The Improved Net Rate Analysis

Song Shi*

School of Economics and Finance, Massey University, Palmerston North, New Zealand

*Email: s.shi@massey.ac.nz; Tel: 0064 6 3569099-2692; Fax: 0064 6 3505660; Address: SST Building 4.29, School of Economics and Finance, Private Bag 11222, Massey University, Palmerston North 4442, New Zealand
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Abstract

This paper proposes an improved net rate methodology to use the assessed land values to proxy the land contribution in real estate appraisals. The assumption in the method is that neighbourhood effects are capitalised into uniform land assessments. Compared to the traditional sales comparison approach, the method has potential to extend the selection of comparable properties. Simulations based on the theoretical and empirical data suggest the method benefit greatly from compensating for assessment errors. Since more sales can be incorporated into the proposed method, it is contended the appraisal result will be more objective and accurate. In practice, the method provides an attractive solution for property valuations in areas where there are limited sales.

Keywords: net rate analysis, sales comparison, valuations, assessed land values, property appraisal
1. Introduction

The sales comparison approach has been a key traditional appraisal method for many years. The method involves collecting sales of comparable properties, and making adjustments for changes in the market between sales and valuation date, for physical characteristics (both land and buildings) and neighbourhood effects between the subject and comparable properties. The methodology is simple and taught in many appraisal textbooks (Betts, 2013; Betts and Ely, 2008). However, the success of the sales comparison method depends on the accuracy of the adjustment process, number and comparability of sales.

Real estate is a heterogeneous product. Often, there are many property attributes and their interaction effects need to be considered in market appraisals. For the above reasons, the development of new appraisal techniques is always of interest in the real estate literature. Lentz and Wang (1998) review the academic research in the development of appraisal methodologies. They classify the evolution of the appraisal methodologies into three categories: the traditional adjustment-grid method, multiple regression method and contemporary adjustment-grid method. The contemporary adjustment-grid method can be viewed as a hybrid method of traditional adjustment-grid and regression methods, which uses minimum-variance (Vandell, 1991) or coefficient of variation (Gau, Lai and Wang, 1992, 1994) for selecting and weighting of comparable sales. Lai and Wang (1996) further derive a technique to estimate the confidence interval for the minimum-variance grid estimator. More recently, Lai, Vandell, Wang and Welke (2008) propose a replication method for estimating property values as an alternative to the traditional grid and regression methods.

Apart from the development of appraisal methodologies in the field to pinpoint the market value of a single family home, techniques in mass appraisals used for property taxation and other purposes have also been advanced. Non-traditional regression models and artificial intelligence methods are tested in residential property value assessments (e.g.
Peters and Flanagan (2009), Zurada, Levitan and Guan (2011) and among others). The latest trend is to incorporate spatial analysis into the hedonic house price modelling. Studies by Bourassa, Cantoni and Hoesli (2010), Osland (2010), and Beamonte, Gargallo and Salvador (2013) have all shown the importance of including spatial characteristics in improving assessment accuracy.

This paper proposes an appraisal technique using assessment values to improve the accuracy of estimating market values of single family residences in areas where there are limited sales. The method could take the advantage of the contemporary adjustment-grid method in selecting and adjusting comparable sales, as well as the development of new techniques in real estate mass appraisals for taxation purposes. The idea is based on the conceptual framework that the total property value can be estimated by distinguishing the contributions of improvements and land, where the land contribution is proxy to the property’s assessed land value. Nowadays, land is typically reassessed on a regular basis for taxation purposes in many countries\(^1\). Generally, assessment values can be readily obtained at no cost. When combined with property transaction data, assessed values can be useful for improving the accuracy of the traditional sales comparison approach.

The key assumption in this method is that neighbourhood effects are capitalised into uniform land assessments. The assumption is based on the valuation principle of highest and best use where land is valued to reflect all neighbourhood amenities. To the extent that the site improvements are not optimal (over or under improved), it will affect the value of improvements but not the land. This is certainly the case in New Zealand and many other countries. Bostic, Longhofer and Redfearn (2007) study the impact of land leverage on home price dynamics in Wichita, Kansas. In their study they decompose the total property value into two parts: structural value and land value, where neighbourhood effects are assumed to be capitalised into land. Their research method is supported by Bourassa, Haurin, Haurin,
Hoesli and Sun (2009). Techniques for separating land values for developed urban properties are also evolving. For example, Longhofer and Redfearn (2009) propose a new methodology in estimating land values using total property sales data for mass appraisals, assuming neighbourhood effects are capitalised into land. More recently, Özdilek (2012) support this separability of land values using residential sales data in Montreal, Canada.

Using assessed values statistics in housing market analysis has been evident in the literature. Most of these works are with respect to house price index construction. Clapp and Giaccotto (1992) show the advantage of using the assessed values (AV) method to produce house price indices compared with the repeated sales method. Their findings are supported by Gatzlaff and Ling (1994) and Gatzlaff and Holmes (2011). Similar works of using assessed value statistics to estimate market house price movements through the Sales Prices Appraisal Ratio (SPAR) method are also found in Bourassa, Hoesli and Sun (2006) and Shi, Young and Hargreaves (2009).

This paper is the first research in the literature to use property’s assessed land values in assisting the estimation of the market value of a single family home. Compared to the traditional sales comparison approach, the proposed method simplifies the sales comparison process and extends the potential pool of comparable properties in the valuation. Although assessment errors are of concern, the impact of measurement errors in assessed land values is small in the proposed method, particularly when more sales (5 or 10 sales) are included for comparison analysis. Since more house sales can be easily incorporated into the proposed approach, appraisal results tend to be more objectively determined. Using residential sales in Palmerston North city New Zealand, it showed the proposed methodology can potentially increase the selection of comparable properties to the city level and the potential impact of measurement errors in assessed land values on the appraisal result is under a 5% margin. In practice, the method could provide an attractive solution for property valuations in an
established urban area where land sales or comparable properties are scarce within the neighbourhood.

The remainder of this study is organised as follows. The valuation methodology is first presented, followed by the simulation framework and the empirical data utilised. The empirical results are then discussed with concluding remarks.

2. Methodology

2.1 The traditional sales comparison approach

The traditional sales comparison approach is based on the hedonic property value estimates. For the sale price of \(i\)th property at time period \(t_1\), it can be written as follows:

\[
SP_{i,t_1} = LV_{i,t_1} + BV_{i,t_1} + NV_{i,t_1}
\]

(1)

Where \(SP_{i,t_1}\) represents the sale price of \(i\)th property at time period \(t_1\), \(LV_{i,t_1}\) represents the value of the vector of land characteristics (including lot size, shape, contour, views and other amenities), \(BV_{i,t_1}\) represents the value of the vector of building characteristics (including building age, floor area, construction materials, condition, modernisation, number of bathrooms, garage and others), and \(NV_{i,t_1}\) is the value of the submarket/neighbourhood dummy variables.

Based on equation (1), the sale price for the \(j\)th property at time \(t_2\) can be written as:

\[
SP_{j,t_2} = LV_{i,t_1} \ast (1 + (L_{i,j})\%) + BV_{i,t_1} \ast (1 + (S_{i,j})\%) + NV_{i,t_1} \ast (1 + (N_{i,j})\%) + \sum_{p=1}^{t_2} T_p
\]

(2)
Where \((L_{i,j})\)% represents the vector of location adjustments in percentage terms between the \(i\)th and \(j\)th properties, \((S_{i,j})\)% represents the vector of structure adjustments and \((N_{i,j})\)% represents the neighbourhood adjustments between the two properties. \(T_p\) is the time impact for property sale prices between the time period \(t_1\) and \(t_2\).

The adjustment process used in the traditional comparison approach is based on the above elements adjustment technique for land, buildings and neighbourhood differences. There may be also interaction effects among land, building structure and neighbourhood characteristics in equation (1). In practice, appraisers often confine their selection to sales within the same locality, in order to minimise the adjustment process. However, this could be a problem in a downward market when the number of property transactions are small\(^2\). When there are limited sales at neighbourhood levels, the traditional comparable approach will not work effectively and the appraisal results may be subjective.

2.2 The net rate analysis

The method has a long history of practice, particularly in the New Zealand Government valuation department for valuing both residential and commercial properties. It is still widely used by valuers (appraisers) in New Zealand to overcome the problems when applying the replacement cost approach (Jefferies, 1991). It involves using property land values to separate improvement values from sales for comparisons, based on a net rate per square meter of dwelling floor area (called “the net rate”). Thus it avoids the necessity for a specific allowance for depreciation and obsolescence in the replacement cost approach to value the improvements. In the net rate analysis, the total property value is decomposed into land and improvements components where land is valued in its highest and best use, and
improvements are valued by the net rate as evidenced in the market. The technique of the net rate analysis involves the following steps:

1) Estimate the market land value of each comparable property at the time of sale.

2) Derive dwelling values by deducting estimated market land values and other improvements (such as garage, shed and fencing, etc.) from total property sale prices.

3) Such derived dwelling values are then analysed and compared on “the net rate” basis for comparisons.

4) Choose the net rate for the subject property and calculate the dwelling value of the subject property.

5) Add the dwelling value and other improvements value of the subject property to its estimated market land value to calculate the total property value.

The above net rate analysis procedure can be written into following equations:

\[ BV_{i,t1}^M = SP_{i,t1} - LV_{i,t1}^M \]  
\[ MV_{j,t2} = LV_{j,t2}^M + BV_{i,t1}^M \times (1 + (S_{i,j}) \%) + \sum_{t3} T_s \]  

Where

- \( t_1 \) represents the time of sale in the past
- \( t_2 \) represents the time of appraisal, where \( t_2 > t_1 \)
- \( BV_{i,t1}^M \) is the estimated building value of the \( i \)th comparable property at time \( t_1 \)
- \( SP_{i,t1} \) is the sale price of the \( i \)th comparable property at time \( t_1 \)
- \( LV_{i,t1}^M \) is the estimated market land value of the \( i \)th comparable property at sales
- \( MV_{j,t2} \) represents the estimated market value for the \( j \)th (subject) property at time \( t_2 \)
- \( LV_{j,t2}^M \) is the subject property’s market land value at time \( t_2 \)
\((S_{i,j})\%\) represents the building structure adjustments in percentage terms

\(T_s\) represents the time impact on the building value during the time period from \(t_1\) to \(t_2\)

\(M\) denotes the market value

It is important to note that dummy variables \(NV_{i,t_1}\) in equation (1) are assumed to be fully capitalised into the market land value \((LV^M_{i,t_1})\) in equation (3). Its drawback is that the method posits a significant burden of estimates in practice as the land contribution from sales must be estimated first in order to derive the net rates for building values. Not only are there often insufficient vacant land sales in urban residential areas, but also land values must be estimated at the date of each sale (Jefferies, 1991).

2.3 The improved net rate analysis

To simplify the above net rate analysis estimation, it suggests to use the assessed land values for taxation purposes to replace their market land values in the net rate analysis. Using assessed land values in the above equations (3) and (4), the improved net rate method can be written as follows:

\[
\begin{align*}
\bar{MV}_{j,t_2} &= LV^A_{j,t_2} + BV^A_{i,t_1} * (1 + (S_{i,j})\%) + \sum_{t_1}^{t_2} T_s \\
&= MV^A_{j,t_2} + BV^A_{i,t_1} * (1 + (S_{i,j})\%) + \sum_{t_1}^{t_2} T_s
\end{align*}
\]  

(5)

Where

\(\bar{MV}_{j,t_2}\) is the estimated total value of the subject property using assessed land value statistics

\(LV^A_{j,t_2}\) is the assessed land value of the subject property

\(BV^A_{i,t_1}\) is the derived improvement value for the \(i\)th comparable property using its assessed land value\(^3\)

A denotes the assessed value.
Table 1 gives an example of how the improved net rate analysis is applied to residential property appraisal. Assume there are five comparable sales for the analysis. For all of the five sales, their most recent assessed land values are available. To calculate the added value of dwelling to the land, appraisers deduct the assessed land value and other improvement value (including garage, shed and fencing, etc.) from the net property sale price. The derived dwelling value from sales is then analysed on the basis of net rate of dwelling floor area, followed by adjustments for time of sale and building physical characteristics (such as dwelling age, construction, condition, floor area, modernisation, building character and appeal, etc.) \(^4\). For calculating the net rate for the subject property, appraisers weight comparable sales according to their market knowledge and experience. Alternatively, it can be equally weighted if appraisers believe all comparable properties are very similar to the subject property. In this example sale 1 and sale 2 are believed to be more comparable to the subject property, therefore they are given higher weights (30% each) than other sales. The weighted average net rate is used to work out the dwelling value. To calculate the total value of the subject property, the calculated dwelling value is added back to the assessed land value of the subject property, plus any value of other improvements. For the market value decomposition, appraisers re-estimate the land using vacant land sales at the valuation date. The improvement value is simply the difference between the total property value and re-estimated market value of land.

<Insert Table 1>

Compared to Equation (4), Equation (5) has greatly simplified the comparison process as the land contribution at the time of sale is no longer required to be estimated. Instead, it is replaced by its most recent assessed land value for taxation purposes. For example, the land
contribution of sale 1 in Table 1 is given as $38,000 from its current land valuation for taxation purposes. However, using assessed values in property valuations can result in potential estimation errors in the improved net rate analysis.

2.4 Estimation errors in the improved net rate analysis

Although the assessment process is different in different countries, the sales comparison approach is still the underlying method used in New Zealand. The method is further supported by the index technique and lump sum adjustment. The index technique is similar to the Computer Assisted Mass Appraisal (CAMA) method which is used to calculate and update assessed values to the time of assessment. The lump sum adjustment method is used to allow individual adjustments of the assessed values when: a) notification is made of changes in property details; b) appeals are made by the homeowners; and c) general property inspections are undertaken. Note that property inspections are generally taken from the roadside which means assessors heavily rely on the historical property data to update their assessments.

Assessments must meet the minimum compliance requirements (e.g. the International Association of Assessing Officers standard (1999)). However, the problem of uniformity in tax assessments such as horizontal and vertical inequities does exist in empirical studies (Allen and Dare, 2002; Cornia and Slade, 2005; Goolsby, 1997)\(^5\). On the other hand, 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 (1990), Sirmans, Diskin & Friday (1995) and Cornia & Slade (2005)). Shi (2014) studied both vertical and horizontal inequities in examining the assessed values for the whole property (land and improvements) from the top 10 cities of New Zealand during the period 1994 - 2009. He found the vertical
inequity is small in the above New Zealand dataset, but the horizontal inequity varies over time and particularly large towards the end of the revaluation period.

There are several sources of assessment errors, including the use of past sale price information to infer the assessed values at the assessment date. Also, the appraiser may not have complete market knowledge or information required for a sales analysis, especially when there are non-notified property changes or limited comparable sales. Others may include time and budget constraints, subjectivity on the part of the appraiser, and the valuation methodology used. In the proposed net rate analysis, bracketing and neighbourhood restriction can be used to minimise the adverse effect of assessment errors. Bracketing the comparable properties with respect to price could reduce the problem of vertical inequity and restricting the selection of comparable properties in the same or similar neighbourhoods could minimise the effect of horizontal inequity. In the meantime, a large sales sample size will help to reduce the effect of both random and systematic assessment errors in the proposed net rate analysis.

It is arguable that problems of assessment errors in assessed land values are likely to be smaller than assessed values in whole. For taxation purposes, land is required to be assessed for its highest and best use assuming no improvements had been made on it\textsuperscript{6}. But the improvements do not include work done in the preparation and servicing of the land for building purposes (such as excavation, retaining walls, street, water, drainage, power and other amenities). Hence the notion of land value is the same or very close to “site value” (Bell and Bowman, 2006). Geographic and environmental information for land contour, lot shape, size, aspect, views, soil, environmental hazards and neighbourhood amenities (distance to the CBD, shopping centre and parks, etc.) are all easy to obtain and usable when assessing land values. This is in sharp contrast to the available information for the physical characteristics of buildings, which is often lacking detail and is subject to change over time. Perhaps the
greatest challenge in urban land valuation is insufficient vacant land sales. Nowadays, there are sophisticated techniques to develop separate land values for urban residential properties through using residential sales (e.g. Clapp (2003), Longhofer & Redfearn (2009) and others). The rich GIS information together with the advanced automated valuation technique for land will help to maintain uniformity in land assessments.

To show the sources of errors using assessed land values in the improved net rate analysis, the appraisal error for the same property is calculated under both equations (4) and (5) as follows:

\[ \hat{M_V}_{i,t2} - M_V_{j,t2} = L_V^A_{i,t2} - L_V^M_{i,t2} + (B_V^A_{i,t1} - B_V^M_{i,t1}) * (1 + (S_{i,j})%) \]  

(6)

Since the sale price of the \(i\)th comparable property should be the same no matter how it is decomposed, we have \((B_V^A + L_V^A) = (L_V^M + B_V^M)\) and \((B_V^A - B_V^M) = (L_V^M - L_V^A)\),

\[ \hat{M_V}_{i,t2} - M_V_{j,t2} = L_V^A_{j,t2} - L_V^M_{j,t2} + (L_V^M_{i,t1} - L_V^A_{i,t1}) * (1 + (S_{i,j})%) \]  

(7)

Equation (7) can be further re-arranged as the change of \(MV_{j,t2}\) (The proof can be found in the appendix):

\[ \frac{\hat{M_V}_{j,t2} - M_V_{j,t2}}{M_V_{j,t2}} = ((\beta - 1)) / ((\gamma \beta (1+\delta) / (\alpha - (1+\delta)) + 1), \quad \gamma \geq \frac{1}{\beta} \]  

(8)

Where

\(\alpha = L_V^A_{j,t2} / L_V^A_{i,t1}\), the ratio of the assessed land value of the \(j\)th (subject) property to the assessed land value of the \(i\)th (comparable) property

\(\beta = L_V^A_{i,t1} / L_V^M_{i,t1}\), the ratio of the assessed land value of the \(i\)th (comparable) property to its market land value at time of sale
\[ \gamma = \frac{SP_{i,t_1}}{LV_{i,t_1}^A}, \] the ratio of the sale price of the \(i\)th (comparable) property to its assessed land value at time of sale

\[ \delta = \left( S_{i,j} \right) \%, \] building structure adjustments in percentage terms between the subject property and comparable properties

Equation (8) provides point estimates of appraisal errors in the improved net rate analysis. It shows that the potential sources of appraisal errors in the improved net rate analysis originate from two parts. Firstly, it depends on a set of factors \(\alpha, \beta, \gamma\) and \(\delta\) between the subject and comparable properties, assuming land is uniformly assessed at the time of assessment (called “within” estimation error). Secondly, it is due to measurement errors in assessed land values of \(LV_{i,t_1}^A\) and \(LV_{j,t_2}^A\) (called “outside” estimation error). The “within” estimation error is correctable once values \(\alpha, \beta, \gamma\) and \(\delta\) between the subject and comparable properties are known, whereas the “outside” estimation error is uncontrollable. Since real estate appraisals often involve multiple sales in the analysis, it is logical to evaluate the accuracy of the proposed method in simulation tests where more sales can be incorporated.

3. Simulation

To test the “within” estimation error, a theoretical simulation procedure is undertaken as follows:

1) Let \(\beta\) change from 0.2 to 5 with steps of 0.1

2) \(\alpha\) is drawn from a log-normal distribution

\[ \alpha \sim LN(0, 0.6) \]

3) \(\gamma\) is drawn from a log-normal distribution

\[ \gamma \sim LN(0.81, 0.3) \]
4) δ is drawn randomly between -0.30 and 0.30

5) Calculate the appraisal errors in equation (8) conditioned on γ ≥ \frac{1}{\beta}

6) Calculate the average result of step 5) for 3, 5 and 10 times respectively

7) Repeat 1,000 times

8) Calculate the average result of step 7)

The selection of boundaries for α, β, γ and δ is based on intuition and empirical evidence. For β, it is set between 0.2 and 5, which means that assessed land values are restricted to a range of 0.2-5 times their market land values within the assessment periods (a maximum period of 3 years in New Zealand). For α, it is likely in log-normal distribution with a mean value of zero and a standard deviation of 0.6. In other words the most likely value for α is close to “1” with two thirds of chances for comparable properties in the simulation having an assessed land value of 0.55-1.82 times the subject property’s assessed land values. The assumption is based on the fact that appraisers will in all situations choose the most “comparable” properties in the sale analysis and the overall comparativeness of properties is somewhat linked to the similarity of property’s land components. For γ, it is assumed in log-normal distribution of (0.81, 0.3). For a mean log value of 0.81, it implies that the comparable property sale price is, on average, 2.25 times its assessed land value. With a standard deviation of a log value 0.3, it implies that the total property sale prices are most likely within a range of 1.67-3.03 times its assessed land value, i.e. the assessed land values of comparable properties are about 33-60% of their total property sale prices. This is generally true in New Zealand. δ is set between -30% and 30%, as outside this range properties are not considered “comparable” to the subject property.
To estimate the “outside” estimation error, assessment errors in land are assumed at 10% and 20% margins of error respectively at any given level of $\beta$. A theoretical simulation procedure is undertaken as follows:

1) Let $\beta$ change from 0.2 to 5 with steps of 0.1

2) $\alpha$ is drawn from a log-normal distribution

$$\alpha \sim LN(0, 0.6)$$

3) $\gamma$ is drawn from a log-normal distribution

$$\gamma \sim LN(0.81, 0.3)$$

4) $\delta$ is drawn randomly between -0.30 and 0.30

5) Calculate the appraisal errors in equation (8) conditioned on $\gamma \geq \frac{1}{\beta}$

6) Re-estimate $\beta$ allowing $LV_{i,t1}^A$ randomly drawn at 10% and 20% margins of error respectively

7) Re-estimate $\alpha$ using $LV_{i,t1}^A$ in step 6) and allowing $LV_{j,t2}^A$ randomly drawn at 10% and 20% margins of error respectively.

8) Re-estimate $\gamma$ using $LV_{i,t1}^A$ in step 6)

9) Calculate the appraisal errors in equation (8) based on the re-estimated values of $\beta$, $\alpha$ and $\gamma$

10) Calculate the difference of appraisal error between step 5) and step 9)

11) Calculate the average result and confidence intervals of step 10) for 3, 5 and 10 times respectively

12) Repeat 1,000 times

13) Calculate the average result of step 12)
In the above simulation procedures, appraisal errors are first estimated at no land assessment errors in step 5). The results are then compared to the estimated appraisal errors at 10% and 20% margins of land assessment errors respectively in step 9). The impact is measured in step 10) by calculating the difference of appraisal error before and after the land assessment errors are taken into account. The assumption of 10% and 20% margins of error in the assessed land values is based on the empirical evidence that the vertical inequity is generally within the range of 0.9 and 1.1 (less than 10%) and the horizontal inequity tends to be large towards the end of reassessment period. Other considerations may include the random assessment errors in land assessments.

Empirical tests using actual transaction data are also carried out at city and suburb levels. Five comparable sales are chosen and the margin of assessment error in land is assumed at 10% at any given level of β. Due to the limited number of sales at suburb levels, empirical simulations are set at 100 times. The estimating procedure is the same as the above theoretical simulation test.

4. Data

The data contains 1,171 single family sales in Palmerston North city, New Zealand between March 2011 and February 2012. Each sale record has information on the net sale price, sale date, assessed property value, assessed land value, floor area, land area and other building variables including age and condition of buildings. General reassessments for taxation purposes are carried out regularly on a 3-year basis. For this particular dataset, assessed values were last carried out in September 2009. The summarised statistics of sales data are presented in Table 2.

<Insert Table 2>
Palmerston North city is an inland provincial city with predominantly flat land and with an estimated population of 80,000 in 2012. There are currently about 30,000 owner occupied dwellings. The average number of property transactions is about 100 per month at the city level, which is about 0.3% of total housing stock. At suburb levels, the average number of sales drops to about 15 - 20 per month. The low level market activity could cause a problem for the use of traditional sales comparison approach for estimating property values due to the lack of recent comparable sales within the vicinity of the subject property to be valued. Land values are likely to be consistently assessed; as such, it provides a good exemplar for testing the proposed net rate analysis. Figure 1 shows suburbs and assessment boundaries for Palmerston North city.

<Insert Figure 1>

5. Results

5.1 Point estimates of appraisal errors

Tables 3a and 3b show the point estimates of equation (8) for a set of values \( \alpha \) and \( \delta \). The results shed some light on the nature of estimated appraisal errors in the proposed method, i.e. the size and direction of the appraisal errors under different scenarios, assuming assessed land values are accurate. Table 3a shows the estimated appraisal errors when \( \alpha=2.0 \) and \( \delta=0.15 \). Several observations are in order. First, when \( \beta<1 \), the appraisal results of using the proposed net rate analysis method are negatively biased. When \( \beta>1 \), the results are positively biased. When \( \beta=1 \), the appraisal will exhibit no bias. Second, the higher values of \( \gamma \), the lower appraisal errors will be. The results make sense. As \( \gamma \) represents the ratio of the comparable property’s sale price to its assessed land value, a high value of \( \gamma \) will indicate a less proportional weight of land values in property’s sale prices. Since the land contribution
becomes relatively less important in the total property sale prices, the proposed net rate method (using the assessed land value to proxy its market land value) is more applicable. Third, when assessed land values are close to their market values, appraisal errors are small. When $\beta$ is between 0.75 and 1.25, appraisal errors are within a 10% margin of error. For comparison, Table 3b shows the estimated appraisal errors of equation (8) when $\alpha=0.5$ and $\delta=0.15$. Note that the signs of estimated errors are opposite to the results of Table 3a. When $\beta<1$, the results are positively biased. When $\beta>1$, the results are negatively biased. When $\beta=1$, the appraisal exhibit no bias.

The results reveal the potential benefit of compensating for errors by including more comparable sales in the net rate analysis. In fact, appraisers can look for “opposite” comparable properties and include them in the sales analysis. The negative and positive errors can somewhat cancel out each other and thereby minimise the overall appraisal error in valuations.

<Insert Tables 3a and 3b>

Table 4 presents the point estimates of required minimal values of $\gamma$, the ratio of the comparable property’s sale price to its assessed land value. The results are useful for choosing “opposite” comparable properties in the net rate analysis. Panel A shows the results when $\alpha=0.5$, i.e. the subject property’s assessed land value is below the comparable property’s assessed land value. Panel B shows the results when $\alpha=1.0$, i.e. the subject property’s assessed land value is close to the comparable property’s assessed land value. Panel C shows the results when $\alpha=2.0$, i.e. the subject property’s assessed land value is more than the comparable property’s assessed land value. For example in Panel A at a 10% margin of valuation error when $\beta$ is at 1.50 and $\delta$ is at 0.30, the minimal value of $\gamma$ is estimated at 2.50, which means the total sale price of a comparable property is required to be at least 2.5
times of its assessed land value. The value of γ will drop to 1.00 in Panel B and 1.50 in Panel C. In each Panel when δ is increasing either positively or negatively, the required value of γ is also increasing. When δ=0, γ has the lowest required values. Moreover the distribution of γ around δ=0 in each Panel is asymmetric. For all Panels the value of γ is increasing when values of α and β are moving away from “1”.

The results indicate that in an urban residential area where land is assessed at particularly low or high market values, the selection of comparable properties is more likely to be restricted. Appraisers need to choose comparable properties for which their assessed land values are similar to the subject property’s assessed land value (α is close to “1”) in the improved net rate analysis.

<Insert Table 4>

5.2 Simulation

Figure 2 shows the theoretical simulation results of “within” estimation errors in the improved net rate analysis, assuming no land assessment errors. The results show the average appraisal error in the proposed method tends to be positively biased under 10%. However the method suffers from a large variation of appraisal errors as indicated by the 95% confidence intervals (CI), particularly when β is departing from “1”. For example, when β=0.5 using 3 comparable sales, the average appraisal error is estimated at 4.5% with the 95% CI between -27% and 36%\(^{12}\). Increasing the number of comparable sales from 3 to 10 will reduce the average appraisal error to 3.4% with the 95% CI between -13.7% and 20.5%. Thus adding more sales will not significantly improve the result. The wide range of appraisal errors in the improved net rate method suggests “within” estimation errors are of concern and must be dealt with in practice. The problem is particularly relevant in valuations when β is
significantly different from “1”. For example, the assessed and market land values could diverge towards the end of reassessment period due to market land price movements.

<Insert Figure 2>

Figure 3 shows the theoretical simulation results of “outside” estimation errors in the improved net rate method. The impact of land assessment errors on the valuation accuracy is measured by the difference of appraisal errors before and after assessment errors are taken into account. The results show the method benefits greatly from compensating for assessment errors, i.e. the impact of positive and negative assessment errors in land tends to cancel out each other in the improved net rate analysis. For example, when $\beta=0.5$ using 3 comparable sales, the 95% CI of appraisal error difference is between -3.8% and 3.7% assuming a 10% margin of assessment error in land. Using 5 comparable sales, the 95% CI will reduce to -3.0% and 3.1%. In fact, using 10 comparable sales the 95% CI of the appraisal error difference is within a 5% margin at any given level of $\beta$. The impact of “outside” estimation errors will gradually increase when the margin of land assessment error is increased to 20%. In general, the impact of land assessment errors in the proposed method is small.

<Insert Figure 3>

Figure 4 shows the empirical simulation results using 5 comparable sales at both city and suburb levels. The top graph in Figure 4 shows the impact of “within” estimation error effect in the improved net rate analysis, whilst the bottom graph in Figure 4 represents the impact of “outside” estimation error effect on the appraisal accuracy, assuming assessment errors are at 10% margin of error. Similar to the theoretical simulation, empirical results report a large variation of 95% CI for the “within” estimation error. For example, when $\beta=0.5$, the 95% CI of the average appraisal error due to the “within” estimation error is between -19.6% and 24.2% at city level. In contrast, the 95% CI of the “outside” estimation error effect is well under a
5% margin for this New Zealand dataset. Thus the impact of assessment errors in land is less important in this empirical test.

The results further show the improved net rate analysis method could perform differently at suburb levels. In some suburbs such as sub 4 and sub 5 where land is relatively homogeneous, the impact of “within” estimation error effect in the proposed method is small. On the other hand in suburbs such as sub 1 and sub 2 where land tends to be heterogeneous in terms of views and contours, the impact is large. The results of using city level data is sitting somewhere in between the results from using suburb level data. Finally, the impact of “outside” estimation error effect is relatively the same among suburbs.

<Insert Figure 4>

5.3 Estimation strategy in the improved net rate analysis

One area of interest is to correct the “within” estimation error and provide a confidence interval for the “outside” estimation error effect in the improved net rate analysis. Table 5 illustrates the process. The subject property and 5 comparable sales are taken from Table 1. For sale 1, $\alpha$ is calculated at $80,000/$38,000= 2.11, $\beta$ is calculated at $80,000/$90,000= 0.89 (assuming land has been uniformly assessed in the locality)\(^{15}\), $\gamma$ is calculated at $175,000 /$38,000= 4.61, and $\delta$ is taken from Table 1. Using equation (8) the point estimated appraisal error for sales 1 is calculated at -2.12%, and so on for all other sales. It shows that the subject property value could be undervalued using sales 1, 4 and 5 and slightly overvalued using sales 2 and 3, assuming all adjustments are correct in Table 1. Amongst all comparable sales, sales 1 and 4 have larger appraisal errors. The results are not surprising. Sale 1 has an unusual high value of $\alpha$ (2.11) and sale 4 has a substantial low value of $\delta$ (-21%), which implies that either the land component in sale 1 or the improvements component in sale 4 are not very “comparable” to the subject property.
The net rates obtained from each sale are used to calculate the land and dwelling value for the subject property (called “prior-to-adjustment values”). There are five such prior-to-adjustment values in this case. Since those prior-to-adjustment values are estimated with errors, it is logical to correct them to obtain the correct values (called “post-adjustment values”). Using the point estimates of appraisal errors for each sale, the calculation of their post-adjustment values is straightforward. The correct value for the subject property’s land and dwelling components is then calculated by taking an equal weight of those post-adjustment values. Adding back the estimated other improvement value to the land and dwelling components, the total property value is estimated. The property value in this case is estimated at $230,000 compared to the value of $225,000 in Table 1, representing about a 2% increase in value for the subject property.

Although measurement errors in land cannot be overcome, one can provide a confidence interval for the above estimated value. As illustrated in the theoretical simulation tests, at β=0.89 the range of 95% CI due to assessments errors in land will be between -1.4% and 1.7% for a 10% margin of error in land assessments, and between -2.5% and 3.7% for a 20% margin of error in land assessments.

6. Conclusions

This paper proposes an improved net rate methodology based on the conceptual framework that the total property value can be decomposed into land and improvement values. The method involves using the assessed land values to proxy the land contribution. The assumption is that neighbourhood effects are capitalised into uniform land assessments. The results show appraisal errors in the proposed method come from two parts. Firstly, it
comes from the “within” estimation error in the method due to a set of factors between the subject and comparable properties. Secondly, it comes from the “outside” estimation error due to assessment errors in land values. The “within” estimation error is correctable but the “outside” estimation error cannot be overcome. Simulation results using theoretical and empirical data reveal the method benefits greatly from compensating for assessment errors. By including more sales (5 or 10 sales), the method can effectively tolerate a lot of assessment errors in land values. Thus the impact of the “outside” estimation error effect is less important in the improved net rate analysis.

The findings suggest that the “within” estimation error in the method is of concern and must be corrected accordingly. Once this error has been corrected, the method can contribute to property valuations by including more sales. As more sales from different suburbs can be easily incorporated into the proposed method, it is contended the appraisal result will be more objective and accurate. A confidence interval for the impact of the “outside” estimation error effect due to land assessment errors can also be estimated. In practice, the method provides an attractive solution for property valuations in area where there are few land sales or total comparable sales are limited.

One of the limitations of this research is that Palmerston North city is geographically isolated and relatively self-contained. This means the results in this study may somewhat lack external validity and will need further modification for wider geographical areas. If the uniformity in assessed land values is indeed of concern particularly towards the end of reassessment period, it is recommended to use the bracketing technique with respect to property sale prices or confine sales to a homogeneous submarket/neighborhood level, in order to minimise the adverse impact of the uniformity problem. There is also scope for further research to extend the study into rural areas where there are typically few sales or other property types such as commercial properties.
Appendix 1: Proof of equation (8)

\[
\frac{M\bar{V}_{j,t_2} - MV_{j,t_2}}{MV_{j,t_2}} = \frac{LV_{j,t_2}^A - LV_{j,t_2}^M + (LV_{i,t_1}^M - LV_{i,t_1}^A) \times (1 + (S_{i,j})\%)}{LV_{j,t_2}^M + BV_{i,t_1}^M \times (1 + (S_{i,j})\%) + \sum_{t_1}^{t_2} T_s}
\]

Since \(BV_{i,t_1}^M = SP_{i,t_1} - LV_{i,t_1}^M\), \(t_1=t_2\) or \(\sum_{t_1}^{t_2} T_s \approx 0\), we have

\[
\frac{M\bar{V}_{j,t_2} - MV_{j,t_2}}{MV_{j,t_2}} = \frac{LV_{j,t_2}^A - LV_{j,t_2}^M + (LV_{i,t_1}^M - LV_{i,t_1}^A) \times (1 + (S_{i,j})\%)}{LV_{j,t_2}^M + (SP_{i,t_1} - LV_{i,t_1}^M) \times (1 + (S_{i,j})\%)}
\]

Simplify the above equation by dividing both the numerator and denominator by \(LV_{i,t_1}^M\), we have:

\[
\frac{M\bar{V}_{j,t_2} - MV_{j,t_2}}{MV_{j,t_2}} = \frac{\frac{LV_{j,t_2}^A}{LV_{i,t_1}^M} - \frac{LV_{j,t_2}^M}{LV_{i,t_1}^M} + \left(\frac{LV_{i,t_1}^M}{LV_{i,t_1}^M} - \frac{LV_{i,t_1}^A}{LV_{i,t_1}^M}\right) \times (1 + (S_{i,j})\%)}{\frac{LV_{j,t_2}^M}{LV_{i,t_1}^M} + \left(\frac{SP_{i,t_1}}{LV_{i,t_1}^M} - \frac{LV_{i,t_1}^M}{LV_{i,t_1}^M}\right) \times (1 + (S_{i,j})\%)}
\]

Since the land component of an improved property is uniformly assessed, let

\[
\alpha = \frac{LV_{j,t_2}^A}{LV_{i,t_1}^M} = \frac{LV_{j,t_2}^M}{LV_{i,t_1}^M}
\]

\[
\beta = \frac{LV_{i,t_1}^A}{LV_{i,t_1}^M} = \frac{LV_{j,t_2}^A}{LV_{j,t_2}^M}
\]

\[
\gamma = \frac{SP_{i,t_1}}{LV_{i,t_1}^A}
\]

\[
\delta = (S_{i,j})\%
\]

We have:

\[
\frac{M\bar{V}_{j,t_2} - MV_{j,t_2}}{MV_{j,t_2}} = \frac{\alpha \times \beta - \alpha + (1 - \beta) \times (1 + \delta)}{\alpha + (\gamma \times \beta - 1) \times (1 + \delta)}
\]
\[ \frac{\bar{MV}_{j,t2} - MV_{j,t2}}{MV_{j,t2}} = \frac{(\beta - 1) \ast (\alpha - \delta - 1)}{\gamma \ast \beta \ast (1 + \delta) + (\alpha - \delta - 1)} \]

\[ \frac{\bar{MV}_{j,t2} - MV_{j,t2}}{MV_{j,t2}} = \frac{(\beta - 1)}{\gamma \ast \beta \ast (1 + \delta) + 1} \]

Since \((SP_{i,t1} - LV_{i,t1}^M) \geq 0\)

\[ \left( \frac{SP_{i,t1}}{LV_{i,t1}^A} - \frac{LV_{i,t1}^M}{LV_{i,t1}^A} \right) = (\gamma - \frac{1}{\beta}) \geq 0 \]

Therefore

\[ \gamma \geq \frac{1}{\beta} \]
References


Acknowledgements

The author is grateful to many colleagues and friends, especially Bob Hargreaves, David Tripe, Iona McCarthy, Andrea Bennett, Rodney Jefferies and seminar participants of Massey University for helpful comments and suggestions. Sincere thanks to the editor, Ko Wang, as well as three anonymous referees for their valuable suggestions. The usual disclaimer applies.
Table 1: Example of improved net rate analysis

<table>
<thead>
<tr>
<th>Comparable sales</th>
<th>Sale 1</th>
<th>Sale 2</th>
<th>Sale 3</th>
<th>Sale 4</th>
<th>Sale 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sale price</td>
<td>175,000</td>
<td>215,000</td>
<td>230,000</td>
<td>250,000</td>
<td>245,000</td>
</tr>
<tr>
<td>Less assessed land value</td>
<td>38,000</td>
<td>81,000</td>
<td>87,000</td>
<td>52,000</td>
<td>78,000</td>
</tr>
<tr>
<td>Improvement value</td>
<td>137,000</td>
<td>134,000</td>
<td>143,000</td>
<td>198,000</td>
<td>167,000</td>
</tr>
<tr>
<td>Less other improvements</td>
<td>10,000</td>
<td>15,000</td>
<td>15,000</td>
<td>18,000</td>
<td>14,000</td>
</tr>
<tr>
<td>Value of the dwelling</td>
<td>127,000</td>
<td>119,000</td>
<td>128,000</td>
<td>180,000</td>
<td>153,000</td>
</tr>
<tr>
<td>Floor area (sqm)</td>
<td>130</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Net Rate ($/psm)</td>
<td>977</td>
<td>992</td>
<td>1,067</td>
<td>1,500</td>
<td>1,275</td>
</tr>
</tbody>
</table>

Adjustments of net rates:

| Sales time      | 5.00% | 3.00% | 2.00% | 2.00% | 2.00% |
| Building age    | -3.00%| 0.00% | -5.00%| 0.00% | 0.00% |
| Construction materials | 5.00% | 0.00% | 0.00% | 0.00% | 5.00% |
| Condition       | 0.00% | 0.00% | 0.00% | -10.00%| -15.00%|
| Floor area      | 0.00% | -3.00%| -3.00%| -3.00%| -3.00% |
| Modernisation/Character/Appeal | 0.00% | 0.00% | 0.00% | -10.00%| -5.00% |
| Total adj.      | 7.00% | 0.00% | -6.00%| -21.00%| -16.00%|
| Adjusted net rate ($/psm) | 1,045 | 992 | 1,003 | 1,185 | 1,071 |
| Weights on comparable sales | 30% | 30% | 15% | 10% | 15% |

Weighted average net rate: 1,041

**Property valuation**

| Floor area of the subject property | 130 sqm |
| Calculated dwelling value | 135,330 |
| Plus the assessed land value | 80,000 |
| Plus other improvements | 10,000 |
| Total current market value of property | 225,330 |

**Market value breakup**

| Market value of land | 90,000 |
| Market value of improvements | 135,330 |
| Current market value of property | 225,330 say 225,000 |

Notes: This table illustrates the adjustment procedures of using the improved net rate analysis method. 5 comparable sales are selected from the market for the comparison. Assessed land values are obtained from the property transaction database or through the local authority. Other improvements include the garage, shed and fencing, etc. Percentage adjustments are based on the market evidence and field inspections of subject and comparable properties. Weights on comparable sales are placed according to the appraiser’s market knowledge and experience. For the subject property, its assessed land value is given at $80,000; its market land value is valued at $90,000. Other improvements value is estimated at $10,000. The assessed land valuations are carried out at the same time for all properties and they are not adjusted to the time of sale.
Table 2: Summarised statistics of dwelling sales for Palmerston North city, March 2011 to February 2012

<table>
<thead>
<tr>
<th></th>
<th>Total sale price ($)</th>
<th>Assessed total values ($)</th>
<th>Assessed land values ($)</th>
<th>Age of dwelling (year)</th>
<th>Floor area (M²)</th>
<th>Land area (M²)</th>
<th>Ratio of sale price to assessed land value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>City</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>302,010</td>
<td>303,695</td>
<td>137,480</td>
<td>47</td>
<td>154</td>
<td>798</td>
<td>2.28</td>
</tr>
<tr>
<td>Maximum</td>
<td>1,101,500</td>
<td>1,375,000</td>
<td>780,000</td>
<td>&gt;100</td>
<td>500</td>
<td>9589</td>
<td>5.71</td>
</tr>
<tr>
<td>Minimum</td>
<td>100,000</td>
<td>113,000</td>
<td>55,000</td>
<td>1</td>
<td>67</td>
<td>220</td>
<td>1.01</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>112,591</td>
<td>115,302</td>
<td>62,757</td>
<td>27</td>
<td>58</td>
<td>624</td>
<td>0.67</td>
</tr>
<tr>
<td>Observations</td>
<td>1,171</td>
<td>1,171</td>
<td>1,171</td>
<td>1,171</td>
<td>1,171</td>
<td>1,171</td>
<td></td>
</tr>
<tr>
<td><strong>Sub 1: Hokowhitu/Aokautere Urban</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>388,886</td>
<td>400,390</td>
<td>207,584</td>
<td>44</td>
<td>182</td>
<td>737</td>
<td>1.98</td>
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<tr>
<td>Maximum</td>
<td>880,000</td>
<td>980,000</td>
<td>780,000</td>
<td>&gt;100</td>
<td>500</td>
<td>2218</td>
<td>3.96</td>
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<tr>
<td>Minimum</td>
<td>175,000</td>
<td>190,000</td>
<td>85,000</td>
<td>1</td>
<td>80</td>
<td>312</td>
<td>1.01</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>128,332</td>
<td>131,526</td>
<td>88,204</td>
<td>28</td>
<td>64</td>
<td>256</td>
<td>0.68</td>
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<tr>
<td>Observations</td>
<td>191</td>
<td>191</td>
<td>191</td>
<td>191</td>
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<td>191</td>
<td></td>
</tr>
<tr>
<td><strong>Sub 2: Terrace End/Roslyn/Brightwater</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Mean</td>
<td>272,758</td>
<td>273,064</td>
<td>133,340</td>
<td>59</td>
<td>138</td>
<td>792</td>
<td>2.11</td>
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<tr>
<td>Maximum</td>
<td>650,000</td>
<td>700,000</td>
<td>390,000</td>
<td>&gt;100</td>
<td>345</td>
<td>9589</td>
<td>4.05</td>
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<tr>
<td>Minimum</td>
<td>100,000</td>
<td>138,000</td>
<td>74,000</td>
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<td>67</td>
<td>279</td>
<td>1.06</td>
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<tr>
<td>Std. Dev.</td>
<td>90,864</td>
<td>90,312</td>
<td>54,158</td>
<td>24</td>
<td>53</td>
<td>752</td>
<td>0.53</td>
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<tr>
<td>Observations</td>
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<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
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<tr>
<td><strong>Sub 3: Riverdale/Awapuni/West End/Papaeoia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>287,847</td>
<td>289,020</td>
<td>150,035</td>
<td>68</td>
<td>144</td>
<td>725</td>
<td>1.92</td>
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<tr>
<td>Maximum</td>
<td>850,000</td>
<td>827,000</td>
<td>492,000</td>
<td>&gt;100</td>
<td>400</td>
<td>2465</td>
<td>3.47</td>
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<tr>
<td>Minimum</td>
<td>110,000</td>
<td>160,000</td>
<td>80,000</td>
<td>10</td>
<td>76</td>
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<td>1.01</td>
</tr>
<tr>
<td>Std. Dev.</td>
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<td>100,801</td>
<td>51,573</td>
<td>24</td>
<td>54</td>
<td>244</td>
<td>0.42</td>
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<td>Observations</td>
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<td>254</td>
<td>254</td>
<td>254</td>
<td>254</td>
<td>254</td>
<td></td>
</tr>
<tr>
<td><strong>Sub 4: Kelvin Grove/Milson/Cloverlea</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>313,875</td>
<td>310,571</td>
<td>111,751</td>
<td>27</td>
<td>164</td>
<td>698</td>
<td>2.75</td>
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<tr>
<td>Maximum</td>
<td>680,000</td>
<td>650,000</td>
<td>240,000</td>
<td>&gt;100</td>
<td>308</td>
<td>2162</td>
<td>5.12</td>
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<td>Minimum</td>
<td>143,000</td>
<td>170,000</td>
<td>72,000</td>
<td>1</td>
<td>80</td>
<td>383</td>
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<tr>
<td>Std. Dev.</td>
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<td>85,054</td>
<td>23,299</td>
<td>21</td>
<td>54</td>
<td>153</td>
<td>0.56</td>
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<td>Observations</td>
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<td>289</td>
<td>289</td>
<td>289</td>
<td>289</td>
<td></td>
</tr>
<tr>
<td><strong>Sub 5: Highbury/Westbrook/Takaro</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>236,286</td>
<td>237,168</td>
<td>111,207</td>
<td>48</td>
<td>130</td>
<td>726</td>
<td>2.11</td>
</tr>
<tr>
<td>Maximum</td>
<td>422,500</td>
<td>440,000</td>
<td>215,000</td>
<td>100</td>
<td>359</td>
<td>2082</td>
<td>3.35</td>
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<tr>
<td>Minimum</td>
<td>140,000</td>
<td>139,000</td>
<td>63,000</td>
<td>1</td>
<td>80</td>
<td>422</td>
<td>1.11</td>
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<tr>
<td>Std. Dev.</td>
<td>58,803</td>
<td>55,772</td>
<td>27,254</td>
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<td>Observations</td>
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</tr>
</tbody>
</table>

Note: Sub 1 includes valuation rolls 14700, 14660, 14670, 14710 and 14720; Sub 2 includes valuation rolls 14570, 14580, 14620, 14680 and 14690; Sub 3 includes valuation rolls 14480, 14730, 14550, 14560, 14600, 14610, 14650 and 14740; Sub 4 includes valuation rolls 14470, 14500, 14510 and 14590; Sub 5 includes valuation rolls 14520, 14530, 14540, 14630 and 14640. Suburb classifications are from Quotable Value New Zealand. The assessed land valuations were carried out in September 2009.
Table 3a: Estimated appraisal errors, when $\alpha = 2.0$ and $\delta = 0.15$

<table>
<thead>
<tr>
<th>$\beta$: the ratio of property's assessed land value to its market land value</th>
<th>0.250</th>
<th>0.500</th>
<th>0.750</th>
<th>1.000</th>
<th>1.250</th>
<th>1.500</th>
<th>1.750</th>
<th>2.000</th>
<th>2.250</th>
<th>2.500</th>
<th>2.750</th>
<th>3.000</th>
<th>3.250</th>
<th>3.500</th>
<th>3.750</th>
<th>4.000</th>
<th>4.250</th>
<th>4.500</th>
<th>4.750</th>
<th>5.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$: the ratio of property's sale price to its assessed land value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Notes: The table presents the point estimates of appraisal errors based on equation (8) using formula $((\beta-1))/((\gamma*\beta(1+\delta))/(\alpha(1+\delta))+1)$, where $\alpha$ is the ratio of the assessed land value of the subject property to the assessed land value of the comparable property, $\beta$ is the ratio of the property’s assessed land value to its market land value, $\gamma$ is the ratio of the comparable property’s sale price to its assessed land value at the time of sale, and $\delta$ is the estimated building structure adjustments in percentage terms between the subject and comparable properties. The reported appraisal errors are based on $\alpha = 2.0$ and $\delta = 0.15$. -- line denotes a 10% margin of error.
<table>
<thead>
<tr>
<th>γ: the ratio of property’s sale price to its assessed land value</th>
<th>0.250</th>
<th>0.500</th>
<th>0.750</th>
<th>1.000</th>
<th>1.250</th>
<th>1.500</th>
<th>1.750</th>
<th>2.000</th>
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<th>4.500</th>
<th>4.750</th>
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<tbody>
<tr>
<td>b: Estimated appraisal error</td>
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<tr>
<td>a: Estimated appraisal error</td>
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<tr>
<td>α: the ratio of the comparable property’s sale price to its assessed land value</td>
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<tr>
<td>δ: the estimated building structure adjustments in percentage terms between the subject and comparable properties</td>
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</tbody>
</table>
| Notes: The table presents the point estimates of appraisal errors based on equation (8) using formula \((\beta - 1)/(\gamma \beta(1+\delta)/(\alpha - (1+\delta)) + 1)\), where α is the ratio of the assessed land value of the subject property to the assessed land value of the comparable property, β is the ratio of the property’s assessed land value to its market land value, γ is the ratio of the comparable property’s sale price to its assessed land value at the time of sale, and δ is the estimated building structure adjustments in percentage terms between the subject and comparable properties. The reported appraisal errors are based on α = 0.5 and δ = 0.15. -- line denotes a 10% margin of error.
Table 4: The required minimal values of γ, at 10% margin of error

| β: the ratio of property’s assessed land value to its market land value | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 3.25 | 3.50 | 3.75 | 4.00 | 4.25 | 4.50 | 4.75 | 5.00 |
| α=0.5 | | | | | | | | | | | | | | | | | | | | | |
| δ=0.30 | 3.00 | 1.00 | 1.75 | 2.50 | 3.00 | 3.50 | 3.75 | 4.00 | 4.25 | 4.50 | 4.75 | 4.75 | 4.75 | 5.00 | 5.00 | 5.00 | >5.00 | | | |
| δ=0.15 | 2.75 | 1.00 | 1.75 | 2.50 | 2.75 | 3.25 | 3.50 | 3.75 | 4.00 | 4.00 | 4.25 | 4.25 | 4.50 | 4.50 | 4.50 | 4.50 | 4.50 | >4.75 | >4.75 | >4.75 | |
| δ=0.00 | 2.50 | 1.00 | 1.50 | 2.00 | 2.50 | 2.75 | 3.00 | 3.25 | 3.50 | 3.75 | 3.75 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | >4.25 | >4.25 | >4.25 | >4.25 |
| δ=-0.15 | 4.75 | 2.00 | 1.00 | 1.25 | 1.75 | 2.00 | 2.50 | 2.50 | 3.00 | 3.00 | 3.25 | 3.25 | 3.25 | 3.25 | 3.25 | 3.25 | 3.50 | 3.50 | 3.50 | |
| δ=-0.30 | 3.25 | 1.50 | 1.00 | 1.00 | 1.25 | 1.50 | 1.75 | 1.75 | 2.00 | 2.00 | 2.00 | 2.25 | 2.25 | 2.25 | 2.25 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| α=1.0 | | | | | | | | | | | | | | | | | | | | | |
| δ=0.30 | 3.00 | 1.50 | 1.00 | 1.00 | 1.00 | 1.25 | 1.50 | 1.50 | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| δ=0.15 | 4.50 | 2.00 | 1.50 | 1.00 | 1.00 | 0.75 | 0.75 | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 |
| δ=0.00 | 4.00 | 2.00 | 1.50 | 1.00 | 1.00 | 0.75 | 0.75 | 0.75 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| δ=-0.15 | 4.50 | 2.00 | 1.50 | 1.00 | 1.00 | 0.75 | 0.75 | 0.75 | 1.00 | 1.00 | 1.00 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.50 | 1.50 | 1.50 | 1.50 |
| δ=-0.30 | 3.50 | 1.50 | 1.00 | 1.00 | 1.25 | 1.75 | 1.75 | 2.25 | 2.50 | 2.75 | 2.75 | 3.00 | 3.00 | 3.25 | 3.25 | 3.25 | 3.25 | 3.50 | 3.50 | 3.50 |
| α=2.0 | | | | | | | | | | | | | | | | | | | | | |
| δ=0.30 | 4.50 | 1.50 | 1.00 | 1.00 | 1.50 | 2.00 | 2.50 | 2.75 | 3.00 | 3.25 | 3.50 | 3.75 | 3.75 | 4.00 | 4.00 | 4.00 | 4.25 | 4.25 | 4.25 | 4.25 |
| δ=0.15 | 1.50 | 1.00 | 1.00 | 1.00 | 2.00 | 2.75 | 3.50 | 4.00 | 4.25 | 4.50 | 4.75 | 5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 |
| δ=0.00 | 2.00 | 1.00 | 1.25 | 2.75 | 3.75 | 4.50 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 |
| δ=-0.15 | 2.75 | 1.00 | 1.75 | 3.75 | 5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 |
| δ=-0.30 | 3.75 | 1.00 | 2.25 | 5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 | >5.00 |

Notes: The table presents the point estimates of required minimal values of γ at a 10% margin of appraisal error. Appraisal errors are estimated using formula \(((β-1))/(γβ(1+δ)/(α(1+δ))+1))\), where α is the ratio of the assessed land value of the subject property to the assessed land value of the comparable property, β is the ratio of the property’s assessed land value to its market land value, γ is the ratio of the comparable property’s sale price to its assessed land value, and δ is the estimated building structure adjustments in percentage terms between the subject and comparable properties.
<table>
<thead>
<tr>
<th>Table 5: Estimation strategy</th>
<th>Sale 1</th>
<th>Sale 2</th>
<th>Sale 3</th>
<th>Sale 4</th>
<th>Sale 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparable sales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>2.11</td>
<td>0.99</td>
<td>0.92</td>
<td>1.54</td>
<td>1.03</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>4.61</td>
<td>2.65</td>
<td>2.64</td>
<td>4.81</td>
<td>3.14</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.07</td>
<td>0.00</td>
<td>-0.06</td>
<td>-0.21</td>
<td>-0.16</td>
</tr>
<tr>
<td><strong>Estimated appraisal errors</strong></td>
<td>-2.12%</td>
<td>0.06%</td>
<td>0.10%</td>
<td>-2.02%</td>
<td>-0.81%</td>
</tr>
<tr>
<td><strong>Land &amp; dwelling values prior to adjustment</strong></td>
<td>215,850</td>
<td>208,960</td>
<td>210,390</td>
<td>234,050</td>
<td>219,230</td>
</tr>
<tr>
<td><strong>Land &amp; dwelling values post to adjustment</strong></td>
<td>220,534</td>
<td>208,838</td>
<td>210,172</td>
<td>238,866</td>
<td>221,031</td>
</tr>
<tr>
<td><strong>Equally weighted average land &amp; dwelling values</strong></td>
<td>219,888</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plus other improvements values</strong></td>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total property value</strong></td>
<td>229,888</td>
<td>say</td>
<td>230,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The table illustrates the process of how to correct the “within” estimation error in using the improved net rate analysis method. The subject property and 5 comparable sales are taken from Table 1. Values of $\alpha$, $\beta$, $\gamma$ and $\delta$ are defined in Equation (8). For sale 1, $\alpha$ is calculated at $80,000 / 38,000 = 2.11$, $\beta$ is calculated at $80,000 / 90,000 = 0.89$ (assuming land has been uniformly assessed in the locality), $\gamma$ is calculated at $175,000 / 38,000 = 4.61$, and $\delta$ is taken from Table 1. For calculating the land & dwelling values prior to adjustments, it uses the net rates estimated in Table 1 multiplied by the subject property's floor area and plus back the subject property's assessed land value. For the land & dwelling values post to adjustment, it uses the land & dwelling values prior to adjustments divided by (1+ the estimated appraisal error).
Figure 1: Suburbs and assessment boundaries for Palmerston North city
Figure 2: Theoretical simulation results of “within” estimation errors

- 3 comparable sales
- 5 comparable sales
- 10 comparable sales

Legend:
- Average appraisal errors
- Upper bound of 95% CI
- Lower bound of 95% CI
Figure 3: Theoretical simulation results of “outside” estimation errors
Figure 4: Empirical simulation results using 5 comparable sales, at a 10% margin of assessment error in land values.
New Zealand has a very robust rating system. Under the Rating Valuations Act 1998 all residential properties in New Zealand are required to be reassessed on a regular basis, every three years or sometimes more frequently. The local authorities contract the assessment to a registered appraiser (called “Valuer” in New Zealand). Under the Act the assessment value (known in New Zealand as “Capital Value”) should be the property’s market value less value of chattels (i.e. fixed floor coverings, blinds, drapes, light fittings and removable appliances), at the assessment date. The assessment results as prepared by registered appraisers have to pass various statistical tests set by the Valuer-General at the time of assessment (see Shi, et al (2009) for more discussions), while the assessments are also subject to the scrutiny of property owners as people can object to the values assessed for their properties.

The limited sales can be caused by both the size and liquidity of the market. Here it is referring to the small size of local housing market. See Mok (2002) for more discussions on the market thickness and the cost of liquidity.

Using equation (3), $BV^A_{t1} = SP_{t1} - LV^A_{t1}$

It is worth noting that percentage adjustments here should be market orientated. A multiple regression model could be useful in estimating the associated percentage adjustments in the above adjustment process.

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. Vertical inequities occur when the assessment is not carried out consistently across low and high-valued properties. Testing methods for the vertical inequity typically include the method of Cheng (1974), International Association of Assessing Officers (1999) and Clapp (1990).

At least this is the case in New Zealand (see the Rating Valuations Act 1998 for the definition of land value). In fact it eliminates any interaction effect of physical characteristics of the building structure on the land.

Uniformity does not necessarily mean accuracy. In practice assessed land values could vary significantly from their market values.
For example, assume the total property sale price is $300,000, its assessed land value ($LV_{i,t1}^A$) is $140,000 and its market land value ($LV_{i,t1}^M$) is $180,000, then we have ($BV_{i,t1}^A + LV_{i,t1}^A$) = 160,000 + 140,000 = 300,000, ($LV_{i,t1}^M + BV_{i,t1}^M$) = 180,000 + 120,000 = 300,000. ($BV_{i,t1}^A - BV_{i,t1}^M$) = 160,000 - 120,000 = 40,000, ($LV_{i,t1}^M - LV_{i,t1}^A$) = 180,000 - 140,000 = 40,000. Therefore, ($BV_{i,t1}^A + LV_{i,t1}^A$) = ($LV_{i,t1}^M + BV_{i,t1}^M$) and ($BV_{i,t1}^A - BV_{i,t1}^M$) = ($LV_{i,t1}^M - LV_{i,t1}^A$).

Statistics New Zealand 2006 census data shows that there are 27,849 owner occupied dwellings in Palmerston North city.

The average number of house sales is about 600 per month (0.8% of total housing stock) in Auckland city, 260 (0.9%) in Wellington city and 710 (1%) in Christchurch city.

Although there is no particular reason why the values of $\alpha$ and $\delta$ must be set like this, it is logical to choose some values for $\alpha$ and $\delta$ which are sufficiently larger from their respective neutral levels (1 for $\alpha$ and 0 for $\delta$) to show the size and direction of appraisal errors.

Statistics results for Figure 2 are available on request.

Statistical results for Figure 3 are available on request.

Statistical results for Figure 4 are available on request.

Because it is assumed that land is uniformly assessed in the locality, all comparable properties have the value of $\beta$ in this instance. There could be some variations in the assumption due to random and systematic assessment errors in land or different land price appreciations during the reassessment period.