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HOUSE PRICE INDICES USING ASSESSED VALUES STATISTICS

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ABSTRACT. This paper investigates tax inequities in assessed values and how these inequities in tax assessments affect house price indices using assessed values statistics. Using the unique rating valuation data from the top 10 cities of New Zealand during the period 1994–2009, it finds that house price measurements using the Sale Price Appraisal Ratio (*SPAR*) method have performed well compared to the repeated sales method suggested by Case and Shiller (1989) and the assessed values (*AV*) method proposed by Clapp and Giaccotto (1992). The presence of systematic estimated errors (both vertical and horizontal inequities) in assessed values posts a concern for house price measurements using assessed values statistics. In this situation, both the *SPAR* and *AV* methods benefit from the law of compensation of errors by using all transaction data. A policy implication is that the *SPAR* model is a good choice when using assessed values to measure house price movements at frequent time intervals, in particular for small countries.

KEYWORDS: Assessed values; Vertical and horizontal inequities; House price indices; *SPAR* method; *AV* method

1. INTRODUCTION

Developing timely and reliable house price indices is of interest worldwide. Several techniques for constructing a constant quality price index are available in the literature. These include mainly hedonic, repeat sales and hybrid methods. However, the effectiveness of these methods depends on the quality and appropriateness of the data employed (Pollakowski 1995). This is particularly true for countries where periodical property sales are small. Nowadays properties are typically reassessed every three to five years for taxation purposes. When combined with transaction data, assessed value (*AV*) statistics can be used for estimating market price movements. Cross countries summaries of house price indices are presented in Table 1.

One of the simplest methods using *AV* statistics to estimate house price movements is called the Sale Price Appraisal Ratio (*SPAR*) method, based on the ratio of sale price (*SP*) to *AV*. The method was proposed by Harrison (1978) and can be viewed as a simplified arithmetic form of the repeated sales method suggested by Shiller (1991). Another method is called the Assessed Value (*AV*) method, which uses the property's assessed value as its first sale and actual transaction as the second sale in a repeated sales regression (see, e.g. Clapp, Giaccotto 1992). In contrast to the standard repeat sales method, indexing methods using *AV* statistics are more appealing as they use all transaction data.

However there are some negative attributes when using assessed value statistics to estimate market price movements. Both random and systematic errors in assessment will influence the accuracy of house price measurements using assessed value statistics. Random errors involve individual assessors and non-notified property changes, while systematic errors refer to inequities in tax assessments. When sale price to assessed value ratios for similarly priced houses are not uniform, horizontal inequities exist. When sale price to assessed value ratios are not consistent across a range of values, vertical inequities exist. Although systematic errors are discouraged and audited by various statistical tests at the time of

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Table 1. Cross countries summaries of house price measures

Country/Region	House Price Index	Method	Source
Denmark	Price Index for Sales of Property	SPAR	Statistics Denmark
Finland	House Price Index	Mix-adj & Hedonic model	Statistics Finland
Hong Kong	House Price Index	SPAR	Rating and Valuation Department
Malaysia	Malaysia House Price Index	Hedonic model	Ministry of Finance Malaysia
Netherlands	Price Index Owner-occupied Existing Dwellings	SPAR	Statistics Netherlands
New Zealand	Quotable Value House Price Index	SPAR	Quotable Value New Zealand
Norway	House Price Index	Mix-adj & Hedonic model	Statistics Norway
Singapore	Private Residential Property Price Index	Mix-adj with median	Urban Redevelopment Authority
South Korea	Kookmin Bank Index	Mix-adj	The Bank of Korea
Sweden	House Price Index	Mix-adj & SPAR	Statistics Sweden
Taiwan	Sinyi House Price Index	Hedonic model	Sinyi Real Estate Development Company

Notes: SPAR denotes for the Sale Price Appraisal Ratio method; Mix-adj denotes for the mix-adjusted method.

assessment, both horizontal and vertical inequities have been found in empirical studies (Allen, Dare 2002; Cornia, Slade 2005; Goolsby 1997). Clapp (1990a) pointed out that house price indices using *AV* statistics can be biased if assessments are not carried out uniformly. Similar concern was also raised by Birch and Sunderman (2003).

Although assessment errors are of concern, one common belief is that the use of all transaction data should make the model tolerant to a lot of errors in assessment practices. In empirical tests, *SPAR* indices have been found to perform well compared with repeat sales or hedonic methods (see, e.g. Clapp *et al.* 1996; Bourassa *et al.* 2006; Shi *et al.* 2009). Similar results are also found in using the *AV* method. Clapp and Giaccotto (1992) showed the advantage of using the *AV* method compared with the repeat sales method. Their findings are supported by Gatzlaff and Ling (1994), where *AV* methods are closely matched to repeat sales methods. More recently, Gatzlaff and Holmes (2013) successfully applied the *AV* method in commercial real estate for estimating price movements. These previous studies, however have not investigated how the presence of systematic errors in assessed values will influence house price measurements in empirical tests. Moreover, comparison between the *SPAR* and *AV* methods has not been documented in the literature.

New Zealand has a very robust rating system. All residential properties in New Zealand are required to be reassessed on a regular basis, every three years or sometimes more frequently. In this study the data consists of a panel of rating valuations from the top 10 cities in New Zealand over 16 years from 1994 to 2009. The uniqueness of this New Zealand dataset will help to understand the nature of assessment errors and how they affect house price measurements using either the *SPAR* or *AV* method, particularly over multiple assessment periods. The results show that the biggest threat for house price measurement using assessed value statistics is from horizontal rather than vertical inequities in assessed values. In this situation, both the *SPAR* and *AV* methods benefit from the law of compensation of errors by using all transaction data, but the *AV* method tends to be more affected by the horizontal inequity issue than the *SPAR* method does.

The remainder of this study is organised as follows: Section 2 presents the theoretical framework for testing tax inequities in assessed values. Section 3 reviews house price indices using the repeat sales, *AV* and *SPAR* methods. Section 4 describes the data utilised. Section 5 reports the empirical results. Section 6 provides conclusions.

2. SYSTEMATIC ERRORS IN ASSESSED VALUES

2.1. Vertical inequity

Vertical inequities occur when the assessment is not carried out consistently across low and high-valued properties. The tax is considered "regressive" if lower valued properties are assessed at a higher proportion of their market values, or "progressive" vice versa (McMillen,Weber 2008). Tests for vertical inequities in property tax assessment have been widely discussed in the literature (e.g. see Sirmans *et al.* 1995). Typical tests include the method of Cheng (1974) and that proposed by International Association of Assessing Officers (IAAO) (1999).

The Cheng (1974) model can be written as follows:

$$Ln\left(AV\right) = \alpha_0 + \alpha_1 \ln\left(SP\right), \tag{1}$$

where: AV represents the assessed values and SP represents the sale prices. The idea is to test whether or not the assessed values are in line with their sale prices. Under the Cheng model, vertical inequities are reflected in the coefficient of natural log sale prices. When $\alpha_1 < 1$, it indicates "regressive"; When $\alpha_1 > 1$, it indicates "progressive"; When $\alpha_1 = 1$, it indicates no vertical inequities.

The IAAO (1999) model can be written as follows:

$$AV/SP = \alpha_0 + \alpha_1 SP, \tag{2}$$

where the test is based on the ratio of assessment values to sale prices. The idea is to check whether or not the assessment ratios are changing with their sale prices. Under the IAAO model, vertical inequities are reflected in the coefficient of natural sale prices. When $\alpha_1 < 0$, it indicates "regressive"; When $\alpha_1 > 0$, it indicates "progressive"; When $\alpha_1 = 0$, it indicates no vertical inequities.

In this study I follow the testing method proposed by Clapp (1990b) while using the method of Cheng (1974) and IAAO (1999) for robustness checks. Clapp's method is considered superior when compared to other testing methods, because it uses a simultaneous equation model to account for measurement errors in assessed values.

The Clapp (1990b) model can be written as follows:

$$\begin{cases} \ln SP_{i0} = \alpha_0 + \alpha_1 \ln AV_{i0} \\ \ln AV_{i0} = \beta_0 + \beta_1 Z \end{cases}, \tag{3}$$

where: SP_{i0} is the sale price of ith property and AV_{i0} is its reassessed value; Z is the instrumental variable with the value of –1 if the AV and SP rank in the bottom one-third of the data, 1 if AV and SP rank in the top one-third of the data and 0 otherwise. Under the Clapp model, vertical inequities are reflected in the coefficient of natural log assessed values. When $\alpha_1 > 1$, it indicates "regressive"; When $\alpha_1 < 1$, it indicates "progressive"; When $\alpha_1 = 1$, it indicates no vertical inequities.

2.2. Horizontal inequity

Horizontal inequities exist when similarly situated properties are assessed differently. The method typically involves testing the assessment ratio on a vector of independent property characteristics and location variables. If it is found that any of those variables has significant influence on the assessment ratio, it could be that horizontal inequity exists in assessed values (e.g. see Allen, Dare 2002; Cornia, Slade 2005; Goolsby 1997).

An alternative to measure the horizontal inequity is measuring the coefficient of dispersion (COD) for the assessment ratio. The idea is that if the dispersion of the assessment ratio is small across many properties within a similar value range, horizontal inequity is low, but if the ratio is quite variable, horizontal inequity is high. The COD is defined as follows:

$$\text{COD} = \frac{100}{Median_{AV/SP}} * \left[\frac{\sum_{i=1}^{n} \left| \left(AV_i/SP_i - Median_{AV/SP} \right) \right|}{n} \right], \tag{4}$$

where: AV_i is the ith property's assessed value and SP_i is the ith property's sale price; $Median_{AV/SP}$ is the median of the distribution of AV_i/SP_i ratio during the time period t and n is the total number of sales during the time period t.

3. HOUSE PRICE INDICES

3.1. The repeat sales method

This paper uses the weighted repeat sales (WRS) method proposed by Case and Shiller (1987, 1989) as a benchmark index to estimate local house price movements. Case and Shiller's method is written as follows:

$$\text{Step 1: } \ln P_i^t - \ln P_i^s = \ln\left(P_i^t / P_i^s\right) = \sum_{t=1}^{T} \gamma^t D_i^t + \mu_i^t; \tag{5}$$

$$\text{Step 2: } \mu_i^{t2} = C_0 + \sum_{t=1}^{T} \gamma^t \mathrm{D}_i^t + \text{error}; \tag{6}$$

$$\text{Step 3: } \ln\left(P_i^t / P_i^s\right) / w_i = C_0 + \sum_{t=1}^{T} \left(\gamma^t D_i^t / w_i\right) + \mu_i^t / w_i, \tag{7}$$

where: P_i^s is the first sale of i^{th} house; P_i^t is the second sale of i^{th} house ($1 \le s < t \le T$); D_i^t is a time dummy variable with the value 1 for the second sale, –1 for the first sale and 0 for no sale; ì $_i^t$ are the residuals in log form and w_i represents the square root of the fitted values of equation (6).

Step 1 is the exactly same as the standard repeat sales method, where the price difference of the same property at different dates is a function solely of the intervening time period. However Case and Shiller believe that the variance of the error term in the first step regression is related to the time interval between sales. In step 2 the variance of the error term is linearly related to the time interval between sales. In step 3 the calculated weight from step 2 is used to reduce the influence from sales with longer time intervals.

One drawback to using the repeat sales method is sample size. As the repeat sales method uses only repeated sales for index construction, the index is more prone to sample selection bias than other index methods that use all transaction sales data. Previous work indicates that frequently traded houses (sold more than twice within a period of time) are more likely to be the “starter” houses or houses for opportune buyers (Clapp, Giaccotto 1992; Haurin, Hendershott 1991). Another possible issue is the index’s revision. Previous study indicates that the repeat sales index is prone to a systematic downward revision due to lagged sales (Clapham *et al.* 2006). More recently researchers have looked at improving the repeat sales method. Like the repeat sales method, McMillen (2012) proposed a matching estimator approach which uses pairs of sales from different dates to estimate the mean difference in sales prices over time. One advantage of applying the matching approach is it preserves a much larger sample size than the repeat sales method. Bourassa, Cantoni and Hoesli (2011) proposed a robust repeat sale method to reduce the impact of problematic transactions in a repeat sales context. Their results show robust methods reduce the magnitude and volatility of index revisions.

3.2. The AV method

The underlying idea of the Clapp and Giaccotto (1992) model is to bring assessed values into the repeat sales method to address the efficiency and sample selection bias faced by the repeat sales method. They further proved that the effect of measurement errors in assessed values on price indices is negligible when the average assessed value is stable from one period to the next. Using the Hartford housing market data they find a similar result of price indices using the repeated sales and *AV* methods.

The *AV* method can be written as follows:

$$\ln P_i^t = c\ln AV_i^0 + \sum_{t=1}^{T}\gamma_t D_i^t + \varepsilon_i^t, \tag{8}$$

where: P_i^t is the sale price for the i^{th} property at time t and AV_i^0 is its assessed value at time t; D_i^t is a time dummy variable with the value 1 for sale at time t and 0 otherwise.

Compared to the standard repeat sales method, equation (8) uses *AV* values to proxy the property’s first sale assuming this occurred at the assessment date. c represents the vertical inequity. If c equals 1, equation (8) becomes exactly the same as the standard repeat sales model. One problem with equation (8) is regarding errors-in-variables, i.e. the presence of measurement errors in *AV* statistics may cause equation (8) to be seriously biased. Clapp (1990a,b) suggested using a two stage least squares (2SLS) equation to weight down the potential errors-in-variables problem in equation (8). The estimated equations for producing *AV* indices over multiple reassessment periods are presented as follows:

$$\ln P_i^t = c\ln AV_i^0 + \sum_{g=1}^{n} R_g c_g \ln AV_i^0 + \sum_{t=1}^{T}\gamma_t D_i^t + \varepsilon_i^t; \tag{9}$$

$$\ln AV_i = \beta_0 + \beta_1 \ln Z_t + \varepsilon_i, \tag{10}$$

where: g represents the number of general revaluations and R is the dummy variable with the value of 1 for sales during the current revaluation period and 0 otherwise; Z_t is the instrumental variable with the value of –1 if the *AV* and *SP* rank in the bottom one-third of the data at time period t, 1 if *AV* and *SP* rank in the top one-third of the data at time period t and 0 otherwise. All other variables are defined as the same with equation (8).

At the time of revaluation, the estimated *AV* index calculated by equations (9) and (10) will be recalibrated. To bridge the gap from the month before revaluation to the month after, Clapp *et al.* (1996) suggested using the average rate of price change between revaluations.

3.3. The *SPAR* method

The *SPAR* method involves calculating the mean *SP*/*AV* ratios from one period to the next and standardises those ratios into a price index. An equally weighted form of a *SPAR* index is given as follows:

$$\begin{cases} SPAR_t = \dfrac{\sum_{i=1}^{n_t} SP_{it}/AV_{i0}}{n_t}, \\ I_t = \dfrac{SPAR_t}{SPAR_{t-1}} I_{t-1} \end{cases} \tag{11}$$

where: SP_{it} is the sale price of the i^{th} property at time t and AV_{i0} its assessed value at time t; n_t is the number of sales during time period t; $SPAR_t$ represents the average ratio of *SP*/*AV* for time period t and I_t is the price index for time period t.

Table 2. Summarised monthly house sales statistics for the top 10 cities in New Zealand, Jan 1994–Dec 2009

Cities	North Shore	Wait-akere	Auck-land	Manu-kau	Hamil-ton	Tau-ranga	Lower Hutt	Welling-ton	Christch-urch	Dunedin
Mean	382	366	596	438	237	254	161	258	713	223
Standard deviation	111	107	157	140	67	75	38	59	181	59
Max	720	652	1,079	784	425	509	269	440	1,217	387
Min	187	152	203	220	117	129	75	107	405	117
Total sales	73,404	70,233	114,522	84,039	45,486	48,801	30,856	49,481	136,905	42,863
Repeated sales	35,025	34,062	47,371	39,181	21,908	22,663	13,768	22,337	62,952	19,973
Percentage[a]	47.7	48.5	41.4	46.6	48.2	46.4	44.6	45.1	46.0	46.6
Population[b]	207,600	183,700	419,800	330,600	131,700	104,700	96,800	183,500	359,900	122,200
No. dwellings[b]	72,900	61,800	145,100	95,100	46,000	40,500	35,500	68,300	134,400	44,800
Sales/dwelling	1.01	1.14	0.79	0.88	0.99	1.20	0.87	0.72	1.02	0.96
Population/dwelling	2.85	2.97	2.89	3.48	2.86	2.59	2.73	2.69	2.68	2.73

Notes: [a]The percentage is for repeated sales. [b]Population and no. of dwellings are sourced from the 2006 census data published by Statistics New Zealand.

The *SPAR* method can be viewed as an arithmetic form of the repeat sales method proposed by Shiller (1991). This implies that for the *SPAR* method, if it is to be effectively applied, assessment errors in assessed values must be small. Unlike the *AV* method, systematic errors such as vertical inequities have not been dealt with in equation (11).

Clapp *et al.* (1996) point out that the *SPAR* method benefits from the law of compensating errors. Both the random and systematic errors tend to offset one another as more sales transactions are added to the data set. They suggest a minimum of 30 sales transactions per period is essential to produce a reliable result in Connecticut. In New Zealand, this has been extended to a minimum of 50 sales per period for producing the official house price index by Quotable Value (QV).

4. DATA DESCRIPTION

This research utilises a data set of 690,590 freehold (fee simple) open market transactions of detached or semi-detached houses for the top 10 cities in New Zealand between 1994 and 2009. Local house price movements are estimated using the WRS, *AV* and *SPAR* methods respectively at monthly intervals. Both the transaction data and assessment data are supplied by Quotable Value (QV), the official database for all property transactions in New Zealand. The amount of data cleaning requirement is large, in particular to match the transaction data with its appropriate assessment data at transaction date. Further any suspicious or non-market transaction has been identified and removed from the data set. This includes the removal of any sales with a *SP*/*AV* ratio more than 2.4 or less than 0.4, when using *AV* statistics to estimate market price movements. As the repeat sales method is vulnerable to outliers (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 have been removed for index calculations. Moreover, since the QV data includes building consent information for all the cities studied except for Auckland City[1], it is possible to eliminate quality changed repeat sales, thus minimizing the constant quality problem faced by the standard repeat sales method. The data set ended at 2009 because this was the latest year for which a complete sale data set could be obtained.

It is important to consider sample sizes when measuring local house price movements at a monthly level. Table 2 illustrates the distribution of monthly house sales. On average monthly house sales for all cities except for Lower Hutt are more than 200, but there are only 7 times when the number of monthly house sales is below 100 during the entire studied period (192 months) from 1994 to 2009.

In order to gain an insight into the size of the repeated sales sample for each local housing market, I have counted the repeated sales for each month. On average repeated sales are between 41 to 48% of all transactions. It has been noticed that the percentage of repeated sales has increased over time. Since 1999 the percentage of repeated sales

[1] Building consent data is collected for revaluation purposes only where QV is the valuation service provider for the Council. For Auckland City, QV is not the valuation service provider for the council and for that reason there is no building consent data for Auckland City.

to total monthly transactions has been around 55 to 67% for this New Zealand data set. Finally, census data of city level population and number of dwellings are added to the monthly house sales data. It shows that local housing markets are relatively liquid during the studied period (1994–2009) as the ratio of sales per dwelling is around 0.8 to 1.1. The number of monthly house sales and the number of repeated sales indicate that there is a sufficiently large sample to estimate market price movements at a monthly level using either *AV* statistics or repeated sales method for the top 10 cities in New Zealand.

Another reason to estimate house price movements on a monthly basis is because there is a market demand to report house price movements in a more timely manner than quarterly in New Zealand (McDonald, Smith 2009). Compared with the quarterly released QV index, the monthly price index will unsmooth the price movement (Englund *et al.* 1999; Geltner, Ling 2006) and increase the number of observations for time series analysis.

5. EMPIRICAL RESULTS

5.1. Estimating the vertical inequity

Vertical inequities for the top 10 cities are first estimated using the method proposed by Clapp (1990b). The results are shown in Table 3. Panel A represents the results of vertical inequities using the first month's sales immediately after each assessment period. Panel B represents the results of vertical inequities using all sale transactions during each assessment period. Temporal effects in Panel B are controlled for by using monthly time dummies in the regression model for each reassessment period. A further assumption for the results in Panel B is that the vertical inequity is constant over time until the next reassessment[2]. Both panel A and panel B indicate that the estimated vertical inequity coefficients of α_1 are generally between 0.9 and 1.1, and the nature of the vertical inequity found for this New Zealand data set is in line with other findings. Empirical studies on vertical inequities in tax assessment generally show the coefficient of vertical inequity is small and ranges from 0.9 to 1.1 (see, e.g., Clapp 1990b; Sirmans *et al.* 1995; Cornia, Slade 2005). The results have been robustly checked against other methods using the Cheng (1974) model and the IAAO model. The results confirmed the regressive nature of tax assessments in this New Zealand dataset (See Appendix 1 for detailed statistics).

5.2. Estimating the horizontal inequity

To estimate horizontal inequities, monthly sales are grouped into 3 categories, i.e. the low, middle or high value group in order to minimise the impact of vertical inequity when analysing horizontal inequities. The low value group is for sales if their prices are ranked at the bottom one-third of the monthly data. The high value group is for sales with their prices ranked at the top one-third of the monthly data. All other sales are classified as middle value group. Within any of these classifications, the CODs of assessment ratios are calculated separately. Table 4 displays the average monthly CODs for the 10 cities from 1994 to 2009.

The results show that on average the horizontal inequity is within the COD requirement as outlined by IAAO (1990)[3]. However, problems of horizontal inequity are not the same across different types of properties. Properties within the low value and high value group are more inequitably valued compared to properties in the middle value group. This could be because properties become more heterogeneous in the low and high value groups. The results further suggest that between the low and high value groups, properties in the low value group tend to bear more problems of horizontal inequity for this New Zealand data set.

It is expected that the COD would vary over time and be particularly large towards the end of the revaluation period. This is because that horizontal inequity could be primarily a function of assessment lag that property related features can appreciate differently, even when they are in similar neighbourhoods and selling in similar markets. Thus, the dispersion of assessment ratios gets larger for the longer time intervals since the revaluation occurred. Another possible explanation is that both buyers and sellers are much reliant on the assessed values for property transactions, in particular when assessed values are newly updated. However, this reliance on assessed values in property transactions could become less observed over time, simply due to the information contained in assessed values is dated. Figure 1 shows the dispersion of the assessment ratio. In fact CODs are getting larger towards the end of each revaluation period and dispersions can be much more volatile over time. The findings imply that indices using *AV* statistics could be biased.

[2] The measure could be subject to some distortion when price changes of higher valued properties are different in related to the price changes of lower valued properties over time.

[3] COD is set at 12 for single family homes.

Table 3. Vertical inequities for selected 10 top cities in New Zealand, 1994–2009

Year	North Shore	Waitakere	Auckland	Manukau	Hamilton	Tauranga	Lower Hutt	Wellington	Christch-urch	Dunedin
	Panel A: Using the first month's sales immediately after the assessment									
1994			1.008			0.997				
1995		1.018			0.985			1.016	0.986	1.078***
1996	1.037*			0.925***			1.033**	0.999		
1997			0.999			0.979	1.014	0.989		
1998		1.025			1.045		1.028	0.968**	0.979	1.091***
1999	1.055**		1.013	1.006				1.016		
2000					1.048	1.144***		1.021		
2001		1.085*					1.086**	1.066***	1.066***	1.101***
2002	1.051**		0.989	1.093***				1.035		
2003					0.971*	1.047**		0.992		
2004		0.991					0.997	0.990	0.980	1.092**
2005	0.967		0.991	1.040				0.968		
2006					1.032	1.025		0.999		
2007		0.966					1.036	1.061*	0.986	1.018
2008	1.012		1.004	1.058***						
2009					1.088***	0.948**		1.008		
	Panel B: Using all sales during each assessment until the next reassessment									
1994			0.856***			0.933***				
1995		0.860***			0.863***			1.023	0.935***	1.066***
1996	1.019*			0.865***			1.061**	0.986		
1997			1.012			1.044***	1.027	0.965*		
1998		1.095***			1.026		0.985	0.963**	1.024***	1.105***
1999	1.078***		1.059***	1.041***				1.004		
2000					1.090***	1.131***		1.039*		
2001		1.066***					1.020**	1.045**	1.049***	1.111***
2002	0.972***		0.979***	1.063***				1.005		
2003					0.910***	0.931***		0.988		
2004		0.956***					0.888***	0.980	0.906***	0.912***
2005	0.969***		1.007***	0.900***				0.979		
2006					1.035***	1.000		0.966**		
2007		1.034***					1.064***	1.032***	0.978***	1.011*
2008	0.995		1.001	1.112***						
2009					1.059***	0.998		1.011		

Notes: The results are based on Clapp (1990b) model. Asterisks indicate significance levels for vertical inequity (α_1) different from 1 at 1%(***), 5%(**), and 10%(*), respectively.

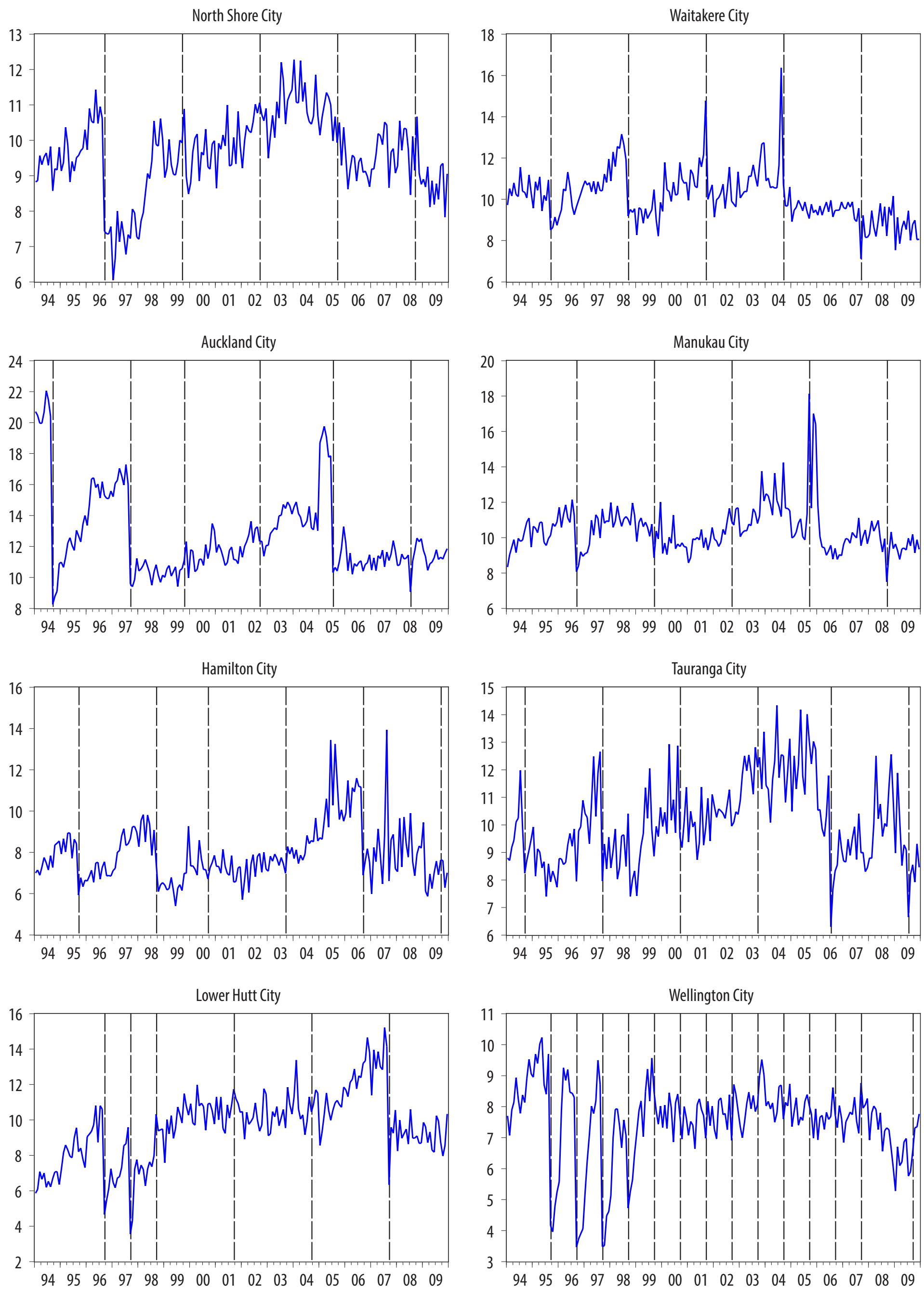
Table 4. Summarised monthly coefficient of dispersion (COD) of assessment ratios, 1994–2009

Cities		Low value	Middle value	High value	Overall
North Shore	Mean (%)	8.660	9.041	10.756	9.629
	Std. Dev (%)	1.303	1.267	1.527	1.131
Waitakere	Mean (%)	9.412	9.039	10.450	10.103
	Std. Dev (%)	1.400	1.399	1.562	1.214
Auckland	Mean (%)	12.687	11.156	12.827	12.665
	Std. Dev (%)	2.588	2.886	2.186	2.710
Manukau	Mean (%)	11.377	8.840	9.080	10.445
	Std. Dev (%)	2.978	1.206	1.253	1.337
Hamilton	Mean (%)	8.466	6.912	7.289	7.940
	Std. Dev (%)	2.444	1.308	1.180	1.410
Tauranga	Mean (%)	10.131	8.663	10.571	10.088
	Std. Dev (%)	2.619	1.519	1.796	1.544

(Continued)

Cities		Low value	Middle value	High value	Overall
(Continued)					
Lower Hutt	Mean (%)	9.924	8.583	8.876	9.627
	Std. Dev (%)	2.734	2.045	1.990	2.010
Wellington	Mean (%)	7.126	6.943	8.098	7.526
	Std. Dev (%)	1.301	1.290	1.681	1.271
Christchurch	Mean (%)	10.081	8.501	9.685	9.634
	Std. Dev (%)	1.397	1.221	1.289	1.168
Dunedin	Mean (%)	11.897	9.705	10.275	11.358
	Std. Dev (%)	2.335	2.076	2.251	2.067

Notes: low value group is for sales if their prices are ranked in the bottom one-third of the monthly data; high value group is for sales if their prices are ranked in the top one-third of the monthly data; all other sales are classified as middle value group.



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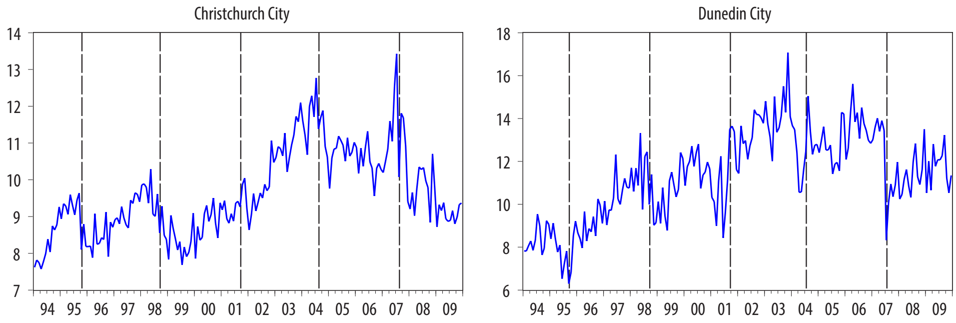

Fig. 1. Estimated monthly coefficient of dispersion (COD) of assessment ratios over time, Jan. 1994 to Dec. 2009
Notes: The vertical line drawn on the date axis indicates the time of reassessment.

5.3. Estimating house price indices by the WRS, AV and SPAR methods

Table 5 reports the correlation results of the house price changes based on the WRS, *AV* and *SPAR* methods. For the *SPAR* method, it is further split into the standard *SPAR* method using equation (11) and the modified *SPAR* method where the vertical inequities have been dealt with first before applying equation (11). For calculating the modified *SPAR* index, the first month's sales immediately after the reassessment has been used to estimate the vertical inequities (see Panel A of Table 3).

Table 5 shows that the average correlation of index changes between the repeated sales index and indices using *AV* statistics are about 0.56 at monthly levels. There is almost no difference between the *AV* and *SPAR* methods in estimating house price changes. On the other hand, the high correlation between the standard and modified *SPAR* indices indicates, although the vertical inequity may bias the standard *SPAR* index, its impact is limited in practice. This could be due to two reasons. First, the size of the vertical inequity is relatively small in this New Zealand data set. Second, the *SPAR* method itself benefits from using all transaction sales. This can be illustrated as following:

Table 5. Correlations of monthly house price index changes, 199–2009

Cities	WRS	AV	Standard SPAR	Modified SPAR
North Shore	1.000	0.617	0.608	0.602
Waitakere	1.000	0.650	0.655	0.651
Auckland	1.000	0.569	0.551	0.548
Manukau	1.000	0.531	0.567	0.556
Hamilton	1.000	0.620	0.610	0.617
Tauranga	1.000	0.435	0.445	0.432
Lower Hutt	1.000	0.535	0.537	0.532
Wellington	1.000	0.447	0.420	0.428
Christchurch	1.000	0.680	0.651	0.650
Dunedin	1.000	0.511	0.514	0.500
Overall	1.000	0.559	0.556	0.552

Notes: WRS denotes the weighted repeated sales index proposed by Case and Shiller (1989); AV represents the assessed values index proposed by Clapp (1990b); Standard SPAR refers to the sales prices appraisal ratio index which does not take account of vertical inequities and modified SPAR is for the SPAR index which takes account of vertical inequities.

Based on equation (11), a standard *SPAR* index can be written as:

$$I_{S-SPAR,\,t} = \frac{\overline{SP_t}}{\overline{SP_0}} \times \frac{\overline{AV_0}}{\overline{AV_t}} I_0, \tag{12}$$

where: $\overline{SP_t}$ represents the average sale price at time period t; $\overline{AV_t}$ is the average assessed values at time t; $\overline{SP_0}$ is the average sale price at time 0 (based period); $\overline{AV_0}$ is the average assessed value at the based period and I_0 represents the based period price index.

Accordingly, a modified *SPAR* index can be written as follows:

$$I_{M-SPAR,\,t} = \frac{\overline{SP_t}}{\overline{SP_0}} \times \frac{\overline{AV^c{}_0}}{\overline{AV^c{}_t}} I_0, \tag{13}$$

where: c represents the vertical inequity.

The difference between the standard *SPAR* index and the modified *SPAR* index can be approximate as follows:

$$Ln\left(I_{S-SPAR,\,t}\right) - Ln\left(I_{M-SPAR,t}\right) =$$

$$Ln\left(\frac{\overline{SP_t}}{\overline{SP_0}} \times \frac{\overline{AV_0}}{\overline{AV_t}} I_0\right) - ln\left(\frac{\overline{SP_t}}{\overline{SP_0}} \times \frac{\overline{AV^c{}_0}}{\overline{AV^c{}_t}} I_0\right) =$$

$$Ln\left(\frac{\overline{AV_0}}{\overline{AV_t}}\right) - Ln\left(\frac{\overline{AV^c{}_0}}{\overline{AV^c{}_t}}\right). \tag{14}$$

When c is close to "1", the above equation (14) can be approximate as follows:

$$\approx Ln\left(\frac{\overline{AV_0}}{\overline{\overline{AV_t}}}\right) - Ln\left(\frac{\overline{AV_0}}{\overline{\overline{AV_t}}}\right)^c = (1-c)Ln\left(\frac{\overline{AV_0}}{\overline{\overline{AV_t}}}\right). \quad (15)$$

As demonstrated in Clapp and Giaccotto (1992), when number of periodical sales becomes large for all time period, there can be no change in average true value. The only source of change is sampling variability. Thus, the set of assessed values AV_0 and AV_t should be very similar to each other and the ratio of $\frac{\overline{AV_0}}{\overline{\overline{AV_t}}}$ closes to 1. Therefore Equation (15) shows that when the vertical inequity c closes to 1, and the number of periodical sales is large, the difference between the standard and modified *SPAR* indices will shrink to zero.

Another noticeable difference among those graphed indices is that indices using *AV* statistics tend to be less volatile than their respective WRS index. Table 6 presents the estimated rate of changes in estimated price indices over the studied period. It shows that *AV* indices often have a similar index rate of change but a smaller standard deviation of index rate of change when compared with their repeated sales indices. This is a very desirable feature of using *AV* statistics to estimate house price movements, especially for producing house price indices at a monthly level. Moreover, the nature of the estimation technique used by the repeated sales method means that there could be significant differences between the WRS and *SPAR* indices for the end of the series, which the repeated sales index is subject to significant index revision (Clapham *et al.* 2006).

5.4. Impacts of horizontal inequity on the SPAR and AV methods

As indicated in the above findings, the impact of vertical inequity on the *SPAR* method is small. In the *AV* method it uses an instrumental variable that classifies properties into low, middle or high value. Within any of these classifications, the problem of vertical inequity should be also small. However, neither the *SPAR* nor *AV* methods have dealt with the horizontal inequity in the index estimation. When the horizontal inequity exists, both the *SPAR* and *AV* indices can be problematic.

For the *SPAR* method it is expected that the positive and negative errors caused by the horizontal inequity problem will cancel out each other for index estimations. Since each period's *SPAR* index is free from the other period's index change (see Equation (11) for the *SPAR* method), a large sample should help to minimise but not totally eliminate the problem caused by measurement errors in assessed values. This places the *SPAR* method in favour of the *AV* method when horizontal inequities exist.

Table 6. Monthly changes in estimated house price indices, 1994–2009

Cities		WRS	AV	Standard SPAR	Modified SPAR
North Shore	Mean (%)	0.553	0.499	0.547	0.545
	Std. Dev (%)	1.510	1.384	1.388	1.410
Waitakere	Mean (%)	0.564	0.578	0.552	0.553
	Std. Dev (%)	1.625	1.577	1.591	1.611
Auckland	Mean (%)	0.640	0.577	0.644	0.644
	Std. Dev (%)	1.602	1.572	1.613	1.613
Manukau	Mean (%)	0.540	0.599	0.562	0.572
	Std. Dev (%)	1.676	1.394	1.361	1.370
Hamilton	Mean (%)	0.479	0.456	0.471	0.469
	Std. Dev (%)	1.646	1.442	1.456	1.458
Tauranga	Mean (%)	0.469	0.471	0.465	0.473
	Std. Dev (%)	1.730	1.710	1.758	1.786
Lower Hutt	Mean (%)	0.545	0.576	0.566	0.567
	Std. Dev (%)	2.078	1.616	1.693	1.704
Wellington	Mean (%)	0.599	0.620	0.608	0.613
	Std. Dev (%)	1.582	1.267	1.329	1.306
Christchurch	Mean (%)	0.491	0.479	0.460	0.465
	Std. Dev (%)	1.210	1.167	1.216	1.215
Dunedin	Mean (%)	0.446	0.519	0.484	0.491
	Std. Dev (%)	2.289	1.824	1.843	1.886

Notes: WRS denotes the weighted repeated sales index proposed by Case and Shiller (1989); AV represents the assessed values index proposed by Clapp (1990b); Standard SPAR refers to the sales prices appraisal ratio index which does not take account of vertical inequities and modified SPAR is for the SPAR index which takes account of vertical inequities.

In contrast, the averaging process in the *AV* method could be more complicated. This is because the OLS estimators in the *AV* method will be biased and inconsistent, when horizontal inequities exist.

Suppose the true market value model is:

$$\ln P_i^t = c\ln AV_i^0 + \sum_{j=1}^{k} \varnothing_j X_i^j + \sum_{t=1}^{T} \gamma_t D_i^t + \upsilon, \quad (16)$$

where: $\sum_{j=1}^{k} \varnothing_j X_i^j$ represents the horizontal inequity such as a group of locational and structural variables; c represents the vertical inequity and υ is the error term which has a zero mean and is uncorrelated with $\ln AV_i^0$ and $\sum_{j=1}^{k} \varnothing_j X_i^j$.

As shown by Wooldridge (2006), if we omit $\sum_{j=1}^{k} \varnothing_j X_i^j$ from the regression equation (16) and run the regression equation (8) instead, the estimation on γ_t will be biased. This is because the error term ε in equation (8) will now be equal to $\sum_{j=1}^{k} \varnothing_j X_i^j + \upsilon$. Let $\widehat{\gamma_t}$ denote the OLS estimator of γ_t, the inconsistency in $\widehat{\gamma_t}$ is:

$$plim\,\widehat{\gamma_t} - \gamma_t = Cov(\varepsilon, D_t) / Var(D_t). \quad (17)$$

Because $Var(D_t) > 0$, the inconsistency in $\widehat{\gamma_t}$ is positive if ε and D_t are positively correlated and vice versa. If ε and D_t are uncorrelated, the $\widehat{\gamma_t}$ will equal to γ_t. In this situation, the *AV* and *SPAR* methods may be very similar in handling assessment errors when constructing their indices. For example, if one takes the coefficient "c" as given in equation (8), and then subtracts the assessed value term from the dependant variable Ln(P) (call this new variable lnP*), the coefficients on the time dummies simply take the average of lnP*. These averages are taken over all properties that transact at any given time t. However, if ε and D_t are correlated, as pointed by Wooldridge (2006) the omitted variable problem in equation (17) does not go away by adding more data to the sample. If everything is equal, the problem will get worse with more data, i.e. the OLS estimator gets closer and closer to its biased value.

Although deriving the sign and magnitude of the inconsistency in $\widehat{\gamma_t}$ is difficult, the results of Table 4 and Figure 1 in Section 5.2 show the horizontal inequity does exist and most likely change over time. To see how the horizontal inequity will affect the *AV* and *SPAR* indices, we have graphed house price indices by using the WRS, *AV* and *SPAR* methods over the studied period. Figure 2 illustrates how closely those indices track each other in levels. In general, the standard and its modified *SPAR* indices track well to each other, with virtually no difference for most local housing markets. They are also the most equivalent indices to the WRS index when compared to the *AV* index. Interestingly, indices developed using *AV* statistics sometimes could depart from their respective WRS index counterparts. The results imply that the inconsistency problem caused by the horizontal inequity is more likely affected the *AV* method. More frequent reassessments will not help to close the gap in this situation[4]. For example in Wellington City where reassessments are carried out annually, house price indices measured by the *AV* statistics have been consistently above the repeated sales index for a long time.

6. CONCLUSIONS

This paper investigates house price measures for a small open economy using *AV* statistics. It shows that the impact of vertical inequities on indices using *AV* statistics is small. There is virtually no difference between the standard and modified *SPAR* indices, where the vertical inequity in assessed values has been rectified. As added to the literature, the results show that the biggest threat for using *AV* statistics to estimate house price movements is from horizontal rather than vertical inequities in assessed values. In this situation, both the *SPAR* and *AV* indices benefit from law of compensation of errors by using all sales. Overall, the results suggest that the *AV* method is roughly the same as the *SPAR* method in measuring the index rate of change, but could be problematic when measuring the index in levels, over multiple assessment periods.

This study has an important policy implication. Measurement errors in tax assessment are inevitable, which means that they are not easy to control. For indices using the *AV* statistics, the results will inevitably be biased in some degree if systematic errors exist. For those countries which have already used, or are going to use the *AV* statistics to produce house price indices, the *SPAR* method is a good alternative. The method is simple and will deliver a similar or even superior measurement reliability compared to the *AV* method.

[4] See discussions in Shi *et al.* (2009).

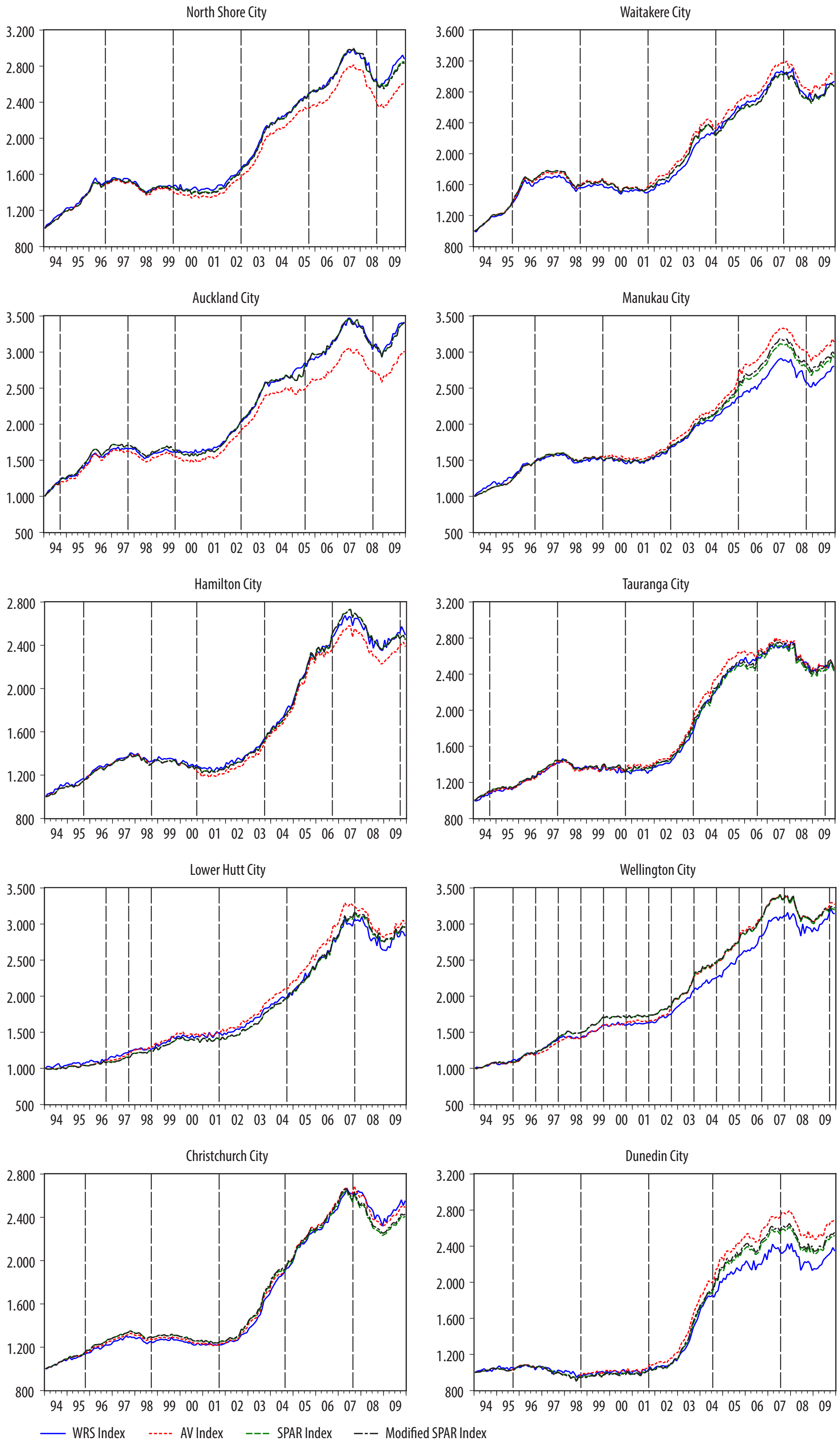

Fig. 2. House price indices for the top 10 cities in New Zealand, Jan. 1994 to Dec. 2009
Notes: The vertical line drawn on the date axis indicates the time of reassessment.

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REFERENCES

Allen, M. T.; Dare, W. H. 2002. Identifying determinants of horizontal property tax inequity: evidence from Florida, *Journal of Real Estate Research* 24(2): 153–164.

Birch, J. W.; Sunderman, M. A. 2003. Estimating price paths for residential real estate, *Journal of Real Estate Research* 25(3): 277–299.

Bourassa, S. C.; Cantoni, E.; Hoesli, M. 2011. *Robust repeat sales indexes*. Swiss Finance Institute.

Bourassa, S. C.; Hoesli, M.; Sun, J. 2006. A simple alternative house price index method, *Journal of Housing Economics* 15(1): 80–97. http://dx.doi.org/10.1016/j.jhe.2006.03.001

Case, K. E.; Shiller, R. J. 1987. *Prices of single-family homes since 1970: new indexes for four cities*. Cambridge, MA: National Bureau of Economics Research.

Case, K. E.; Shiller, R. J. 1989. The efficiency of the market for single-family homes, *American Economic Review* 79(1): 125–137.

Cheng, P. 1974. Property taxation, assessment performance and its measurement, *Public Finance* 29(3): 268–284.

Clapham, E.; Englund, P.; Quigley, J. M.; Redfearn, C. L. 2006. Revisiting the past and settling the score: index revision for house price derivatives, *Real Estate Economics* 34(2): 275–302. http://dx.doi.org/10.1111/j.1540-6229.2006.00167.x

Clapp, J. M. 1990a. A methodology for constructing vacant land price indices, *Real Estate Economics* 18(3): 274–293. http://dx.doi.org/10.1111/1540-6229.00522

Clapp, J. M. 1990b. A new test for equitable real estate tax assessment, *Journal of Real Estate Finance and Economics* 3(3): 233–249. http://dx.doi.org/10.1007/BF00216188

Clapp, J. M.; Giaccotto, C. 1992. Estimating price indices for residential property: a comparison of repeat sales and assessed value methods, *Journal of the American Statistical Association* 87(418): 300–306. http://dx.doi.org/10.1080/01621459.1992.10475209

Clapp, J. M.; Giaccotto, C.; Richo, G. 1996. Estimating time adjustments with sales prices and assessed values, *Appraisal Journal* 64(3): 319–327.

Cornia, G. C.; Slade, B. A. 2005. Property taxation of multifamily housing: an empirical analysis of vertical and horizontal equity, *Journal of Real Estate Research* 27(1): 17–46.

Englund, P.; Quigley, J. M.; Redfearn, C. L. 1999. The choice of methodology for computing housing price indexes: comparisons of temporal aggregation and sample definition, *Journal of Real Estate Finance and Economics* 19(2): 91–112. http://dx.doi.org/10.1023/A:1007846404582

Gatzlaff, D. H.; Ling, D. C. 1994. Measuring changes in local house prices: an empirical investigation of alternative methodologies, *Journal of Urban Economics* 35(2): 221–244. http://dx.doi.org/10.1006/juec.1994.1014

Gatzlaff, D.; Holmes, C. 2013. Estimating transaction-based price indices of local commercial real estate markets using public assessment data, *Journal of Real Estate Finance and Economics* 46(2): 260–281. http://dx.doi.org/10.1007/s11146-011-9333-0

Geltner, D.; Ling, D. C. 2006. Considerations in the design and construction of investment real estate research indices, *Journal of Real Estate Research* 28(4): 411–444.

Goolsby, W. C. 1997. Assessment error in the valuation of owner-occupied housing, *Journal of Real Estate Research* 13(1): 33–46.

Harrison, H. S. 1978. The residential appraiser: direct sales comparison approach (market data approach), part II: making adjustments, *Real Estate Appraiser and Analyst* 44(6): 72–79.

Haurin, D. R.; Hendershott, P. H. 1991. House price indexes: issues and results, *Real Estate Economics* 19(3): 259–269. http://dx.doi.org/10.1111/1540-6229.00552

International Association of Assessing Officers (IAAO). 1999. Standard on ratio studies, *Assessment Journal* 6(5): 23–64.

McDonald, C.; Smith, M. 2009. *Developing stratified housing price measures for New Zealand*. Wellington: Reserve Bank of New Zealand.

McMillen, D. P. 2012. Repeat sales as a matching estimator, *Real Estate Economics* 40(4): 745-773. http://dx.doi.org/10.1111/j.1540-6229.2012.00343.x

McMillen, D. P.; Weber, R. N. 2008. Thin markets and property tax inequities: a multinomial logit approach, *National Tax Journal* 61(4): 653–671.

Meese, R.; Wallace, N. 1997. The construction of residential housing price indices: a comparison of repeated-sales, hedonic-regression, and hybrid approaches, *Journal of Real Estate Finance and Economics*, 14(1-2): 51–73. http://dx.doi.org/10.1023/A:1007715917198

Pollakowski, H. O. 1995. Data sources for measuring house price changes, *Journal of Housing Research* 6(3): 377–387.

Shi, S.; Young, M.; Hargreaves, B. 2009. Issues in measuring a monthly house price index in New Zealand, *Journal of Housing Economics* 18(4): 336–350. http://dx.doi.org/10.1016/j.jhe.2009.06.001

Shiller, R. J. 1991. Arithmetic repeat sales price estimators, *Journal of Housing Economics* 1(1): 110–126. http://dx.doi.org/10.1016/S1051-1377(05)80028-2

Sirmans, G. S.; Diskin, B. A.; Friday, H. S. 1995. Vertical inequity in the taxation of real property, *National Tax Journal* 48(1): 71–84.

Wooldridge, J. M. 2006. *Introductory econometrics: a modern approach*. 3 ed. Mason: Thomson South-Western.

APPENDIX 1

Results for vertical inequity models

Valuation date	Cheng (1974)		IAAO (1999)		Clapp (1990b)		Vertical inequity
	North Shore City						
1/09/1996	0.914	***	–2.47E-07	***	1.037	*	R/R/R
1/09/1999	0.895	***	–2.03E-07	***	1.055	**	R/R/R
1/09/2002	0.865	***	–1.92E-07	***	1.051	**	R/R/R
1/09/2005	0.914	***	–1.06E-07	***	0.967		R/R/P
1/09/2008	0.939	***	–3.59E-08		1.012		R/R/R
	Waitakere City						
1/09/1995	0.939	***	–1.89E-07	***	1.018		R/R/R
1/09/1998	0.846	***	–6.34E-07	***	1.025		R/R/R
1/09/2001	0.782	***	–8.27E-07	***	1.085	*	R/R/R
1/09/2004	0.873	***	–2.83E-07	***	0.991		R/R/P
1/09/2007	0.953	**	–6.85E-08	*	0.966		R/R/P
	Auckland City						
1/09/1994	0.961	***	–1.09E-07	***	1.008		R/R/R
1/09/1997	0.934	***	–1.36E-07	***	0.999		R/R/N
1/10/1999	0.927	***	–1.28E-07	***	1.013		R/R/R
1/09/2002	0.961	***	–4.75E-08	***	0.989		R/R/P
1/07/2005	0.948	***	–5.38E-08	***	0.991		R/R/P
1/07/2008	0.953	***	–3.47E-08	***	1.004		R/R/R
	Manukau City						
1/09/1996	1.020		4.78E-08		0.925	***	P/P/P
1/09/1999	0.930	***	–2.64E-07	***	1.006		R/R/R
1/09/2002	0.853	***	–3.63E-07	***	1.093	***	R/R/R
1/09/2005	0.716	***	–4.96E-07	*	1.040		R/R/R
1/09/2008	0.899	***	–2.13E-07	***	1.058	***	R/R/R
	Hamilton City						
1/09/1995	0.967	*	–1.73E-07	*	0.985		R/R/P
1/09/1998	0.910	***	–3.97E-07	***	1.045		R/R/R
1/09/2000	0.929	***	–3.41E-07	**	1.048		R/R/R
1/09/2003	0.969	**	–9.22E-08		0.971	*	R/R/P
1/09/2006	0.891	***	–2.24E-07	***	1.032		R/R/R
1/09/2009	0.855	***	–3.21E-07	***	1.088	***	R/R/R
	Tauranga City						
1/09/1994	0.955	**	–1.44E-07		0.997		R/R/P
1/09/1997	0.944	**	–2.17E-07	**	0.979		R/R/P
1/09/2000	0.832	***	–5.98E-07	***	1.144	***	R/R/R
1/09/2003	0.863	***	–3.45E-07	***	1.047	**	R/R/R
1/07/2006	0.945	***	–7.34E-08	**	1.025		R/R/R
1/07/2009	0.997		–3.77E-09		0.948	**	R/R/P
	Lower Hutt City						
1/09/1996	0.962	***	–2.03E-07	***	1.033	**	R/R/R
1/09/1997	0.980	**	–1.01E-07	*	1.014		R/R/R
1/09/1998	0.936	***	–2.48E-07	*	1.028		R/R/R
1/09/2001	0.873	***	–4.09E-07	***	1.086	***	R/R/R
1/09/2004	0.943	***	–1.33E-07	*	0.997		R/R/P
1/09/2007	0.939	***	–1.16E-07	***	1.036		R/R/R

(Continued)

Valuation date	Cheng (1974)		IAAO (1999)		Clapp (1990b)		Vertical inequity
(Continued)							
	Wellington City						
1/09/1995	0.963	***	–1.12E-07	***	1.016		R/R/R
1/09/1996	0.988		–3.59E-08		0.999		R/R/P
1/09/1997	0.998		1.30E-10		0.989		R/P/P
1/09/1998	1.003		2.45E-09		0.968	**	P/P/P
1/09/1999	0.896	***	–2.79E-07	***	1.016		R/R/R
1/09/2000	0.917	***	–2.48E-07	***	1.021		R/R/R
1/09/2001	0.925	***	–2.19E-07	***	1.066	***	R/R/R
1/09/2002	0.925	***	–2.10E-07	***	1.035		R/R/R
1/09/2003	0.920	***	–1.59E-07	***	0.992		R/R/P
1/09/2004	0.947	***	–9.30E-08	***	0.990		R/R/P
1/09/2005	0.945	**	–9.34E-08	*	0.968		R/R/P
1/09/2006	0.942	***	–8.74E-08	***	0.999		R/R/N
1/09/2007	0.901	***	–1.04E-07	**	1.061	*	R/R/R
1/09/2009	0.974		–2.04E-08		1.008		R/R/R
	Christchurch City						
1/10/1995	0.980	**	–4.01E-08		0.986		R/R/P
1/09/1998	0.968	**	–1.03E-07		0.979		R/R/P
1/09/2001	0.879	***	–4.52E-07	***	1.066	***	R/R/R
1/08/2004	0.952	***	–1.15E-07	***	0.980		R/R/P
1/08/2007	0.927	***	–1.04E-07	***	0.986		R/R/P
	Dunedin City						
1/09/1995	0.909	***	–6.10E-07	***	1.078	***	R/R/R
1/09/1998	0.879	***	–9.41E-07	***	1.091	***	R/R/R
1/09/2001	0.844	***	–1.04E-06	***	1.101	***	R/R/R
1/07/2004	0.839	***	–6.38E-07	***	1.092	**	R/R/R
1/07/2007	0.939	***	–2.01E-07	***	1.018		R/R/R

Notes: The vertical inequity (α_1) is estimated using the first month's sales immediately after the assessment. Asterisks indicate significance levels of vertical inequity in assessed values at 1%(***), 5%(**), and 10%(*), respectively.