for small cities may contribute to the above findings, as the volatility of monthly returns becomes too noisy for these to be used for long-horizon returns forecast in small cities[22].

Panel C represents the results for the WRSQ index for comparison purposes. It shows a very similar pattern when compared to panel B. Monthly returns are positively correlated for most large cities and either negatively or positively correlated for small cities. The returns for the Wellington City are even more negatively correlated in panel C when compared to the results in panel B. This might be due to the problem of the SPAR index itself for Wellington in Panel B. The study in the first essay showed there is positive bias in the estimated Wellington SPAR index[23].

Both the autocorrelation and variance ratio tests show that returns are more inclined to correlate over a longer term than the shorter term. The random walk hypothesis has been easily rejected. An interesting question is: in an upwards market if price returns

[22] The results of variance ratios of quarterly price changes for small cities are available in Table C.2, in Appendix C1. The results show an improved predictability in housing returns for most small cities.

[23] The Wellington City Council carries out the general reassessment for all properties on an annual basis, whilst most other local authorities in New Zealand reassess them on a 3 yearly basis. The inconsistency (uniformity) problem between reassessments will cause the SPAR index to be biased. The more frequent the reassessment, the more likely the SPAR index is to be biased. This has been seen in the SPAR index for Wellington. Therefore, readers need to be cautious here when interpreting the results for Wellington.

are so persistent (positively correlated), do the high house prices reflect market fundamentals? In other words, can other public information help to explain the price increases?

4.5.2 Semi-Strong Form Efficiency Tests

This section tested the semi-strong form of the EMH. Public information such as market rents and interest rates were utilised in the study to see if they were helpful in the prediction of house price movements. As implied by the present value model, house prices (fundamental values) are simply capitalised future cash flows (rents). Any deviations from the fundamentals are viewed as temporary and prices should revert to the fundamentals in the longer term. A long-run relationship between house price, market rent and interest rates is expected. Moreover, if the housing market is inefficient the observed long-run relationship should have the power to predict future house price movements. Meese and Wallace (1994) tested the present value model to the efficient market hypothesis. They found the present value model is valid in the long-run.

In order to test the long-run relationship between house prices, rents and interest rates, the routine unit roots test for all time series was utilised. The results showed all prices, rents and interest rates were integrated of order one I(1). This meant that they became stationary at first differences[24]. One interesting finding was the log rent-price ratio was not stationary at levels. According to the dividend-ratio model proposed by Campbell and Shiller (1988a; 1988b), this suggested that the expected return was non-stationary. That is, house prices exhibited an explosive nature over the study period.

[24] Statistical results on unit root test are presented in Appendix C2.

The results of unit root tests on rent-price ratios were consistent with the above random walk tests, which showed that monthly returns were persistent over a long period of time.

Since the log rent-price ratios were not stationary, use of the ratios in regressions to forecast returns was dropped due to the potential spurious regression problem. Instead cointegration tests were applied to the long-run relationship between prices, rents and interest rates. The results are presented in Table 4.3.

Table 4.3 Johansen cointegration test of prices, rents and interest rates

	r=0			r=1			r=2			No. of cointegration	Optimal Lags in levels
	Eigen	Trace	P - value	Eigen	Trace	P - value	Eigen	Trace	P - value		
Large Cities:											
North Shore City											
MDAN	0.220	40.706	0.002	0.054	8.383	0.425	0.009	1.179	0.278	1	2
SPAR	0.203	40.428	0.002	0.059	10.878	0.219	0.022	2.955	0.086	1	2
WRSQ	0.178	35.667	0.009	0.054	10.124	0.271	0.022	2.890	0.089	1	2
Waitakere City											
MDAN	0.194	37.144	0.006	0.043	9.140	0.353	0.026	3.390	0.066	1	2
SPAR	0.278	53.049	0.000	0.055	10.661	0.233	0.025	3.318	0.069	1	2
WRSQ	0.149	33.807	0.016	0.060	12.822	0.122	0.037	4.842	0.028	1	2
Auckland City											
MDAN	0.156	34.679	0.013	0.083	12.554	0.132	0.010	1.294	0.255	1	2
SPAR	0.266	50.846	0.000	0.065	10.701	0.231	0.015	1.955	0.162	1	2
WRSQ	0.177	36.068	0.008	0.069	10.676	0.232	0.010	1.361	0.243	1	2
Manukau City											
MDAN	0.176	35.104	0.011	0.068	9.920	0.287	0.006	0.774	0.379	1	2
SPAR	0.464	88.017	0.000	0.042	6.409	0.647	0.006	0.782	0.377	1	1
WRSQ	0.435	81.443	0.000	0.046	6.764	0.605	0.004	0.576	0.448	1	1
Wellington City											
MDAN	0.231	44.921	0.001	0.080	10.847	0.221	0.000	0.023	0.880	1	2
SPAR	0.290	51.026	0.000	0.045	6.121	0.681	0.001	0.150	0.699	1	1
WRSQ	0.273	53.163	0.000	0.087	11.799	0.167	0.000	0.030	0.864	1	2
Christchurch City											
MDAN	0.129	26.869	0.105	0.056	8.876	0.377	0.010	1.317	0.251	none	2
SPAR	0.175	33.102	0.020	0.057	8.111	0.454	0.003	0.446	0.504	1	2
WRSQ	0.242	43.717	0.001	0.057	7.732	0.495	0.001	0.158	0.691	1	2
Small Cities:											
Papakura District											
MDAN	0.236	48.337	0.000	0.072	13.389	0.101	0.028	3.721	0.054	1	2
SPAR	0.154	34.606	0.013	0.062	12.806	0.122	0.034	4.511	0.034	1	2
WRSQ	0.154	34.651	0.013	0.063	12.843	0.121	0.034	4.450	0.035	1	2
Porirua City											

MDAN	0.271	53.021	0.000	0.084	12.019	0.156	0.005	0.590	0.443	1	2
SPAR	0.252	51.247	0.000	0.092	13.580	0.095	0.008	1.066	0.302	1	2
WRSQ	0.254	51.258	0.000	0.094	13.249	0.106	0.003	0.355	0.552	1	2
Upper Hutt City											
MDAN	0.151	30.847	0.038	0.071	9.661	0.308	0.001	0.101	0.751	1	3
SPAR	0.174	40.344	0.002	0.094	15.529	0.049	0.020	2.638	0.104	2	2
WRSQ	0.152	29.714	0.051	0.056	8.272	0.437	0.006	0.749	0.387	none	2
Hutt City											
MDAN	0.222	43.680	0.001	0.081	11.105	0.205	0.001	0.072	0.788	1	2
SPAR	0.387	69.189	0.000	0.026	5.008	0.808	0.012	1.557	0.212	1	1
WRSQ	0.224	43.831	0.001	0.072	10.839	0.222	0.009	1.174	0.279	1	2
Palmerston North City											
MDAN	0.280	50.554	0.000	0.059	7.931	0.473	0.000	0.012	0.912	1	2
SPAR	0.286	71.271	0.000	0.180	27.533	0.001	0.013	1.695	0.193	2	2
WRSQ	0.223	57.741	0.000	0.155	24.970	0.001	0.023	3.053	0.081	2	2
Nelson City											
MDAN	0.256	47.632	0.000	0.068	9.256	0.342	0.001	0.148	0.701	1	2
SPAR	0.149	35.663	0.009	0.106	14.665	0.066	0.001	0.146	0.702	1	2
WRSQ	0.190	42.238	0.001	0.107	14.777	0.064	0.001	0.136	0.713	1	2

Notes:

1. The optimal lag is determined by SIC criteria at a maximum lag of 12 with seasonal dummies.
2. Test includes a constant in CE and a constant and 11 seasonal dummy variables in the VAR.

These results show that house prices, rents and interest rates are cointegrated in the long run for almost all local housing markets in this New Zealand data set. The findings are in line with Meese and Wallace (1994) where they found that house prices, rents and cost of capital are cointegrated. In this case, the monthly yield of the one year fixed mortgage rate is a good proxy for expectations of the homeowner cost of capital. Based on the cointegration relationship above, an error correction model is designed as:

$$x_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i x_{t-i} + \sum_{i=1}^{6} \beta_i y_{t-i} + \sum_{i=1}^{6} \gamma_i z_{t-i} + \delta_1 \mu_{t-1} + 11\, seasonal\ dummies + \varepsilon_t \qquad (4.15)$$

where *x*, *y* and z are price, rent and interest rate in first differences, α_0 is a constant, μ is the error correction term and ε is white noise. Seasonal dummy variables are included to deal with the seasonal effects in price series[25] and a VAR(6) for the test. The results are presented in Table 4.4.

[25] Seasonal dummies are actually the monthly dummies as the data are monthly time series. Seasonal effects in monthly price series are tested by the HEGY test as suggested by Franses (1990; 1991). Results show that the seasonal effect can be approximately modelled by using monthly dummy variables rather than by using a higher order of seasonal differencing for the time series. Testing results for the seasonal unit roots are available on request.

Table 4.4 Results of VECM for house prices, rents and interest rates

	Cointegrating coefficients				F-statistic				Error-corr.		Coefficient
	Price	Rent	Interest	Constant	Lag. rent		Lag. inter.		(μ)		of μ.
Large Cities:											
North Shore City											
MDAN	1	-1.478	0.282	2.627	0.865		0.537		-2.560	**	-0.234
SPAR	1	-1.597	0.187	3.673	2.547	**	1.176		-3.126	**	-0.100
WRSQ	1	-1.596	0.185	3.656	0.293		0.685		-2.798	**	-0.109
Waitakere City											
MDAN	1	-1.654	0.354	3.738	0.700		0.754		-3.800	**	-0.331
SPAR	1	-1.726	0.173	4.595	1.780		1.062		-4.383	**	-0.360
WRSQ	1	-1.666	0.170	4.203	0.525		0.997		-2.074	**	-0.134
Auckland City											
MDAN	1	-1.741	0.323	4.431	1.704		0.319		-3.285	**	-0.289
SPAR	1	-1.904	0.324	5.538	1.211		0.856		-2.798	**	-0.105
WRSQ	1	-1.919	0.401	5.495	0.433		0.828		-2.747	**	-0.100
Manukau City											
MDAN	1	-1.813	0.367	4.838	0.730		0.573		-1.979	*	-0.190
SPAR	1	-1.882	0.130	5.802	0.797		0.500		-1.766	*	-0.111
WRSQ	1	-1.820	0.117	5.381	0.510		1.196		-0.787		-0.054
Wellington City											
MDAN	1	-2.328	0.095	9.033	0.988		0.861		-2.641	**	-0.182
SPAR	1	-2.248	0.093	8.514	1.113		1.380		-2.217	**	-0.061
WRSQ	1	-2.185	0.049	8.161	0.566		1.267		-0.225		-0.009
Christchurch City											
MDAN	1	-1.674	0.237	4.197	2.714	**	1.423		-4.485	**	-0.228
SPAR	1	-1.536	0.013	3.642	2.493	**	1.004		-3.531	**	-0.126
WRSQ	1	-1.873	0.003	6.041	2.264	**	2.981	**	-2.067	**	-0.047
Small Cities:											
Papakura District											
MDAN	1	-1.650	0.224	4.077	0.721		1.526		-3.172	**	-0.526
SPAR	1	-1.962	-0.071	6.861	0.849		1.103		-1.639		-0.099
WRSQ	1	-1.933	-0.006	6.510	0.710		0.215		-1.850	*	-0.128
Porirua City											
MDAN	1	-2.495	0.018	10.381	1.427		0.608		-1.730	*	-0.183
SPAR	1	-2.773	0.028	12.360	2.096	*	1.661		0.085		0.003
WRSQ	1	-2.761	-0.012	12.329	0.827		1.088		0.328		0.013
Upper Hutt City											
MDAN	1	-4.285	-0.616	24.766	0.558		1.968	*	-1.260		-0.045
SPAR	1	-4.733	-0.368	27.499	0.658		0.906		-0.983		-0.011
WRSQ	1	-4.138	-0.559	23.530	0.418		0.745		-0.052		-0.001
Hutt City											
MDAN	1	-2.689	-0.103	12.348	1.274		0.844		-1.416		-0.081
SPAR	1	-2.736	-0.079	12.570	1.458		1.068		0.575		0.011
WRSQ	1	-2.772	-0.210	13.067	0.204		0.594		-0.211		-0.005
Palmerston North City											
MDAN	1	-2.059	0.089	7.204	0.314		0.540		-0.860		-0.111
SPAR	1	-1.331	-0.321	2.970	3.293	**	2.000	*	3.251	**	0.082
WRSQ	1	-2.189	0.025	8.246	0.168		1.292		0.263		0.013
Nelson City											
MDAN	1	-2.090	-0.135	7.886	2.959	**	1.122		-3.301	**	-0.463
SPAR	1	-2.168	-0.493	9.268	0.956		1.846		-1.355		-0.039
WRSQ	1	-2.197	-0.211	8.917	0.682		0.978		-2.643	**	-0.110

Notes:

1. the VECM model is defined as follows:

$$x_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i x_{t-i} + \sum_{i=1}^{6} \beta_i y_{t-i} + \sum_{i=1}^{6} \gamma_i z_{t-i} + \delta_1 \mu_{t-1} + 11\ seasonal\ dummies + \varepsilon_t$$

where x, y and z are log prices, rents and interest rates in first differences, α_0 is a constant, μ is the error correction term and ε is white noise. The mean time, μ, which represents the long-run relationship between house prices, rents and interest rates, is calculated by the Johansen maximum likelihood approach.

** Significance at 5% level.

* Significance at 10% level.

The cointegrating coefficients were standardised to set the log price to 1. Therefore, a positive sign means a negative correlation with log price and vice versa. For large cities prices are positively correlated with rents but negatively correlated with interest rates. The results are totally in line with the present value model predicted. In this study, it was found that, holding interest rates fixed, when rents increase by 1%, would increase prices by 1.6% to 1.9% for large cities. Among all large cities, prices in Wellington are the most sensitive to rental levels, where a 1% rent change will result in a 2.2% price movement.

The interest rate is a nationwide variable. However, its effect on local house prices for the time period studied is generally weak and differs across local markets. Among all large cities, Auckland is the most influenced by interest rate changes, an upward movement of interest rate by 1% is forecast to drop house price by about 0.3% to 0.4%. In contrast, Christchurch is the city least influenced by interest rate changes, with a 1% increase in interest rate dropping prices by 0.01% as indicated by the SPAR index. Similarly, changing the interest rate appears to have little impact on house price movements in Wellington. One explanation for this is the economic structure in local housing markets is quite different between cities. Auckland City is generally regarded as the country's leading economic centre, where the average house price is the highest for a New Zealand city and households may have large mortgage loans. Thus it is understandable households are likely to be more sensitive to interest rate movements in the Auckland area[26]. On the other hand, Wellington is the capital of New Zealand.

[26] The property statistics from the Quotable Value Ltd, an official statistics provider for measuring house price movements in New Zealand, showed that in March 2009 the average property value was reported at $496,000 for the Auckland region, $430,000 for the Wellington region and $349,000 for Christchurch. The national average property value was estimated at $378,000 over the same period.

Households in Wellington may differ in both behaviour and composition. For example, workers in Wellington City have the highest average wage in the country with a large percentage of them being government employees who are generally well educated. As long as rental levels hold, households in Wellington seem less concerned about interest rate changes. Finally, Christchurch is the largest city in the South Island, where the local economy is mainly reliant on the Canterbury farming sector and manufactured exports. Historical house prices are substantially lower in Christchurch when compared to Auckland. As such households in Christchurch appear to be least sensitive to interest rate changes.

For small cities, the long-run relationship of prices, rents and interest rates do not exactly follow the present value model. Results show rents are positively correlated with prices but interest rates are also positively correlated with prices for most small cities. The results indicate efficient-market studies for small cities are difficult due to the potential problem of small sample sizes. However, the findings might also have another untested policy implication, i.e. high interest rates will dampen house prices in large cities more quickly than in small cities.

Since house prices, rents and interest rates are cointegrated in the long-run, the research further studied local house dynamics using the VECM model. In Table 4.4, the short-run dynamics are represented by the F-statistics of lagged rents and interest rates, and the significance of the long-run relationship is measured by the *t*-statistic of the error correction terms. For large cities except for Christchurch, results show that the short-run dynamics of rent and interest rate changes on price changes are not important when the lagged price change themselves are included in the model. This is in sharp contrast to the long-run dynamics as represented by the error correction terms, which are negative and very significant for all large cities. The findings imply that local house price changes are mean-reverting to their long-run fundamentals, which indicates local housing markets are not semi-strong form market efficient. The speed of adjustment towards the long-run equilibrium is about 10% for most large cities at a monthly level. For small cites, the results are inconclusive and again most likely suffer from the problem of small sample sizes.

When comparing indices used in the study, all three indices have performed reasonably well in the above VECM model for large cities. However, there are some noticeable differences between indices. Firstly, the median price index tends to report a much higher impact of interest rates on prices in the cointegration analysis and a higher speed of mean reversion in the VECM model when compared to the quality controlled SPAR and WRSQ indices. The finding of stronger mean reversion in the median price index is in line with the analysis of variance ratios in Section 4.5.1. As shown in panel A of Table 4.2, variance ratios are less than one and shrinking significantly over time, which indicates the median prices are mean-reverting. This phenomenon may be due to a problem with the median price index itself as the index is not quality controlled and is more volatile at monthly levels.

In addition, when comparing the SPAR index with the WRSQ index, the WRSQ index often reports smaller error correction coefficients in the VECM model for large cities. Moreover, the *t*-statistics for the error correction term are less significant or even not significant. The results show that local house prices are less inclined to mean reversion under the repeat sales price index. Alternatively, house prices are likely to be subject to self-fulfilled price bubbles. Since the repeat sales index uses only the repeated sales for index construction, the index itself is more subject to sample selection bias. It has been found that frequently traded houses are more likely to be the houses of opportune buyers (Goetzmann & Spiegel, 1995). Therefore, it is not surprising to find that the repeat sales index itself is more affected by speculative activities than are other indices such as the SPAR index, which uses all market transactions for indexing.

4.6 CONCLUSIONS

This essay examined both the weak-form and semi-strong form of the efficient market hypothesis. It is concluded that local housing markets are generally not efficient in either form. Information such as past price movements, rents and interest rates have the power to forecast future price movements. Moreover, the predictability in housing returns is increasing through time. In the longer term, local house price movements are mean-reverting towards their long-run equilibrium – the market fundamentals as suggested by the present value model.

For index comparisons, the study utilised three indexing methods to estimate local market house price movements. The median price index is more likely to reject the efficient market hypothesis. This is evidenced by the fact that median house prices are more serially correlated and more inclined to mean-reversion than those of the SPAR and repeat sales indices. In most cases, the SPAR index has similar statistical results to the repeat sales index, particularly for large cites. Among all three indices, the repeat sale index gives the weakest statistical evidence for rejecting the efficient market hypothesis.

These findings have important implications for both monetary policy makers and academic researchers. Interest rates appear to have little impact on short-term house price movements. The long-run effects on the housing market are also weak and very different across local housing markets. From an academic viewpoint, a large number of observations will certainly be more desirable when carrying out variance ratios and cointegration tests. However, the indexing problem for small cities at a monthly level will often result in inconclusive results in this type of efficient-market study.

It is important to note that although these findings provided evidence the housing market is not efficient, they did not necessarily imply investors can consistently make abnormal/excess returns in the housing market. One of reasons for this is the high transaction costs in the housing market. Real estate agency fees, searching costs (information gathering and processing expenses), capital gains tax for property traders and moving costs for home owners could easily consume any profits from frequent trades. On the other hand, housing is also regarded as a consumption good. Like many asset pricing models of financial markets, the present value model utilised here might not fully reflect the "fundamental" value of owning a house as distinct from the economic value. Since the EMH theory was developed for the stock market, the real estate market is unlikely to behave in the same way.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This final chapter provides a summary of the thesis. Section 5.2 summarises the key findings from each of the three essays. It also attempts to link these findings and provide a case for establishing monthly price indices in New Zealand. The policy implications are then discussed in Section 5.3, followed by the academic contributions in Section 5.4. Section 5.5 identifies the limitations of this thesis. Finally, Section 5.6. highlights some areas for future research.

5.2 MAJOR FINDINGS

5.2.1 Essay One

The first essay showed the SPAR method itself can be viewed as a simplified arithmetic form of the repeat sales method or a special case of the Assessed Value (AV) method. This implied that for the SPAR method to be successfully applied, the assessed values must be, in general, statistically accurate as at the revaluation date. Fortunately, this turned out to be the case in New Zealand. Research by the New Zealand Valuer General shows all statistical estimates and their 95% percent confidence interval boundaries for the 2006/2007 general revaluations were well within the internal standard of the International Association of Assessing Officers.

Furthermore, the research results showed high correlations for quarterly price indices between the SPAR and repeat sales methods, further supporting the above contention.

Next the essay summarised the benefits of utilising the SPAR method for constructing a price index. Firstly, the method utilises almost all transaction data rather than just the repeat sales. This is an obvious advantage, as data availability for building a reliable index is a key consideration, particularly at a monthly reporting level. Secondly, the method is less problematic in index revision due to late sales. Late sales will only affect their own period's estimate in the SPAR index but do not affect the results for another period. This is in contrast to the chained nature of the repeat sales index when it is being revised. All these factors added weight to argument for using the SPAR method to report local house price movements at a monthly level in New Zealand.

Temporal aggregation tests showed both the index's overall volatility and stability per reporting period were increased at the monthly level, but not in an excessive way when compared to the quarterly index. The monthly index required collection of a larger percentage of sales than its quarterly index, for the same level of index accuracy. For large cities, the monthly SPAR index normally requires more than 70% of sales for that period to be collected before index reporting. For small cities, the requirement increased to 90%.

When estimating the effect of measurement errors in assessed values on the accuracy of the SPAR index it was found that the random measurement error in assessed values has little impact on the precision of the SPAR index. On the other hand, the systematic error between reassessments (inconsistency problem) can bias the SPAR index over time. As a result, the more frequent reassessments were, the more likely the SPAR index was to be biased. For example, the monthly SPAR index in Wellington, where the reassessments are taken on an annual basis, was upwardly biased by about 1.47% over the study period. For all other cities, where their reassessments were based on a 2 or 3 yearly cycle, the estimated impacts due to the inconsistency problem in assessed values were very small.

When comparing the SPAR index to the repeat sales index, the results showed correlations between the two indices were high at a quarterly level but low at a monthly level. The low correlations at a monthly level suggested considerable noise in monthly price indices. The research also showed the repeat sales index accurately measured the price movements in large cities, but could be problematic for medium and small cites due to the price noise.

Overall, the findings in the first essay generally confirmed the viability of the monthly SPAR index. The data currently available seemed to be sufficient, at least for large cities. However, the relatively low correlations between the monthly SPAR and repeat sales indices were of concern and require further investigation. In the next two essays, the monthly SPAR index, together with other price indices, was compared in empirical real estate research.

5.2.2 Essay Two

Two empirical topics were investigated in the second essay by using the monthly price indices developed in the first essay. One was for house price and volume dynamics and the other was the ripple effect of local house price movements.

In the study of house price and volume dynamics, it was found that although all existing theories could explain the observed positive correlation between the price and trading volume, they differed in terms of the direction of causality. Both the down-payment and loss aversion models suggested causality is from price to volume, whilst the frictional search model implied the direction is from volume to price. Empirical tests in the second essay showed house prices and trading volumes were cointegrated in this New Zealand data set. The direction of causality is from volume to price for most cities, which supported the frictional search model in general. When comparing the estimated results of the monthly SPAR index with those obtained from the repeat sales index, most of time the two indices produced similar results in the study of large cities. For small cities, the results varied according to the indices adopted.

In the analysis of local house price comovements, the ripple effect of local house price movements was constrained within the region and there was little evidence to suggest that it would spread out nationally. These findings were somewhat different from what has been seen in the UK housing market, but the results were consistent with economic theory. This study revealed geographic and economic conditions determine local house price movements. With the exception of for Wellington, the SPAR index generally performed well in this analysis as it tended to have similar results to those produced by the repeat sales index.

Overall, the results in the second essay supported using the monthly SPAR index for large cities but questions remain about its application for medium and small cities. The low correlations between the two indices found in the first essay do not have great impact on the results for large cities. Due to the fact that the repeat sales index for medium and small cities may not be appropriately measured, the comparisons between the SPAR and repeat sales indices for medium and small cities were therefore inconclusive. One possible explanation is both the SPAR and repeat sales index at a monthly reporting level suffered from the problem of small sample sizes in medium and small cities. This aspect is investigated in the third essay. Among all large cities, the SPAR index for Wellington was once again problematic as it often reported different results when compared to its equivalent repeat sales index. One explanation is the bias found for the Wellington SPAR index as discussed in the first essay.

5.2.3 Essay Three

The third essay examined the efficient market hypothesis for local housing markets by using the monthly price indices developed previously. It showed that local housing markets were neither weak form efficient nor semi-strong form efficient. The predictability in housing returns increased through time. Apart from price, other public information was also useful in the prediction of local house price changes. House prices, rents and interest rates are cointegrated. In a long run relationship, rents were shown to have a much greater influence on price than did interest rates. Furthermore, the observed cointegration relationship was significant in explaining current price changes. The findings suggested local house price movements were subject to mean reversion for this New Zealand data set.

In this market efficiency study, for large cities the SPAR index generally showed similar results to those obtained from the repeat sales index. However, for Wellington the SPAR index showed some inconsistencies when compared to the repeat sales index. Finally, the empirical results for small cities produced strong evidence that both the SPAR and repeat sales indices were suffering from the problem of small sample size.

In conclusion, all the three essays presented in this thesis supported a monthly SPAR index for large cities. When applied, it should perform similarly to its equivalent repeat sales index. In addition, a quality controlled price index was preferred in empirical real estate research. The median house price, which does not control for quality, was very noisy and the analysed results differed from those produced by the quality-controlled price indices. Among all available methods for constructing a quality controlled monthly price index, the SPAR method appeared to be the best option for New Zealand.

5.3 POLICY IMPLICATIONS

For market regulators, changing the reporting of the SPAR index from quarterly to monthly for the selected large cities is not administratively difficult. As long as the rating system is robust and regularly maintained, the statistical quality of a SPAR index at a monthly level is close to the equivalent repeat sales index. Monthly reporting is an obvious improvement over quarterly reporting for the Reserve Bank of

New Zealand's monetary policy settings, which are forward looking. Reliance on the monthly median house price tends to overstate price increases as houses are getting bigger and more elaborate over time and could mislead policy makers. On the other hand, a paucity of data with repeated sales means the difficulty with end of period data, delayed reporting and problems with index revision due to lagged sales.

The practical issue of how long it will take to accumulate the required reporting sample sizes depends on the choice of required relative standard errors and data collection system. In New Zealand it means a 2 or 3 months lag to index reporting when using officially released sales data. Administrators are speeding up the data collection process, including sales reporting being moved from a paper based process to an electronic one. On the other hand, policy makers should discourage reassessments on a less than three-yearly basis. This is because the more frequent reassessments are, the more likely the SPAR index is to be biased. In addition, there are obvious cost savings with less frequent assessments.

Another policy implication is for the Reserve Bank's interest rate setting. House prices may not respond faster and deeper to changes in interest rates as policy makers believed. Results of quality controlled price indices showed a much slower speed of adjustment between house prices and new interest rates than those revealed by the median price index. If house price inflation is the main concern for the Reserve Bank, it should move interest rates more boldly than it has done in the past when setting monetary policy.

Finally, trading volume has shown a positive correlation with price movement. In New Zealand, the Real Estate Institute of New Zealand (REINZ) publishes monthly median prices for local markets in a timely way. Although the median price can be questioned as an accurate measure of house price movements, the turnover information for traded properties is much more valuable. The Reserve Bank could work with the REINZ to collect monthly turnover data for long term house price forecasting.

5.4 ACADEMIC CONTRIBUTIONS

This thesis contributes to the literature on the use of the SPAR method to develop a monthly house price index for local housing markets in New Zealand, where housing transactions per period are relatively low but there is a standard system of valuation for rating (taxation) purposes. Essay One has examined this possibility by reviewing the New Zealand rating valuation system, the SPAR method itself and the associated repeat sales method and assessed value methods. Temporal aggregations at both the quarterly and monthly level are studied, with attention given to the impact of assessment errors in valuations on the SPAR index. Accordingly, Essay One contributes much needed knowledge to the literature on the use of the SPAR method for index construction.

The low correlation between the monthly SPAR index and the repeat sales index found in the first essay, initiates the need for testing the monthly SPAR index with other alternative indices in empirical studies. Essay Two contributes to the literature on house price and trading volume dynamics, local house price comovements as well as the impact on the analysed results of using different indexing methods. The results from Essay Two further enhance understanding of local housing market price dynamics. House price movements are local phenomena and buyers' expectations on price are adjusted more rapidly than sellers'. The index adopted does affect the final conclusions but the impact on the quality controlled indices for large cities is limited.

Finally, the third essay contributes to the literature on housing market efficiency studies. The housing market is believed to be relatively inefficient and the findings in the third essay reinforce this belief. In the long run, the housing market is subject to mean reversion as suggested by the present value model. Through using various price indices, the research further reveals the problem of measurement errors in monthly price indices for small cities.

Overall, the thesis contributes to the academic literature by showing that the SPAR index can be an alternative method for measuring house price movements at a monthly level for small countries like New Zealand, where market transaction volume per period is small. The findings support a monthly index for large cities but reject it for small cities. Moreover, a monthly SPAR index will benefit research on a volatility-based local housing market and the results from using the SPAR index should be close to those produced by the equivalent repeat sales index.

5.5 LIMITATIONS OF THE THESIS

Although this thesis attempts to utilise a complete transaction data set, building consent data for Auckland City was unfortunately unavailable. This affected the "quality" of the constructed repeat sales index for Auckland City. Thus, index comparisons for Auckland City in this thesis need to be interpreted with some caution.

Another area of limitation in the first essay is it only approximated the impacts of systematic errors in assessed values on the accuracy of the SPAR index. It does not quantify these systematic errors by running empirical regression tests. In fact, the thesis relies on the assumption New Zealand has a robust rating system and the assessed values are statistically close to their market values as at revaluation dates.

In the second and third essays, the time span is only an 11 year period. The data covers just one property cycle and is considered short in the long run relationship analysis. Furthermore, since the SPAR index for Wellington is found to have been upwardly biased over the study period, specific conclusions regarding Wellington house price movements in this thesis need to be interpreted with caution.

5.6 SUGGESTIONS FOR FURTHER RESEARCH

The assumption that rating valuations are reliable and closely approximate market value as at reassessment dates is important when considering the usefulness of the SPAR index. This assumption could be examined in future research by calculating the vertical inequity parameters by means of a regression test. This could help to quantify the inconsistency problem found in the first essay and improve the SPAR index by correcting the problem before the index is estimated. Further, comparison between the SPAR index and assessed value index is also of interest.

In terms of the data set, it would be worthwhile to expand it to cover more recent years. The extended time series are useful when using the simple trend extrapolation approach for local housing market forecasting. In this context, the ARIMA or

GARCH model could be useful for price forecasting and index comparisons between the SPAR index and other quality-controlled price indices.

Other suggestions include testing the hypothesis that a buyer's expectation about house price movements responds more rapidly than the seller's. This has been seen in the second essay, where volume Granger causes price for most local markets. If information about a seller's listing price could be obtained, it is very possible to provide further evidence on this debate as we have a better data set (monthly data) for price to examine the problem.

APPENDIX A

FOR ESSAY ONE

A1 EXPLANATION OF STATISTICAL TESTS FOR RATING REVALUATIONS

Table A.1 illustrates how the first three statistical tests were calculated. In this case, 9 houses sold within the 3 months prior to the effective date of the revaluation are used. For all of the properties, both the net sale price and the proposed revaluation were available for calculation. The value price ratios were calculated for each property and the median value price ratio of 0.986 was determined. To calculate the coefficient of dispersion (COD), the absolute differences between the median value price ratio for each of the individual value price ratios was first calculated. Then the summed absolute differences were divided by the number of sales to arrive at the average. Finally, the averaged absolute differences were divided by the median value price ratio and multiplied by 100 to get the COD. In this case, the estimated COD was 5.84; to obtain the price related differential (PRD), the mean and weighted mean of value price ratios were first calculated. The mean is the sum of all value price ratios divided by the number of sales and the weighted mean is the sum of revaluations divided by the sum of net sale prices. Finally, the PRD is the mean divided by the weighted mean. In the current example, the calculated PRD was 0.999.

Table A.1 Calculation of Statistical Tests for Rating Revaluations

Sale Number	Valuation Roll	Asset Number	Sale Date	Net Sale Price (NSP)	Revaluation (CV)	Ratio (CV/NSP)	Absolute Difference
1	2110	501	2/08/2004	255,000	240,000	0.941	0.045
2	2110	7502	15/08/2004	270,000	250,000	0.926	0.061
3	2110	1520	20/08/2004	370,000	365,000	0.986	0.000
4	2110	610	15/08/2004	365,000	350,000	0.959	0.028
5	2110	5151	26/08/2004	275,000	250,000	0.909	0.077
6	2110	2103	25/08/2004	210,000	225,000	1.071	0.085
7	2110	2118	12/08/2004	285,000	300,000	1.053	0.066
8	2110	7305	18/08/2004	350,000	385,000	1.100	0.114
9	2110	8806	28/08/2004	335,000	345,000	1.030	0.043
(1) Median Value Price Ratio						**0.986**	
Sum of absolute differences							0.519
Sum of absolute differences/number of sales							0.058
*(2) COD = 0.058/Median 0.986 * 100*							**5.844**
Sum of net sale prices				2,715,000			
Sum of revaluations					2,710,000		
Mean of Value Price Ratios						0.997	
Weighted Mean = Sum of revaluations/Sum of net sale prices						0.998	
(3) Price Related Differential = Mean/Weighted Mean						0.999	

Source: The Committee LINZ VAH (2004), pp. 26.

A2 POPULATION, DWELLINGS AND HOUSE SALES FOR THE SELECTED AREAS

Table A.2 Population and Dwellings

City/Region	Population	% of total NZ	Private dwellings	% of total NZ
Auckland region	1,321,074	32.8%	439,080	29.7%
Wellington region	456,654	11.3%	169,344	11.5%
Christchurch City	348,435	8.7%	135,261	9.1%
Palmerston North City	75,543	1.9%	27,849	1.9%
Nelson City	42,891	1.1%	17,328	1.2%
…	…	…	…	…
Total New Zealand	4,027,947	100.0%	1,478,709	100.0%

Source: Statistics New Zealand (2006)

Table A.3 Quarterly House Sales

City/Region	No. of sales	% of total NZ	% of Main urban areas
Auckland region	5,446	25.6%	42.3%
Wellington region	1,552	7.3%	12.0%
Christchurch City	2,247	10.6%	17.4%
Palmerston North City	439	2.1%	3.4%
Nelson City	245	1.2%	1.9%
…	…	…	…
Total New Zealand	21,275	100.0%	100.0%

Notes:

1. Sales information is for the quarter ending 30 September 2005.
2. The data is obtained from Quotable Value (2005).

A3 THE PROOF OF EQUATION (2.18)

The proof of $(1+d_1)(1+d_2)...(1+d_n) \approx (1+\bar{d})^n$ when d is small is based on the fact that the arithmetic mean is greater than the geometric mean. For $x_i, \quad i = 1,...,n$

$$\left((x_1 + x_2 + ... + x_n)/n\right) \geq \left(x_1 x_2 ... x_n\right)^{1/n}$$

Now let $x_i = (1+d_i)$, $i = 1,...,n$

The above equation becomes:

$$\left(1+\bar{d}\right) \geq \left((1+d_1)(1+d_2)...(1+d_n)\right)^{1/n} \Rightarrow \left(1+\bar{d}\right)^n \geq \left((1+d_1)(1+d_2)...(1+d_n)\right)$$

For small values of d

$\log(1+d) \approx d$ (The approximation is best when d is really small)

So $\log(1+d_i) \approx d_i, \quad i = 1,..,n$

Adding

$$\log(1+d_1)+\log(1+d_2)+...\log(1+d_n)\approx(d_1+d_2+..d_n)$$
$$\log\left((1+d_1)(1+d_2)...(1+d_n)\right)\approx n\overline{d}\approx n\log(1+\overline{d})=\log(1+\overline{d})^n$$
$$\Rightarrow(1+d_1)(1+d_2)...(1+d_n)\approx(1+\overline{d})^n$$

A4 ESTIMATED IMPACTS OF INCONSISTENCY ON SPAR INDICES

Table A.4 Estimated Impacts of Inconsistency Bias on SPAR Indices

	Models	
Region	Months (%)	Quarters (%)
North Shore City	0.03	-0.06
Waitakere City	-0.05	-0.73
Auckland City *	0.00	-0.64
Manukau City	0.05	-0.19
Papakura District	0.46	0.57
Porirua City	-0.20	-0.19
Upper Hutt City	0.05	0.84
Hutt City	-0.17	0.49
Christchurch City	0.01	0.81
Wellington City	1.47	4.63
Palmerston North	0.22	0.44
Nelson City	0.03	0.47

A5 REGRESSION ANALYSIS OF THE ESTIMATED INDICES

Regression analysis of index rate of change is also performed for model comparison. The regression model, which is proposed by Gatzlaff and Ling (1994), is as follows:

$$\Delta INDEX_i=\alpha+\beta\Delta INDEX_b+e \qquad \text{(A.1)}$$

where the $\Delta INDEX_i$ is the change rate of predicated index, and the $\Delta INDEX_b$ is the change of rate of benchmark index, which is the quality controlled WRSQ index.

The null hypothesis in the above regression is: $\alpha = 0$ and $\beta = 1$ will not be rejected. The results in Table A.6 show that $\beta = 1$ is rejected for all cities and $\alpha = 0$ is rejected for the SPAR index for most large cities except Waitakere City and Christchurch City. This is again evidence that there is substantial noise in monthly price indices. For example, the ΔWRSQ% explains only 35% to 45% of the variation in the ΔSPAR% for large cities, 25% to 30% for medium cities and 10% to 15% for small cities or districts. Among all the twelve cities studied, Wellington City and Hutt City have the lowest results of 12% and 8% respectively. However, from an economic viewpoint, the magnitude of the coefficient of estimate β in the ΔSPAR% regression is generally large with a small standard error. In large cities, β is generally above 0.5 with a standard error of 0.06. This is in contrast to the magnitude of the coefficient estimate of α , which is under 0.005 for all cities or districts.

When compared to the median price index, the results show that the ΔWRSQ% has almost no power (below 10%) to explain the variation in ΔMedian Index % for all cities. The magnitude of the coefficient estimates of α and β are large but often associated with substantial standard errors (SE). In other words the median price seems to be a good trend indicator in general but not in an accurate sense.

Table A.5 Regression Summary of Monthly Index Rate of Change, 1994M1 – 2004M12

	(△Median index%=α+β△WRSQ%+e)				(△SPAR index%=α+β△WRSQ%+e)			
	Observations	α	β	adj. R^2	Observations	α	β	adj. R^2
Cities	SER	(SE)	(SE)	DW	SER	(SE)	(SE)	DW
North Shore City	131	0.0060	0.2356	0.0016	131	0.0030	0.5308	0.3470
	0.0393	0.0037	0.2145	2.4978	0.0116	0.0011	0.0634	2.5319
Waitakere City	131	0.0031	0.6059	0.0797	131	0.0017	0.6884	0.4496
	0.0333	0.0031	0.1731	2.8210	0.0128	0.0012	0.0665	2.1932
Auckland City*	131	0.0043	0.4789	0.0247	131	0.0036	0.5260	0.3537
	0.0452	0.0044	0.2310	2.8842	0.0121	0.0012	0.0619	2.4941
Manukau City	131	0.0036	0.5275	0.0296	131	0.0036	0.3869	0.2395
	0.0497	0.0046	0.2368	2.8607	0.0125	0.0012	0.0597	2.5600
Papakura District	131	0.0102	-0.1385	-0.0055	131	0.0038	0.3568	0.1219
	0.0906	0.0081	0.2557	2.9988	0.0290	0.0026	0.0818	2.8489
Porirua City	131	0.0064	0.8580	0.0508	131	0.0038	0.3646	0.1686
	0.1049	0.0094	0.3041	2.8949	0.0240	0.0021	0.0697	3.0757
Upper Hutt City	131	0.0068	0.1588	-0.0024	131	0.0039	0.1890	0.0822
	0.0678	0.0060	0.1914	2.8452	0.0188	0.0017	0.0531	2.8992
Hutt City	131	0.0094	-0.3004	0.0005	131	0.0038	0.2344	0.0817
	0.0691	0.0063	0.2907	3.0319	0.0157	0.0014	0.0661	2.5031
Wellington City	131	0.0069	0.1995	-0.0025	131	0.0048	0.2862	0.1179
	0.0435	0.0041	0.2425	2.9746	0.0120	0.0011	0.0667	2.3375
Christchurch City	131	0.0033	0.4384	0.0338	131	0.0016	0.5810	0.3473
	0.0259	0.0025	0.1860	2.7359	0.0096	0.0009	0.0694	2.4925
Palmerston North City	131	0.0021	0.7713	0.0380	131	0.0017	0.4614	0.3111
	0.0625	0.0056	0.3113	2.9273	0.0120	0.0011	0.0597	2.8094
Nelson City	131	0.0053	0.6198	0.0362	131	0.0028	0.4276	0.2514
	0.0674	0.0060	0.2554	2.7629	0.0169	0.0015	0.0640	2.3479

Note: for Auckland City, the WRSQ is replaced by WRS since building consents data is not available for Auckland City in this study.

A6 MONTHLY AND QUARTERLY CORRELATIONS OF REPEAT SALES INDEX

Table A.6 Correlations of WRSQ Index Rate of Change, 1994 - 2004

Cities	Monthly level	Quarterly level
Large Cities:		
North Shore City	0.548	0.996
Waitakere City	0.614	0.996
Auckland City	0.522	0.995
Manukau City	0.423	0.991
Wellington City	0.388	0.988
Christchurch City	0.605	0.997
Medium Cities:		
Hutt City	0.24	0.982
Palmerston North City	0.387	0.997
Nelson City	0.484	0.994
Small Cities:		
Papakura District	0.317	0.965
Porirua City	0.175	0.963
Upper Hutt City	0.185	0.968

Notes:

1. At monthly level, the corresponding quarterly index is transformed into a monthly index by using linear match last method provided in Eviews.
2. At quarterly level, the corresponding monthly index is transformed into quarterly index by using average method provided in Eviews.

APPENDIX B

FOR ESSAY TWO

B1 REASONS FOR USING LOG TRANSFORMATIONS

Exponential price growth in levels can become linear growth in transformed series. The use of natural logarithmic transformations on house price movements allows the variance to be stabilised and outliers to be less influential. Furthermore, the coefficients in the proposed VAR models for such transformed price series will have a percentage change interpretation. The first differencing of log prices is approximate to the growth rates of price movements. This is demonstrated in the following algebraic exercise:

$$\begin{aligned}
\Delta \log(X_t) &= \log(X_t) - \log(X_{t-1}) \\
&= \log\left(\frac{X_t}{X_{t-1}}\right) \\
&= \log\left(1 + \frac{X_t - X_{t-1}}{X_{t-1}}\right) \\
&\approx \frac{X_t - X_{t-1}}{X_{t-1}}
\end{aligned}$$

B2 ADDITIONAL STATISTICAL RESULTS

Table B.1 Standard Granger Causality Tests of Price and Volume

Null hypothesis		*P*-values MDAN	SPAR	WRSQ
Large Cities:				
North Shore City				
	∆P does not Granger cause ∆V	0.583	0.106	0.762
	∆V does not Granger cause ∆P	0.626	0.039	0.006
Waitakere City				
	∆P does not Granger cause ∆V	0.496	0.339	0.558
	∆V does not Granger cause ∆P	0.065	0.035	0.071
Auckland City				
	∆P does not Granger cause ∆V	0.201	0.247	0.295
	∆V does not Granger cause ∆P	0.375	0.024	0.084
Manukau City				
	∆P does not Granger cause ∆V	0.309	0.478	0.812
	∆V does not Granger cause ∆P	0.458	0.004	0.002
Wellington City				
	∆P does not Granger cause ∆V	0.205	0.077	0.290
	∆V does not Granger cause ∆P	0.162	0.036	0.001
Christchurch City				
	∆P does not Granger cause ∆V	0.123	0.104	0.492
	∆V does not Granger cause ∆P	0.613	0.103	0.087
Small Cities:				
Papakura District				
	∆P does not Granger cause ∆V	0.512	0.098	0.575
	∆V does not Granger cause ∆P	0.503	0.064	0.506
Porirua City				
	∆P does not Granger cause ∆V	0.568	0.992	0.725
	∆V does not Granger cause ∆P	0.549	0.948	0.854
Upper Hutt City				
	∆P does not Granger cause ∆V	0.262	0.508	0.462
	∆V does not Granger cause ∆P	0.231	0.309	0.286
Hutt City				
	∆P does not Granger cause ∆V	0.371	0.163	0.221
	∆V does not Granger cause ∆P	0.889	0.163	0.261
Palmerston North City				
	∆P does not Granger cause ∆V	0.995	0.144	0.912
	∆V does not Granger cause ∆P	0.050	0.099	0.037
Nelson City				
	∆P does not Granger cause ∆V	0.289	0.451	0.487
	∆V does not Granger cause ∆P	0.179	0.383	0.235

Notes:

The VAR model is based on the following equation:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + \sum_{i=1}^{3} \lambda_i \Delta p_{t-i} + 11\ seasonal\ dummies + \varepsilon_t$$

where x and y are log prices and log volumes and vice versa, α_0 is constant and ε is white noise. P is the spatial lag. For the Auckland region, p is the log price for Auckland City. For the Wellington region, p is the log price for Wellington City. For other cities, no spatial lags are incorporated in the above model

Table B.2 Johansen Cointegration Tests of Price and Volume

	r=0			r=1			No. of cointegration	Optimal Lags in levels
	Eigen	Trace	P - value	Eigen	Trace	P - value		
Large Cities:								
North Shore City								
MDAN	0.166	23.469	0.003	0.001	0.065	0.799	1	3
SPAR	0.512	93.535	0.000	0.002	0.195	0.659	1	2
WRSQ	0.378	61.441	0.000	0.001	0.117	0.732	1	3
Waitakere City								
MDAN	0.204	30.677	0.000	0.009	1.224	0.269	1	3
SPAR	0.477	88.334	0.000	0.025	3.311	0.069	1	1
WRSQ	0.450	79.559	0.000	0.013	1.762	0.184	1	2
Auckland City								
MDAN	0.269	39.817	0.000	0.001	0.087	0.769	1	5
SPAR	0.307	47.845	0.000	0.004	0.507	0.477	1	3
WRSQ	0.334	53.180	0.000	0.002	0.246	0.620	1	2
Manukau City								
MDAN	0.114	15.560	0.049	0.002	0.215	0.643	1	5
SPAR	0.451	78.540	0.000	0.005	0.619	0.432	1	2
WRSQ	0.278	42.804	0.000	0.004	0.490	0.484	1	2
Wellington City								
MDAN	0.205	28.904	0.000	0.001	0.180	0.671	1	7
SPAR	0.312	48.596	0.000	0.000	0.047	0.828	1	2
WRSQ	0.132	17.543	0.024	0.001	0.174	0.677	1	9
Christchurch City								
MDAN	0.129	18.866	0.015	0.007	0.925	0.336	1	2
SPAR	0.317	49.528	0.000	0.000	0.006	0.938	1	2
WRSQ	0.372	60.642	0.000	0.002	0.258	0.611	1	2
Small Cities:								
Papakura District								
MDAN	0.071	9.903	0.288	0.004	0.507	0.476	none	4
SPAR	0.268	40.568	0.000	0.004	0.569	0.451	1	4
WRSQ	0.220	32.268	0.000	0.003	0.438	0.508	1	4
Porirua City								
MDAN	0.081	10.801	0.224	0.001	0.124	0.724	none	5
SPAR	0.120	18.715	0.016	0.017	2.168	0.141	1	3
WRSQ	0.128	19.522	0.012	0.016	2.001	0.157	1	4
Upper Hutt City								
MDAN	0.109	16.088	0.041	0.016	1.932	0.165	1	9
SPAR	0.171	26.893	0.001	0.021	2.773	0.096	1	3
WRSQ	0.148	24.687	0.002	0.032	4.175	0.041	2	4
Hutt City								
MDAN	0.069	9.111	0.355	0.001	0.090	0.764	none	5
SPAR	0.161	25.661	0.001	0.024	3.081	0.079	1	3
WRSQ	0.103	15.963	0.043	0.015	1.959	0.162	1	3
Palmerston North City								
MDAN	0.084	17.258	0.027	0.047	6.170	0.013	2	5
SPAR	0.356	62.348	0.000	0.043	5.649	0.018	2	3
WRSQ	0.318	56.370	0.000	0.053	7.090	0.008	2	3
Nelson City								
MDAN	0.118	16.044	0.041	0.000	0.029	0.864	1	4
SPAR	0.140	20.042	0.010	0.006	0.805	0.370	1	4
WRSQ	0.150	21.065	0.007	0.002	0.273	0.601	1	4

Notes:

1. The optimal lag is determined by AIC criteria at a maximum lag of 12 with seasonal dummies.
2. Test includes a constant in CE and a constant and 11 seasonal dummy variables in the VAR.

Table B.3 Granger Causality Test of Price and Volume Based on the VECM

	H_0: ΔV does not Granger cause ΔP		H_0: ΔP does not Granger cause ΔV	
	F-statistic	Error-corr.	F-statistic	Error-corr.
Large Cities:				
North Shore City				
MDAN	0.627	-3.552 **	0.770	-1.034
SPAR	1.367	-4.148 **	1.473	-1.447
WRSQ	1.195	-5.099 **	0.519	-1.438
Waitakere City				
MDAN	0.939	-4.062 **	0.897	-0.768
SPAR	1.069	-4.564 **	1.051	-1.053
WRSQ	1.170	-3.791 **	0.825	-0.851
Auckland City				
MDAN	0.710	-3.670 **	1.443	-1.855
SPAR	0.598	-4.864 **	1.545	-1.783
WRSQ	1.037	-3.289 **	1.196	-1.803
Manukau City				
MDAN	0.565	-3.223 **	1.094	-1.428
SPAR	1.385	-4.179 **	0.808	-2.221 **
WRSQ	1.867	-3.537 **	0.391	-1.991 **
Wellington City				
MDAN	1.500	-1.568	0.865	-3.695 **
SPAR	1.810	-1.505	1.129	-3.693 **
WRSQ	2.107 **	-3.172 **	1.011	-3.739 **
Christchurch City				
MDAN	0.732	-4.217 **	1.516	-0.995
SPAR	0.733	-3.627 **	1.632	-1.149
WRSQ	0.917	-3.509 **	0.979	-1.077
Small Cities:				
Papakura District				
MDAN	1.057	-2.225 **	0.920	-0.799
SPAR	1.474	-2.534 **	1.220	-2.179 **
WRSQ	1.338	-0.901	0.626	-1.732
Porirua City				
MDAN	1.074	-0.829	0.853	-2.183 **
SPAR	0.457	-0.440	0.339	-2.574 **
WRSQ	0.552	-1.185	0.589	-2.523 **
Upper Hutt City				
MDAN	1.782	-0.322	1.108	-1.674
SPAR	0.998	-2.481 **	0.787	-1.846
WRSQ	0.901	-3.189 **	0.765	-1.874
Hutt City				
MDAN	0.671	-2.081 **	0.928	-2.418 **
SPAR	1.279	-1.353	1.219	-2.383 **
WRSQ	1.237	-0.366	1.004	-2.613 **
Palmerston North City				
MDAN	2.135 **	-0.726	0.299	-2.027 **
SPAR	1.455	-1.516	1.528	-0.920
WRSQ	1.084	-4.060 **	0.529	-0.828
Nelson City				
MDAN	0.803	-3.567 **	0.795	-2.282 **
SPAR	0.571	-3.036 **	0.760	-2.223 **
WRSQ	1.069	-2.294 **	0.674	-2.227 **

Notes:

1. the VECM model is defined as follows:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{12} \alpha_i \Delta x_{t-i} + \sum_{i=1}^{12} \beta_i \Delta y_{t-i} + \alpha_1 \mu_{t-1} + \sum_{i=1}^{3} \lambda_i \Delta p_{t-i} + 11\, seasonal\ dummies + \varepsilon_t$$

where x and y are log prices and log volumes and vice versa, α_0 is constant, μ is the error correction term and ε is white noise. P is the spatial lag. For the Auckland region, p is the log price for Auckland City. For the Wellington region, p is the log price for Wellington City. For other cities, no spatial lags are incorporated in the above model.

Table B.4 The estimates of the coefficients for the error-correction terms in equation (3.14)

	Auckland Region					Wellington Region	
	CointEq1	CointEq2	CointEq3	CointEq4		CointEq1	CointEq2
MDAN index:					MDAN index:		
NS	-0.251	0.082	0.311		PR	-0.203	0.022
WK	0.057	-0.241	0.153		UH	0.130	-0.185
AK	0.165	-0.167	-0.098		HT	-0.148	-0.111
MK	0.285	-0.190	-0.262		WT	-0.022	0.021
PP	-0.397	0.187	0.397				
SPAR index:					SPAR index:		
NS	0.004	-0.102			PR	0.008	
WK	0.007	-0.187			UH	-0.062	
AK	-0.030	0.045			HT	-0.105	
MK	-0.071	0.014			WT	-0.082	
PP	-0.214	0.112					
WRSQ index:					WRSQ index:		
NS	-0.153	0.077	0.101	0.059	PR	0.006	-0.073
WK	0.308	-0.272	-0.110	0.131	UH	0.086	-0.391
AK	0.053	-0.015	0.018	0.078	HT	-0.062	-0.222
MK	0.031	0.196	0.223	-0.579	WT	-0.019	0.065
PP	0.070	-0.542	0.087	-0.153			

Note:

1. The number of cointegration equation (CointEq) is determined in the Johansen cointegration rank test

APPENDIX C

FOR ESSAY THREE

C1 RANDOM WALK TESTS FOR QUARTERLY PRICE CHANGES

Table C.1 Results of Autocorrelations of Quarterly Price Changes

	Autocorrelation at lag				p-values	
City	1	2	3	4	Q2	Q4
Panel A: Median Index						
Large Cities:						
North Shore CIty	0.012	0.162	0.163	-0.069	(0.538)	(0.599)
Waitakere City	0.23	0.06	0.353	0.104	(0.273)	(0.058)
Auckland City	-0.055	0.285	0.021	0.122	(0.137)	(0.316)
Manukau City	-0.153	-0.052	0.024	-0.015	(0.548)	(0.871)
Wellington City	-0.173	0.105	-0.237	0.366	(0.389)	(0.024)
Christchurch City	0.339	0.138	0.127	0.462	(0.045)	(0.001)
Small Cities:						
Hutt City	-0.335	0.027	-0.236	0.458	(0.074)	(0.001)
Palmerston North City	-0.336	0.215	0.084	0.102	(0.025)	(0.083)
Nelson City	-0.163	0.084	0.32	-0.066	(0.460)	(0.151)
Papakura City	-0.421	-0.058	0.255	-0.27	(0.016)	(0.005)
Porirua City	-0.525	0.138	-0.188	0.214	(0.001)	(0.001)
Upper Hutt City	-0.273	-0.063	0.052	0.094	(0.163)	(0.381)
Panel B: SPAR Index						
Large Cities:						
North Shore City	0.659	0.418	0.365	0.392	(0.000)	(0.000)
Waitakere City	0.65	0.287	0.176	0.182	(0.000)	(0.000)
Auckland City	0.569	0.263	0.277	0.267	(0.000)	(0.000)
Manukau City	0.61	0.405	0.294	0.379	(0.000)	(0.000)
Wellington City	0.32	0.133	-0.141	-0.072	(0.062)	(0.149)
Christchurch City	0.649	0.532	0.48	0.457	(0.000)	(0.000)
Small Cities:						
Hutt City	0.584	0.344	0.248	0.279	(0.000)	(0.000)
Palmerston North City	0.671	0.544	0.483	0.361	(0.000)	(0.000)
Nelson City	0.698	0.505	0.391	0.199	(0.000)	(0.000)
Papakura City	0.441	0.419	0.331	0.292	(0.000)	(0.000)
Porirua City	-0.061	0.052	0.015	0.213	(0.862)	(0.634)
Upper Hutt City	0.294	0.31	0.323	0.197	(0.014)	(0.004)
Panel C: WRSQ Index						
Large Cities:						
North Shore City	0.624	0.425	0.329	0.294	(0.000)	(0.000)

Waitakere City	0.65	0.345	0.297	0.295	(0.000)	(0.000)
Auckland City	0.534	0.299	0.236	0.229	(0.000)	(0.000)
Manukau City	0.56	0.348	0.33	0.213	(0.000)	(0.000)
Wellington City	0.308	0.199	0.144	-0.095	(0.045)	(0.105)
Christchurch City	0.815	0.738	0.542	0.444	(0.000)	(0.000)
Small Cities:						
Hutt City	0.129	0.195	0.207	0.025	(0.278)	(0.323)
Palmerston North City	0.525	0.416	0.491	0.299	(0.000)	(0.000)
Nelson City	0.66	0.508	0.364	0.229	(0.000)	(0.000)
Papakura City	0.115	0.246	0.212	0.219	(0.176)	(0.091)
Porirua City	0.019	0.088	0.156	0.044	(0.825)	(0.798)
Upper Hutt City	-0.062	0.135	0.25	0.073	(0.594)	(0.364)

Note: The figures presented are the autocorrelations up to and including that lag. P-values associated with the Q-statistics are presented in parentheses. Sample period is from Q1, 1994 to Q4, 2004. Total sample size is 44.

Table C.2 Results of Variance Ratios on Quarterly Price Change

	Quarterly price changes								
City	q=2	Z*(q)		q=4	Z*(q)		q=8	Z*(q)	
				Panel A: Median Index					
Large Cities:									
North Shore City	1.04	0.25		1.34	1.11		2.11	2.36	**
Waitakere City	1.28	2.04	**	1.76	2.68	**	2.91	4.33	**
Auckland City	0.96	-0.27		1.30	1.10		2.02	2.43	**
Manukau City	0.88	-1.02		0.78	-0.92		0.97	-0.07	
Wellington City	0.83	-1.13		0.81	-0.68		0.95	-0.12	
Christchurch City	1.39	2.51	**	1.90	3.01	**	2.74	3.43	**
Small Cities:									
Hutt City	0.68	-2.03	**	0.45	-1.98	**	0.47	-1.20	
Palmerston North City	0.69	-1.88	*	0.84	-0.53		0.86	-0.30	
Nelson City	1.04	0.25		1.34	1.11		2.11	2.36	**
Papakura City	0.60	-2.30	**	0.50	-1.52		0.50	-0.97	
Porirua City	0.48	-2.90	**	0.26	-2.47	**	0.21	-1.88	*
Upper Hutt City	0.74	-1.79	*	0.60	-1.50		0.66	-0.81	
				Panel B: SPAR Index					
Large Cities:									
North Shore City	1.73	4.04	**	2.91	6.01	**	5.12	8.99	**
Waitakere City	1.69	3.63	**	2.50	4.65	**	4.08	6.87	**
Auckland City	1.60	3.74	**	2.37	4.75	**	4.12	7.27	**
Manukau City	1.68	3.44	**	2.80	5.35	**	5.02	8.31	**
Wellington City	1.38	2.44	**	1.78	2.78	**	2.04	2.39	**
Christchurch City	1.68	3.13	**	3.12	5.50	**	5.34	7.63	**
Small Cities:									
Hutt City	1.63	3.38	**	2.56	4.78	**	3.35	4.97	**
Palmerston North City	1.71	3.24	**	3.00	5.30	**	4.54	6.50	**
Nelson City	1.77	2.98	**	3.10	4.52	**	5.10	6.07	**
Papakura City	1.49	3.16	**	2.54	5.39	**	4.51	8.25	**
Porirua City	0.98	-0.13		1.11	0.34		1.44	0.91	
Upper Hutt City	1.31	2.32	**	2.14	4.06	**	2.77	4.03	**
				Panel C: WRSQ Index					
Large Cities:									
North Shore City	1.69	4.17	**	2.82	6.01	**	4.89	8.89	**
Waitakere City	1.71	3.85	**	2.73	5.34	**	4.74	8.26	**
Auckland City	1.58	3.60	**	2.34	4.74	**	4.09	7.40	**
Manukau City	1.59	3.59	**	2.56	5.24	**	4.54	8.18	**
Wellington City	1.36	2.47	**	1.99	3.56	**	2.51	3.45	**
Christchurch City	1.90	3.65	**	3.66	6.08	**	5.87	8.05	**
Small Cities:									
Hutt City	1.12	1.01		1.59	2.64	**	1.95	2.49	**
Palmerston North City	1.55	2.79	**	2.64	4.69	**	3.83	5.38	**
Nelson City	1.72	2.84	**	2.98	4.24	**	4.85	5.51	**
Papakura City	1.17	1.08		1.74	2.58	**	2.93	4.54	**
Porirua City	1.01	0.04		1.34	1.21		1.64	1.50	
Upper Hutt City	0.93	-0.47		1.29	1.05		1.64	1.47	

Notes:

1. Column m represents the variance ratios of that overlapping q-period return, z(q) represents the standardized heteroskedasticity consistent test for that variance ratio. Under the random walk hypothesis, the value of the variance ratio should be equal to one. Sample period is from Q1, 1994 to Q4, 2004. Total sample size is 44.

** indicates statistical significant at the 0.05 level
* indicates statistical significant at the 0.10 level

C2 RESULTS OF UNIT ROOT TEST FOR HOUSE PRICE, RENT AND RENT TO PRICE RATIO

Table C.3 Results of ADF Unit Roots Test

City	Index	Level (constant)	Level (constant & trend)		1st Diff (constant)	
Large Cities:						
North Shore City						
	MDAN	-0.454	-1.443		-11.351	**
	SPAR	-0.461	-1.391		-3.986	**
	WRSQ	-0.514	-1.354		-3.679	**
	Rent	-1.411	-1.861		-3.363	*
	R/P $ratio_m$	-0.672	-2.730		-10.421	**
	R/P $ratio_s$	-0.006	-0.916		-10.421	**
	R/P $ratio_r$	0.048	-0.825		-11.014	**
Waitakere City						
	MDAN	-1.577	-2.003		-11.124	**
	SPAR	-1.909	-2.185		-4.826	**
	WRSQ	-1.071	-1.711		-3.899	**
	Rent	-2.088	-3.187		-1.806	
	R/P $ratio_m$	-0.874	-2.444		-9.891	**
	R/P $ratio_s$	-1.873	-2.641		-6.940	**
	R/P $ratio_r$	-0.680	-1.470		-8.179	**
Auckland City						
	MDAN	0.097	-1.474		-4.131	**
	SPAR	-0.804	-1.601		-4.815	**
	WRSQ	-0.440	-1.375		-4.776	**
	Rent	-1.882	-1.865		-11.275	**
	R/P $ratio_m$	0.543	-1.367		-9.806	**
	R/P $ratio_s$	-0.420	-1.821		-10.712	**
	R/P $ratio_r$	0.128	-1.298		-11.258	**
Manukau City						
	MDAN	-1.009	-3.291		-8.806	**
	SPAR	-0.749	-1.759		-2.987	*
	WRSQ	-0.542	-1.312		-5.382	**
	Rent	-1.923	-2.873		-2.956	*
	R/P $ratio_m$	-1.267	-5.920	**	-10.034	**
	R/P $ratio_s$	-0.817	-1.893		-9.902	**
	R/P $ratio_r$	-0.486	-1.814		-10.030	**
Wellington City						
	MDAN	0.190	-2.010		-3.694	**
	SPAR	0.318	-1.597		-12.022	**
	WRSQ	-0.156	-1.715		-5.021	**
	Rent	-1.975	-4.005	*	-6.630	**
	R/P $ratio_m$	0.346	-4.266	**	-8.662	**
	R/P $ratio_s$	-0.102	-3.557	*	-10.715	**

	R/P ratio$_r$	0.035	-2.979	-11.882 **
Christchurch City				
	MDAN	1.869	0.390	-1.113
	SPAR	-1.245	-2.492	-2.582
	WRSQ	-0.103	-2.181	-1.739
	Rent	0.505	-0.727	-1.849
	R/P ratio$_m$	-0.638	-2.313	-16.152 **
	R/P ratio$_s$	-1.904	-2.317	-14.035 **
	R/P ratio$_r$	-0.315	-0.981	-1.941
<u>Small Cities:</u>				
Hutt City				
	MDAN	0.756	-2.857	-9.531 **
	SPAR	1.569	-1.565	-4.497 **
	WRSQ	1.864	-0.682	-12.187 **
	Rent	-1.746	-1.558	-6.639 **
	R/P ratio$_m$	1.816	-1.849	-7.275 **
	R/P ratio$_s$	2.326	-1.203	-9.040 **
	R/P ratio$_r$	2.292	-0.313	-6.771 **
Palmerston North City				
	MDAN	1.470	-0.549	-8.848 **
	SPAR	2.856	2.711	-1.435
	WRSQ	4.826	2.389	-3.215 *
	Rent	2.325	0.934	-3.953 **
	R/P ratio$_m$	-0.640	-2.503	-9.128 **
	R/P ratio$_s$	1.403	0.785	-2.558
	R/P ratio$_r$	2.491	0.829	-2.587
Nelson City				
	MDAN	-0.291	-2.117	-2.104
	SPAR	-1.112	-2.024	-2.248
	WRSQ	-0.565	-1.830	-2.658
	Rent	-0.061	-1.533	-2.895 *
	R/P ratio$_m$	-0.214	-1.708	-2.741
	R/P ratio$_s$	-0.791	-1.282	-3.990 **
	R/P ratio$_r$	-1.126	-1.824	-11.453 **
Papakura District				
	MDAN	-1.029	-2.967	-7.801 **
	SPAR	-0.975	-1.733	-17.693 **
	WRSQ	-1.411	-1.774	-15.724 **
	Rent	-2.092	-2.317	-19.070 **
	R/P ratio$_m$	-0.140	-9.720 **	-5.041 **
	R/P ratio$_s$	-1.452	-1.927	-12.417 **
	R/P ratio$_r$	-1.300	-2.914	-9.297 **
Porirua City				
	MDAN	0.623	-2.927	-9.126 **
	SPAR	1.520	-1.401	-11.927 **
	WRSQ	1.492	-1.235	-9.826 **
	Rent	-0.941	-6.900 **	-8.967 **
	R/P ratio$_m$	-0.432	-3.079	-10.765 **
	R/P ratio$_s$	1.929	-1.653	-8.652 **
	R/P ratio$_r$	1.459	-2.035	-8.938 **

Upper Hutt City					
	MDAN	2.217	-2.372	-8.256	**
	SPAR	2.938	-0.233	-18.700	**
	WRSQ	2.057	-0.673	-13.166	**
	Rent	-0.861	-2.087	-7.330	**
	R/P $ratio_m$	1.739	-0.987	-3.987	**
	R/P $ratio_s$	1.113	-1.314	-12.430	**
	R/P $ratio_r$	1.940	-0.805	-13.404	**
Critical value at 1%		-3.482	-4.032	-3.482	
Critical value at 5%		-2.884	-3.446	-2.884	

[a] The optimum lag is determined by AIC criteria at a maximum lag of 12.

**Significant at 1% level

*Significant at 5% level

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