EVALUATING A HOUSE PRICE INDEX BASED ON THE SALE PRICE APPRAISAL RATIO (SPAR) METHOD

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Abstract

This paper contributes to the literature on the sale price appraisal ratio (SPAR) as an alternative house price index methodology. Housing market transaction data for 12 cities or districts in New Zealand for the period 1994 – 2004 is utilised to test the effect of measurement errors in assessed values on index accuracy and temporal aggregation on index stability. The main findings are: 1) temporal aggregation effect on the SPAR index stability is a constraint at the monthly level with respect to this New Zealand data set. 2) reporting sample size has a much larger effect on the precision of the SPAR index than the frequency of reassessments. Random measurement errors in assessed values tend to cancel out each other when the number of sales per period is large. 3) Any reassessment tends to disturb the SPAR index for the reassessment period. Consistency errors in assessed values tend to be more likely to accumulate when more frequent reassessment exercises are engaged.

Keywords: SPAR House Price Index

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1. Introduction

In New Zealand the official house price index is produced by Quotable Value Ltd (QV). The QV House Price Index (HPI) measures the movement in house prices for local authorities throughout New Zealand on a quarterly basis. The method used by QV HPI is called the Sale Price Appraisal Ratio (SPAR) method which is different from the most widely accepted alternative approaches to index construction, such as the hedonic model and the repeat sales model.

So far only a few countries in the world including New Zealand, Denmark, Sweden and the Netherlands use the SPAR technique to produce house price indices. For this reason it is not surprising that there is not of much literature regarding the testing the reliability of the SPAR technique. Recent scholarly works include Bourassa et al (2006), Wal, Steege and Kroese (2006, November) and Rosini and Kershaw (2006). Bourassa et al (2006) compared the SPAR index with other alternatives including repeat sales and hedonic models. They promoted the SPAR index technique as an alternative to other methods. However their comparisons are on a semi-annual basis compared to the official QV HPI. The measurement errors in assessment values by producing the SPAR index itself and the temporal aggregation effect on index stability are not investigated. Based on house price data in Netherlands, Wal et al (2006, November) achieved similar results as Bourassa et al (2006) but they were cautious about the reliability effect of the appraisal data set on the SPAR index as a whole. In 2006 Rosini and Kershaw tested the temporal aggregation effect on the SPAR index for Australia. They used the coefficient of variation as a tool to measure the index lumpiness and their findings showing that the SPAR index outperformed others at weekly level in terms of the index lumpiness.

The many and varied approaches used to construct a house price index have been a key focus of real estate market research since the 1960's. An important conclusion from these past and new developments in housing index literature is that we need a good and simple price index for analysis using the finest time interval if possible. The SPAR index appears to be within the good index criteria as tested by Bourassa et al (2006). However the index's reliability is subject to more robust research (Wal et al., 2006, November). Unless this situation is rectified, it is unlikely that the SPAR technique itself will be seen as a robust alternative method when calculating movement in house prices internationally. These factors lead to the conclusion that this paper is important, particularly in New Zealand or other places that are currently using or contemplating a SPAR index.

The findings in this paper have some important policy implications. The results show that reporting the SPAR index at a monthly level is quite possible, especially for large cities. This is an obvious improvement as index timeliness is likely to become more important, particularly for property derivatives. Another somewhat surprising implication is that the SPAR index may not perform as well as expected if the assessment values are reassessed frequently. This was seen in the quarterly SPAR index for Wellington City where assessments were done annually and was upwardly biased by an average of 4.63% in total over the time period between 1994 and 2004. The result is in sharp contrast to the less frequently reassessed SPAR indices for which the accumulated reassessment errors are within positive or negative 1% range in total over the same time period. Finally the SPAR technique is more data efficient than the repeated sales method since it uses almost all sales rather than just repeated sales. This implies that in small countries like New Zealand where both the housing market and transaction volume per period is small, the SPAR index is a good choice of measurement of changing house prices.

This paper is organised as follows. Section 2 provides background information about the New Zealand house price index and rating system. Section 3 reviews the housing price index mainly focusing on the repeat sales method and the SPAR technique. Section 4 describes the New Zealand data utilised in this research. Section 5 discusses the empirical results of the SPAR technique for temporal aggregation and measurement errors in assessed values. Section 6 provides a conclusion.

2. The New Zealand House Price Index and Rating System

Two housing price indices are available in New Zealand for the measurement of housing market movement. One is the quarterly QV house price index using the SPAR technique and the other is the monthly Real Estate Institute of New Zealand (REINZ) median house price index. Quotable Value (QV) collects the sales data through the legal reporting system for sales and calculates house price index on a quarterly basis, with a three month lag to ensure that the index takes into account as many sales for that period as possible. By using the real estate agency reporting system the Real Estate Institute of New Zealand (REINZ) reports the monthly house price index with only about a few weeks lag.

Under the Rating Valuations Act 1998, all residential properties in New Zealand are required to reassess their tax values on a regular basis. This is often done by local authorities on a 3 yearly basis although some local authorities, such as the Wellington City Council, reassess their properties on an annual basis. In theory the assessment values (known in New Zealand as “Capital Values”) should be very close to their market values (sale prices) less chattels as at the assessment date. In practice, as has been well discussed in the literature (Berry and Bednarz, 1975; Goolsby, 1997), assessment errors in assessed values do exist systematically and randomly throughout the whole housing stock. There are several sources for these 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 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.

With respect to the methodology used in valuing residential properties for rating purposes, the sales comparison approach is the underlying method which is often supported by using the index technique and lump sum adjustment. The index technique is similar to using 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.

However, rating valuations (assessment values) have to meet the minimum statistical compliance requirements as contained in the Rating Valuations Rules version 3.1 (2002) in New Zealand. The statistical test is very similar to the standard as outlined in International Association of Assessing Officers (1999) and we do not intend to review all these statistical tests in detail in this study.

3. Repeat Sales Method and SPAR Technique

Apart from developments with the repeat sales method, it is suggested that the traditional repeat sales method provides a geometric measurement of house price appreciation. It is well known that arithmetic means are always greater than or equal to the geometric means. Some researchers are investigating the arithmetic forms of the repeat sales method. Among them Shiller (1991) proposed the value-weighted arithmetic repeat sales estimator based on the BMN method, which can be expressed as follows:

$$Y = \beta X + u \qquad (1)$$

Where β is coefficient vector, X is a n×T (time period) matrix with the first sale price being a negative, the second sale price being a positive and zero for no transactions. Y is n dimensional column vector with the first sale price in base period 0 and zero for all others.

By calculating the ordinary least-squares (OLS) regression coefficient vector β, the price index in period *t* can be expressed as the ratio of the average sale prices of all houses sold in period *t* divided by their average 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).

$$\hat{\beta}_t^{-1} = \frac{\sum_{i=1}^{n_t} P_{it}}{\sum_{i=1}^{n_t} \hat{\beta}_{t'} P_{it'}} \qquad (2)$$

Where $\hat{\beta}_t^{-1}$ is the estimated index for the time period *t* in related to the base period 0. n_t is the number of sales in period *t*. P_{it} is the *i*th property sale price in the time period *t*. $P_{it'}$ is the *i*th property sale price in the previous time period *t'*. $\hat{\beta}_{t'}$ is the reverse of the estimated house price index for time period *t'.*

By dividing each row of Y and X in the above equation (1) by the price of the first sale corresponding to that row, an equally-weighted arithmetic repeat sales price index can be obtained.

The SPAR index, which is formulated by relating property sale prices to their respective assessed values, can be viewed as one of the above arithmetic forms of the repeat sales methods regardless whether it is equally weighted or value weighted. The only difference between the SPAR technique and Shiller's arithmetic forms of the repeat sales method is that the 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).

The value weighted form of a SPAR index can be written as:

$$\begin{cases} SPAR_{Vt} = \dfrac{\sum_{i=1}^{n_t} P_{it}}{\sum_{i=1}^{n_t} V_{i0}} \\ I_{Vt} = \dfrac{SPAR_{Vt}}{SPAR_{Vt-1}} \end{cases} \quad (3)$$

Where $SPAR_{Vt}$ is the value-weighted SPAR ratio at the *t* time period. I_{Vt} is the *t* time period value-weighted price index relative to the base period 0. n_t is the total number of sales at the time period *t*. P_{it} represents the ith property sold in time period *t*. V_{i0} is the *i*th property's assessed value in the base period 0.

The equally weighted form of a SPAR index is:

$$\begin{cases} SPAR_{Et} = \dfrac{\sum_{i=1}^{n_t} P_{it} / V_{i0}}{n_t} \\ I_{Et} = \dfrac{SPAR_{Et}}{SPAR_{Et-1}} \end{cases} \quad (4)$$

where $SPAR_{Et}$ is the equal-weighted SPAR ratio at the *t* time period. I_{Et} is the *t* time period equal-weighted price index relative to the base period 0.

Therefore if the base period appraisal values are similar to their "inferred" base period prices, the SPAR technique will be superior to the repeat sale method as the SPAR technique is far more data efficient than the repeat sale method. However if the base period assessed values are different from their "inferred" prices at large, it would be difficult to predict which method is better.

One problem associated with the SPAR index is that for rating purposes assessed values are often 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 before the next reassessment. In other words, the above formulas (3) and (4) are the correct SPAR index forms within each assessment period. As at the reassessment period, both the current SPAR ratio (calculated by using the new updated assessed values) and the previous SPAR ratio (calculated by staying with the old assessed values) have to be calculated in order to bring the index over time. A general expression of a SPAR index can be as follows:

$$\begin{cases} I_t = \dfrac{Current\ SPAR_t}{Current\ SPAR_{t-1}} \times I_{t-1} \quad when\ t \neq reassessment\ \ period \\ I_t = \dfrac{\Pr evious\ SPAR_t}{Current\ SPAR_{t-1}} \times I_{t-1} \quad when\ t = reassessment\ \ period \end{cases} \quad (5)$$

Where the current and previous *SPAR* ratios are calculated from formula (3) or (4) depending on whether the index is equal-weighted or value-weighted.

One of the unique features of the SPAR index technique is that the SPAR index is independently related to the base period's price index. Late sales only affect their own period's index but do not affect other periods as the repeat sales method does. However reassessments tend to disturb the index's consistency over time since the new assessed values will form a new relevant reference point for the SPAR index's construction until the next reassessment period. How this will affect the SPAR index is of interest.

For this research the equal weighted form of the SPAR technique (formula 4 & 5) is used for investigation.

4. The Data and Preparation

This research utilises a rich dataset of 449,221 freehold open market transactions of detached or semi-detached houses in selected urban areas in New Zealand between 1994 Q1 and 2004 Q4. The data was supplied from Quotable Value (QV) New Zealand, the official database of all property transactions in New Zealand, which is considered as very comprehensive and highly reliable in terms of individual property details and receiving notification of changes from councils as well as regular site or roadside inspections when updating the data base.

For each transaction it includes a property ID, total selling price, value of chattels, sale date, 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 prior to the sale either from the local authority or from the home owners. Unfortunately the building notice of change data for Auckland City is not available in this supplied data set.

The geographical areas cover:

- The Auckland region: including North Shore, Waitakere, Auckland, Manukau and Papakura
- The Wellington region: including Porirua, Upper Hutt, Hutt and Wellington
- Christchurch City
- Nelson City
- Palmerston North City

The primary reasons for choosing the Auckland region, Wellington region and Christchurch City in this study are because of their significant influence on the overall housing stock as a whole in New Zealand and their larger periodical sale volumes. The combined population of the above three areas is more than half the national figure and the combined quarterly sales is more than two thirds of the total sales of the main urban areas.

In this study, the North Shore, Waitakere, Auckland, Manukau, Wellington and Christchurch City are considered large cities because they have average quarterly sales of above 800. Hutt City, Nelson City and Palmerston North City are regarded as provincial cities because they have average quarterly sales are between 300 and 500. Porirua City, Upper Hutt City and Papakura District are regarded as small cities or districts with average quarterly sales below 200. They are all included in this study to allow us to see how well the SPAR method performs in large cities in comparison to provincial or small cities/districts where there are a relatively small number of sales for each index construction period.

In this research total sale price less value of chattels is used as "sale price" to form SPAR ratios by applying formula (4). Both the current SPAR ratio and previous SPAR ratio are calculated for all cities at quarterly, monthly and weekly time intervals. Substantial data cleaning jobs have been done in this process in order to ensure the appropriate assessed values are used when formulating the SPAR ratios. Furthermore any ratio which is more than 2.4 or less than 0.4 has been treated as a missing value for statistical analysis. This data cleaning criteria is in line with the data cleaning process utilised by QV for the official SPAR index publications.

5. The Empirical Results

Temporal Aggregation

Depending on the available sales data and methodologies used, house price indices can be reported annually, semi-annually, quarterly, monthly or even weekly. However a yearly or half-yearly time period for determining a price index has been seen as too long by many market participants and policy makers, and quarterly house price indices have become more popular. Examples are: the Office of Federal Housing Enterprise Oversight (OFHEO) 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 Quotable Value House Price Index (QVHI) in New Zealand which uses the SPAR technique. Some indices have gone even further and are reported at a monthly interval, 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.

Academic research shows that a house price index should be estimated using the finest disaggregation of time variable as possible (Englund et al., 1999; Geltner and Ling, 2006). There is an obvious benefit for building an index at a higher frequency level both for academic research and practical application. A timely and frequently reported index will unsmooth the true price movement and tend to better address market efficiency questions. However two criteria have to be taken into account when using a small data set at a higher frequency level for index reporting. The first criterion is the index's stability at various sample sizes. The second criterion is the index's consistency when updated. In other words, what the overall index's volatility is when the next period's sales or previous period's late sales are added on later.

From a statistical point of views shortening the data collection time will imply that: (1) a smaller sample size (sub-sample) will be used; and (2) such a collected sub-sample will represent the sample population. The sample size is related to the precision of the estimate (usually precision is inversely proportional to the square root of the sample size). Often it uses a confidence interval to express the precision. The other thing which we need to be concerned with if a small sample size is used, is whether we can assume normality of the population. Asymptotic normality is assumed for many econometric estimators but it only holds the sample contains large number of observations. How "large" a sample size is needed for asymptotic analysis to be appropriate depends on the underlying population distribution. Obviously there is a balance between the sample size and temporal aggregation in real estate index construction. Sommervoll (2006) showed there was a complex interplay between sample size and temporal aggregation by a simulation approach in repeat models.

Simulation of index's stability

Unlike the chained nature of the repeat sales method, the SPAR technique allows the index estimates to be independently adjustable relative to the base point. In other words, additional sales for any one period only affect the estimate in that particular period making it unnecessary to revise any other SPAR estimates. This implies that the index's stability can be measured by the stability of the each period's SPAR ratios. Accordingly a bootstrap simulation test on the SPAR ratio's stability is set up as follows.

1. Identify total sales population for each time period.
2. The simulation sample size is predetermined at 10%, 20%, …, and 90% of the total population for each reporting period.
3. For each simulation sample size, randomly select sale observations from the total population without replacement.
4. The SPAR ratio is calculated accordingly.
5. Steps 3 and 4 are repeated 500 times.
6. Record the calculated mean and standard deviation of the SPAR ratio.
7. Perform steps 1 to 6 for the next time period.
8. Perform steps 2 to 7 for the next simulated sample size

In this simulation process the index's stability is measured by the averaged relative standard error (RSE) of SPAR ratios at different sample sizes (10%, to 90% of the number of sales per period). The RSE is calculated by the standard error (SE) over its arithmetic mean. An approximate 95% confidence interval (CI) of SPAR ratios to its arithmetic mean expressed in percentage can be calculated as:

$$\left(1 \pm 2 \bullet rse(\bar{y})\right) \times 100 \qquad (6)$$

Where $\bar{y}$ is the mean SPAR ratio for each index reporting period.

The results of the average RSEs across different sample sizes over the time period 1994 and 2004 are reported in Table 1. For quarterly SPAR indexes, the average RSEs are much more stable over different sample sizes. For large cities such Auckland City, the range is between 0.0126 and 0.0014 when the sample size increases from 10% to 90% of total quarterly sales. For Wellington City, the range is between 0.0118 and 0.0013, and for Christchurch City it is between 0.0088 and 0.0010. If a RSE of 0.005 at index level is chosen as a criterion for evaluating the stability of an index, for large cities 50% of the total sales for each period will be required for index reporting. For provincial cities this will mean at least 60 to 70% of total sales for each period and for small cities or districts at least 70% of total sales for each period. If the same criterion is applied to evaluate the monthly SPAR index, sample size will need to be increased from 50% to 70% for large cities, 60% to 80% for provincial cities and 70% to 90% for small cities or districts.

<Insert Table 1>

The results from this simulation indicate that if we want a monthly SPAR index to have the same level of index's stability as a quarterly SPAR index we have to collect a higher percentage of sales data for each period. This is difficult for small cities or districts due to the small number of sales at a monthly level.

One argument is that since house sales data are not randomly entered into the reporting system (i.e. the later sales will be of course be notified later), this will cause problems when the sale samples are randomly drawn from the each period's total sales by simulation test. What is more, the direction and size of this kind of bias is difficult to predict. We argue that there may not be a clear pattern to indicate why some sales have been late in being reported, some even as late as 2 or 3 months from the contract becoming unconditional, although it appears that delayed settlement and human errors are the main causes for such delay. Therefore the assumption that we are dealing with random samples in the simulation test is supportable by bearing in mind that the sample size of such delayed sales is often small after an appropriate lag time has already been given for index reporting purpose. Unfortunately we can not identify such late sales from this supplied data set.

Overall index volatility

Unlike the stock market where share prices can be much more volatile on a daily basis, the housing market is believed 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 an important consideration especially when dealing with a small sample size. In this section the index's overall volatility is measured by the coefficient of variation (COV) of index rates of change, which is defined as the standard deviation in the index rates of change divided by its arithmetic mean. A higher COV indicates the index itself is much more volatile. The calculated COVs of index rates of change for all cities are summarised in Table 2.

<Insert Table 2>

The research shows that the quarterly SPAR indices smooth the price movement volatility more than the monthly and weekly indices. In general the estimated COVs will increase as the time aggregations are increased from quarterly to weekly but the increase is not proportional to the time intervals. By moving from a quarterly SPAR index to a monthly index, COVs of monthly indices are about one and half times larger than the respective COVs of quarterly indices for large cities, two and half times for provincial cites and three and half times for small cities or districts. In contrast, the COVs of weekly indices are almost five times larger than the monthly indices across all cities. On average the monthly SPAR indices reflect a less smooth price movement volatility, indicated by a COV of 2.8, when compared to the quarterly COV of 1.5 and weekly COV of 15.3. Large weekly COVs across all cities in this study simply indicates that there are not enough sales at weekly time intervals and the weekly index tends to be too "noisy" for index reporting purposes. Even for large cities such as Auckland City, Wellington City and Christchurch City, the calculated weekly COVs are above 10.

Measurement Errors in Assessed Values and the Precision of the SPAR Index
Two issues have to be addressed here. First, what is the effect of measurement errors on the overall precision of the SPAR index? Second, what is the effect of measurement errors on the index's consistency when assessed values are updated? By the SPAR technique, the first issue is believed to have a minor effect on the overall precision of the SPAR index as long as the number of sales in each period is large enough. The second issue is more difficult to resolve as any reassessment tends to disturb the index itself. Whether or not the benefits from more frequently engaged reassessment exercises outweigh their "disturbing" effect is subject to more investigation.

The precision of the SPAR index is measured by the RSE of SPAR ratios. The results are presented in Table 3. The range of estimated relative standard errors of monthly SPAR ratios is between 0.005 and 0.008 for large cities, and is from 0.010 to 0.015 for small cities or districts. At the quarterly level the range is between 0.003 and 0.005 for large cities and is between 0.006 and 0.010 for small cities or districts. In other words, provided the sample size at a monthly level is sufficiently large, the monthly index precision as indicated by a 95% CI of SPAR ratios from using formula (6) is between 1.0% to 1.6% for large cities, 1.7% to 2.2% for provincial cities and between 2.6% to 3.6% for small cities or districts.

<Insert Table 3>

It is interesting to note that although the Wellington City Council reassesses all properties annually, the precision of the SPAR indices both at quarterly and monthly levels is marginally improved when compared to other large cities where properties are reassessed on a 3 yearly basis.

The second issue of the index's consistency problem is measured by the current SPAR ratio and previous SPAR ratio. In this process, all sales with a building notice of change prior to the sale date have been eliminated. In theory if reassessments are carried out consistently over time, the index rates of change as measured both by the current SPAR ratio and previous SPAR ratio from the same properties shall be the same or very similar over time. If not, the index's consistency problem will be either positively or negatively built up over time. The results are presented in Table 4.

<Insert Table 4>

In this data set the assessed values are fairly consistent for all cities over time except for Wellington City. The previous SPAR ratio changes are highly correlated to the current SPAR ratio changes both at the monthly and quarterly levels. 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 except for Auckland City (no building notice of change data is available for Auckland City). For provincial cities the correlations are mostly between 0.80 and 0.85 at the monthly level and are between 0.85 and 0.95 at the quarterly level. Further the *t* statistics for measuring the difference between the two ratio series are statistically insignificant for most cities except for Wellington City.

For Wellington City we find that the *t* statistics are significant at the 10% level for both monthly and quarterly intervals indicating that the consistency problem does exist in Wellington SPAR indices. We use the following compounding formula to estimate its accumulated bias.

$$\left((dif.+1)^{\wedge n}-1\right)\times 100 \qquad (7)$$

Where $dif.$= previous SPAR – current SPAR from the Table 4. n is the number of reassessments being taken over the time period of 1994 and 2004.

<Insert Table 5>

The calculated potential accumulated errors are shown in Table 5. Table 5 indicates that for Wellington City a total upward error of 4.61% may have been accumulated for a quarterly reported SPAR index during the period from 1994 to 2004 and 1.47% for a monthly reported SPAR index during the same period. In contrast the accumulated errors are found to be less than ±1% for all other cities both at the quarterly and monthly intervals.

Overall, the results in this session imply that the number of sales in each period will lead to a more precise SPAR index than the frequency of reassessment. The random measurement errors in assessed values tend to cancel out each other when the sample size is large.

6. Conclusions

Establishing a reliable housing price index is important for both academic research and practical applications. Unless users can be confident about the quality of a housing price index, it is unlikely that our understanding of property cycles, market efficiency and housing affordability will be improved. This research examines the SPAR technique in the following three areas: 1) temporal aggregation and 2) measurement errors.

With temporal aggregation, we test the SPAR indices under quarterly, monthly and weekly time intervals and compare their index's volatility and stability. The average coefficients of variation (COVs) of index change rates for the twelve cities is 1.4 for quarterly indices, 2.5 for monthly indices and 14.4 for weekly indices. Further the simulation test on various sample sizes (number of sales for each period) indicates that the quarterly and monthly SPAR indices are reasonably stable. The averaged relative standard errors of the SPAR ratio is below 0.005 if the monthly reporting sample size is exceeding 70% of total monthly sales for large cities, 80% for provincial cities and 90% for small cities or districts.

Measurement errors in assessed values and the precision of SPAR indices are another aspect of interest. The findings indicate that the measurement errors in assessed values are not important for most cities as long as there are enough sales. More frequent reassessment exercises can marginally improve the precision of a SPAR index but consistency errors in assessed values can also be built up more quickly if reassessments have not been done consistently over time. Overall our research shows that a more frequently reassessed SPAR index tends to be more either positively or negatively biased than indices in the less frequently reassessed areas.

The empirical results of this study indicate that the SPAR technique can be successfully applied to a monthly reported house price index without losing much precision for large cities as long as the reassessment period is kept on a 3 yearly basis. Depending on the index precision level required and data collection system utilised, the actual reporting time for a monthly SPAR index in large cities can involve a 2 or 3 months lag from the market.

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Table 1: Simulation tests of average relative standard errors of SPAR ratios by sample sizes, 1994M1-2004M12

		Sample Sizes									No. of Sales for Each Period		
Region	Time Period	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max	Min	Mean
North Shore City													
	Months	0.0218	0.0145	0.0112	0.0089	0.0073	0.0060	0.0048	0.0037	0.0024	650	181	378
	Quarters	0.0127	0.0085	0.0064	0.0052	0.0043	0.0034	0.0028	0.0021	0.0014	1,724	689	1,134
Waitakere City													
	Months	0.0231	0.0154	0.0118	0.0095	0.0078	0.0064	0.0051	0.0039	0.0026	646	193	358
	Quarters	0.0134	0.0090	0.0069	0.0055	0.0045	0.0037	0.0029	0.0023	0.0015	1,798	658	1,073
Auckland City													
	Months	0.0216	0.0145	0.0111	0.0089	0.0073	0.0059	0.0048	0.0036	0.0024	1,075	195	607
	Quarters	0.0126	0.0083	0.0064	0.0051	0.0042	0.0034	0.0027	0.0021	0.0014	2,763	920	1,821
Manukau City													
	Months	0.0215	0.0145	0.0111	0.0088	0.0072	0.0059	0.0047	0.0036	0.0024	783	218	409
	Quarters	0.0124	0.0084	0.0064	0.0051	0.0042	0.0034	0.0027	0.0021	0.0014	2,170	778	1,228
Papakura District*													
	Months	0.0495	0.0347	0.0267	0.0216	0.0173	0.0142	0.0113	0.0085	0.0054	114	19	57
	Quarters	0.0308	0.0207	0.0158	0.0128	0.0103	0.0085	0.0067	0.0052	0.0034	285	90	170
Porirua City*													
	Months	0.0448	0.0309	0.0240	0.0192	0.0156	0.0128	0.0102	0.0077	0.0049	104	40	69
	Quarters	0.0273	0.0186	0.0142	0.0114	0.0093	0.0076	0.0061	0.0046	0.0031	276	144	207
Upper Hutt City*													
	Months	0.0355	0.0246	0.0191	0.0153	0.0124	0.0102	0.0082	0.0061	0.0038	94	32	62
	Quarters	0.0223	0.0151	0.0115	0.0093	0.0076	0.0061	0.0049	0.0037	0.0025	254	106	186
Hutt City													
	Months	0.0287	0.0193	0.0148	0.0120	0.0097	0.0080	0.0064	0.0048	0.0032	264	76	164
	Quarters	0.0169	0.0113	0.0086	0.0070	0.0057	0.0047	0.0037	0.0028	0.0019	643	348	490
Wellington City													
	Months	0.0200	0.0135	0.0103	0.0083	0.0068	0.0055	0.0044	0.0034	0.0022	414	181	267
	Quarters	0.0118	0.0079	0.0060	0.0048	0.0039	0.0032	0.0026	0.0020	0.0013	1,082	598	802
Christchurch City													
	Months	0.0150	0.0100	0.0077	0.0062	0.0050	0.0041	0.0033	0.0025	0.0017	1,192	398	698
	Quarters	0.0088	0.0059	0.0045	0.0036	0.0029	0.0024	0.0019	0.0015	0.0010	3,143	1,316	2,095

Palmerston North City#													
	Months	0.0247	0.0168	0.0129	0.0104	0.0084	0.0070	0.0055	0.0042	0.0027	188	59	128
	Quarters	0.0146	0.0099	0.0075	0.0061	0.0049	0.0040	0.0032	0.0025	0.0017	515	252	385
Nelson City#													
	Months	0.0312	0.0214	0.0165	0.0132	0.0107	0.0088	0.0070	0.0054	0.0034	160	57	98
	Quarters	0.0189	0.0128	0.0097	0.0079	0.0064	0.0052	0.0042	0.0032	0.0021	446	193	295

* A minimum of 80 sales per reporting period is required for 500 repeats of the simulation exercise in this study. We randomly draw 500 times without replacement for various sample sizes both at quarterly and monthly levels for keeping the simulation results on the same level for comparison. However, simulation results at a monthly level for small cities and districts require some caution.

For provincial cities, the number of times for monthly sales fall below 80 sales are infrequent. This has occurred only once for Palmerston North city and 3 times for Nelson city over the entire 11 years time period. Therefore the simulation results on the monthly level for provincial cities should be reliable.

Table 2: COVs of index rates of change, 1994M1 – 2004M12

	SPAR Index			Total Number of Sales
	Quarters	Months	Weeks	
North Shore City	1.417	2.214	14.214	51,887
Waitakere City	1.846	2.722	15.654	49,915
Auckland City	1.295	1.902	9.946	83,268
Manukau City	1.272	2.387	15.240	56,434
Papakura District	1.561	5.137	19.659	7,977
Porirua City	1.158	4.286	21.907	9,187
Upper Hutt City	1.274	3.871	19.889	8,303
Hutt City	1.080	3.128	17.491	21,838
Wellington City	0.954	1.894	13.152	36,362
Christchurch City	1.458	2.443	12.450	93,766
Palmerston North City	1.733	4.162	26.918	17,143
Nelson City	2.319	3.844	19.415	13,141
Overall Values*	1.412	2.548	14.413	449,221

Note: Index rate of change is calculated by ($Index_t$- $Index_{t-1}$) / $Index_{t-1.}$ The overall values* of COVs are calculated on sale numbers weighted basis.

Table 3: Precision of the SPAR index as measured by the relative standard errors (RSE) of SPAR ratios, 1994M1 - 2004M12

		Model			
		Months		Quarters	
Regions		RSE	95% CI	Quarters	95% CI
North Shore City					
	mean	0.0074	1.47%	0.0043	0.86%
	Std.	0.0015		0.0008	
Waitakere City					
	mean	0.0079	1.58%	0.0046	0.93%
	Std.	0.0018		0.0009	
Auckland City					
	mean	0.0070	1.40%	0.0042	0.83%
	Std.	0.0013		0.0007	
Manukau City					
	mean	0.0073	1.47%	0.0043	0.86%
	Std.	0.0014		0.0007	
Papkura District					
	mean	0.0183	3.67%	0.0107	2.15%
	Std.	0.0061		0.0022	
Porirua City					
	mean	0.0163	3.27%	0.0095	1.90%
	Std.	0.0032		0.0013	
Upper Hutt City					
	mean	0.0130	2.60%	0.0077	1.55%
	Std.	0.0033		0.0017	
Hutt City					
	mean	0.0099	1.99%	0.0058	1.16%
	Std.	0.0018		0.0010	
Wellington City					
	mean	0.0070	1.39%	0.0042	0.83%
	Std.	0.0012		0.0005	
Christchurch City					
	mean	0.0051	1.01%	0.0030	0.60%
	Std.	0.0008		0.0005	
Palmerston North City					
	mean	0.0086	1.73%	0.0051	1.02%
	Std.	0.0019		0.0008	
Nelson City					
	mean	0.0111	2.21%	0.0065	1.29%
	Std.	0.0025		0.0013	

Note: For each reporting period the SE of SPAR ratio is calculated by the sample standard deviation divided by the square root of the total number of sales in the period. The RSE is then calculated by the obtained SE divided by its sample mean. The mean of RSE is the average RSE over the period 1994 and 2004.

Table 4: Consistency errors in SPAR ratios, 1994M1 - 2004M12

Region		Months			Quarters			Reassessment
		Previous Ratio	Current Ratio	dif.	Previous Ratio	Current Ratio	dif.	(yearly)
North Shore City								
	Mean	0.0066	0.0066	0.0001	0.0207	0.0208	-0.0001	3
	Std. Dev.	0.0165	0.0153	0.0073	0.0292	0.0293	0.0044	
	T test			0.1185			-0.1966	
	P value			0.9059			0.8454	
	Correlation	0.8973	1.0000		0.9887	1.0000		
Waitakere City								
	Mean	0.0066	0.0067	-0.0001	0.0181	0.0200	-0.0018	3
	Std. Dev.	0.0206	0.0175	0.0107	0.0387	0.0347	0.0135	
	T test			-0.1318			-0.8012	
	P value			0.8959			0.4286	
	Correlation	0.8539	1.0000		0.9381	1.0000		
Auckland City *								
	Mean	0.0074	0.0074	0.0000	0.0206	0.0228	-0.0021	2 or 3
	Std. Dev.	0.0275	0.0158	0.0515	0.0461	0.0312	0.0362	
	T test			0.2234			-0.3512	
	P value			0.8263			0.7275	
	Correlation	0.3937	1.0000		0.6215	1.0000		
Manukau City								
	Mean	0.0065	0.0064	0.0002	0.0186	0.0193	-0.0006	3
	Std. Dev.	0.0171	0.0152	0.0088	0.0237	0.0246	0.0052	
	T test			0.1953			-0.7233	
	P value			0.8455			0.4742	
	Correlation	0.8592	1.0000		0.9773	1.0000		
Papakura District								
	Mean	0.0078	0.0067	0.0012	0.0180	0.0166	0.0014	3
	Std. Dev.	0.0562	0.0322	0.0448	0.0855	0.0290	0.0760	
	T test			0.2860			0.1115	
	P value			0.7754			0.9119	
	Correlation	0.6033	1.0000		0.4792	1.0000		
Porirua City								
	Mean	0.0046	0.0051	-0.0005	0.0171	0.0176	-0.0005	3
	Std. Dev.	0.0334	0.0285	0.0153	0.0270	0.0206	0.0107	
	T test			-0.3649			-0.2550	
	P value			0.7158			0.8003	
	Correlation	0.8901	1.0000		0.9325	1.0000		
Upper Hutt City								
	Mean	0.0051	0.0050	0.0001	0.0172	0.0151	0.0021	3
	Std. Dev.	0.0263	0.0243	0.0131	0.0187	0.0201	0.0091	
	T test			0.1088			1.3685	
	P value			0.9136			0.1801	
	Correlation	0.8681	1.0000		0.8930	1.0000		
Hutt City								
	Mean	0.0061	0.0065	-0.0003	0.0172	0.0162	0.0010	1 or 3
	Std. Dev.	0.0189	0.0160	0.0120	0.0172	0.0164	0.0075	
	T test			-0.3197			0.7482	
	P value			0.7498			0.4598	
	Correlation	0.7752	1.0000		0.9019	1.0000		
Christchurch City								

	Mean	0.0033	0.0033	0.0000	0.0193	0.0173	0.0020	3
	Std. Dev.	0.0374	0.0251	0.0199	0.0275	0.0248	0.0102	
	T test			0.0088			1.1615	
	P value			0.9930			0.2535	
	Correlation	0.8701	1.0000		0.9286	1.0000		
Wellington City								
	Mean	0.0078	0.0063	0.0015	0.0253	0.0207	0.0045	1
	Std. Dev.	0.0160	0.0130	0.0089	0.0205	0.0188	0.0071	
	T test			1.7226			3.0513	
	P value			0.0878			0.0059	
	Correlation	0.8315	1.0000		0.9379	1.0000		
Palmerston North								
	Mean	0.0038	0.0033	0.0006	0.0099	0.0087	0.0011	3
	Std. Dev.	0.0195	0.0149	0.0118	0.0193	0.0168	0.0091	
	T test			0.5236			0.7172	
	P value			0.6015			0.4781	
	Correlation	0.7966	1.0000		0.8815	1.0000		
Nelson City								
	Mean	0.0047	0.0046	0.0001	0.0139	0.0127	0.0012	3
	Std. Dev.	0.0209	0.0219	0.0106	0.0337	0.0356	0.0111	
	T test			0.0857			0.6275	
	P value			0.9319			0.5345	
	Correlation	0.8787	1.0000		0.9499	1.0000		

Note: * No building consent data is available for Auckland city in this study, therefore caution is needed for Auckland city's results.

Table 5: Accumulated consistency errors of SPAR indices, 1994M1 - 2004M12

Region		Models	
		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

Note: The accumulated consistency errors are calculated by using formula 7