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Further Empirical Examination of an Improved Sales Comparison Approach

Lin, Tzu-Chin
Associate Professor
Department Land Economics
National Chengchi University
64, Sec. 2, Zhi-Nan Rd., Taipei City 11605, Taiwan
Tel: Int.-886-2-29393091 ext. 51536
E-mail: tclin@nccu.edu.tw

Liao, Ying-Chih
Land Administration Department, Taichung City, Taiwan

Abstract. *Despite the significant advances in applying regression analysis into property valuation, the main features of the sales comparison approach lack thorough research. A series of works have endeavoured to retain the essence of the sales comparison approach, while at the same time take advantage of regressions to derive not only the implicit values of property attributes, but also the degree of similarity between properties. Despite these improvements, the determination of the best regression forms and the piecemeal-type of price adjustment remain vexing problems. The nearest neighbours method assumes that the effects of all attribute differences between the subject and comparable properties are captured by the Mahalanobis distance. The indicated market value of the subject property is simply a weighted average of the actual selling prices of the comparable properties. This method sidesteps the above vexing difficulties and seems worth employing. The present study extends the application of the nearest neighbours method to high-density residential properties, which have not previously been examined. In terms of both the average and coefficient of variations for prediction errors, neither the conventional regression nor the nearest neighbours method outperforms the other. Nevertheless, the distribution of the accumulated prediction errors suggests that the nearest neighbours method is superior over the regression analysis approach. Our empirical findings are, therefore, in favour of further pursuit along the small sample (comparables) methods.*

Keywords: *sales comparison approach, grid-adjustment regression, nearest neighbours method*

1 Principles of the sales comparison approach and criticisms it has attracted

The sales comparison approach is defined as "A comparative approach to value that considers the sales of similar or substitute properties and related market data and establishes a value estimate by process involving comparison…" (International Valuation Standards 2005: 405). Alternatively, it is said to be "A set of procedures in which a value indication is derived by comparing the property being appraised to similar properties that have been sold recently, applying appropriate units of comparison, and making adjustments to the sale prices of the comparables based on the elements of comparison…" (Appraisal Institute 2001: 63). The amount that an appraiser adds to or subtracts from the price of a comparable property is an estimate of the market value of attributes. This estimate is done on the basis of experience, judgment, and knowledge of how individual buyers and sellers tend to price these attributes (Brueggeman and Fisher 2001: 168). The appraiser then gives weights to adjusted prices of comparable properties and uses the weighted average price as the final indicated value (Corgel et al. 2001: 305). Therefore, to some extent, the sales comparison approach is seen as a subjective process and serious errors can result without justifiable adjustments (Brueggeman and Fisher 2001: 228). Lusht (2001: 115) makes a fair statement: this (sales comparison) approach is rooted in two simple but powerful principles; market value is what the market says something is worth, and identical products should have identical prices. Although the principles are simple, substantial judgment is required in applying this approach.

Therefore, the above discussion suggests three essential elements involved in the sales comparison approach, which places high demands upon appraisers' professional judgments and often attracts criticism, namely the selection of comparable properties, price adjustments for attribute differences, and allocation of weights among comparable properties. To what extent these three seemingly subjective processes could be made more objective has received continuing attention in literature.

2 Modernizing the sales comparison approach

The application of regression analysis to property valuation has a long history, which dates back at least to 1922 by Haas (Colwell and Dilmore 1999) on agricultural land. Through regression analysis, the respective price of individual attributes is estimated on the foundation of hedonic pricing models. Sirmans et al. (2005) in a recent review of hedonic pricing models in real properties conclude that the most frequently included attributes are lot size, square feet, age, the number of stories, and a time trend. These variables generally have the expected signs, although in some instances they are not significant. A total of slightly less than 200 pieces of empirical work are cited. Through regression analysis, implicit prices of individual property attributes are estimated in an objective way. Appraisers do not need to make subjective guesses.

Despite the significant advances in applying regression analysis into property valuation, as suggested above, the main features of the sales comparison approach lack thorough research. When regressions are applied to valuing properties, price of the subject property is derived as the sum of values of respective attributes multiplied by their magnitudes. This regression process itself does not explicitly consider selecting comparable properties, deriving adjusted values of comparables, and assigning weights among them. To be more precise, all sample properties used in a regression are regarded as comparables to the subject property, and each sample is given an equal weight in determining the final value. They are apparently in conflict with the essence of the sales comparison approach. The sales comparison approach aims to find those comparable properties, usually a small number, and reach the final value judgment based on the weighted average of comparables' adjusted values that account for the price differences resulting from different attributes. Regression analysis is a good method to find the implicit prices of individual property attributes; however, it is not designed to select the qualified comparables or to give weights.

In contrast to the replacement of the sales comparison approach by a straightforward application of regression analysis, a number of studies have attempted to keep the essence of sales comparison while also taking advantage of regression analysis. Colwell et al. (1983) reason that the value of a subject property is inferred from the value of comparables after adjusting for the price differences due to differences in attributes. The process of attribute-associated price adjustment is often called grid-adjustment in appraisal literature. Colwell et al. (1983) identify three most popular grid-adjustment methods, including the additive dollar adjustment method, the additive percentage adjustment method, and the multiplicative percentage adjustment method. These three methods respectively correspond to linear, semi-log, and double-log regression models. The use of the above regression models facilitates finding the implicit attribute values. Those values then become inputs into the sales comparison method to arrive at the adjusted values of comparable sales, followed by the weighting scheme to reach the final value of the subject property. In so doing, regression analysis is incorporated into the sales comparison approach. This kind of approach can be called grid-adjustment regression. The authors conclude that on a theoretical ground the grid-adjustment regression is generally less biased than the regression method. They also propose possible weighting schemes for reconciliation of adjusted values. Kang and Reichert (1991) later provide empirical evidence with respect to the superior accuracy of price prediction between regression and grid-adjustment regression analysis. The absolute value of the net adjustment factor is proposed to measure the similarity among potential comparable properties. This factor is the sum of attribute price obtained by regression, multiplied by the difference between subject property, and potential comparables on values of individual attributes. The importance of individual attributes is represented by their regression coefficients. They examine sales prices of 1,751 houses during 1986 for three Chicago suburban areas: Lombard, Wheaton, and Naperville. The forecasting errors of regression analysis are in the range of 6.25 and 10.04 percent. In contrast, the forecasting error of grid-adjustment regression ranges from 3.3 through 11.64 percent. The study areas are broken down into submarkets in terms of price and quality of neighbourhoods. It is shown that grid-adjustment regression is superior to regression, where a market is in equilibrium and housing and neighbourhood characteristics are homogeneous. Huang (2002) extends the grid-adjustment regression method to property valuation for taxation purposes in Taichung City, Taiwan. In comparison with regression, the grid-adjustment regression improves the accuracy and also reduces the variability of valuation results.

Isakson (1986) attempts to complete the selection of comparable sales and weight allocation among adjusted values in a coherent process. In his proposed nearest neighbours method, the attributes of an individual property are viewed as coordinates along the n-dimensional axis and every property is thus given a particular point in the n-dimensional space. Calculation of Mahalanobis distances between the subject property and individual potential comparables enables the properties to be identified in the order of their nearness (similarity) to the subject property. In addition, the weights for comparable properties are in inverse proportion to their respective Mahalanobis distances. Nearness measured by Mahalanobis distance is employed both for selection of comparables and weight allocation. The nearest neighbours method assumes that the effects of all attribute differences between the subject and comparable properties are captured by the Mahalanobis distance. The indicated market value of the subject property is simply a weighted average of the actual selling, not adjusted, prices of the comparable properties. This method sidesteps the often criticized piecemeal adjustments for attribute differences. Empirical study is undertaken to analyse housing sales in Spokane, Washington from July 1, 1978 through September 30, 1978. Sales of 563 houses are included to establish the price prediction model by which prices of another 112 houses are estimated. It is concluded that the nearest neighbours method is statistically more accurate than the grid-adjustment regression method in terms of sum-of-squared errors in price prediction. Isakson (1988) later extends the nearest neighbours method to a variety of commercial real estate in Dallas, Texas. Estimates of value using the nearest neighbours method are significantly more accurate than ordinary least squares estimates for retail and miscellaneous properties. Furthermore, they are more accurate, but not significantly so, than OLS estimates for condominium buildings, industrial properties, and office buildings.

This series of work undertaken by Colwell et al (1983), Kang and Reichert (1991), and Huang (2002), all endeavour to retain the essence of the sales comparison approach, while at the same time to take advantage of regressions to derive not only the implicit values of property attributes but also the degree of similarity between properties. A combination of the sales comparison approach and regression analysis seems to have proven fruitful. Despite these improvements to the sales comparison approach, the determination of the best regression forms and the piecemeal-type of price adjustment remain vexing problems. Isakson (1986, 1988) offers the nearest neighbours method as an alternative to the grid-adjustment regression method. The nearest neighbours method avoids the previously described vexing difficulties, and instead, frames the unknown value of the subject property as a weighted value of a small number of similar properties. It is noted that all the above referred to studies prefer a small sample of comparables to a large sample base. Rationales behind the preference of a small sample are well presented in Kummerow and Galfalvy (2002). They argue that random errors of sampling distributions decrease with sample size, but misspecification and measurement errors resulting from heterogeneity of properties, locations, and submarkets increase with sample size at the same time. The phenomenon of error trade-off leads the optimal sample size to being quite small. The optimal number of comparables are found to be three (Isakson 1986) and five (Kummerow and Galfalvy 2002), respectively. More comparables are found to add little or to even reduce valuation accuracy.

The authors provide a theoretical explanation as to why many practicing appraisers still rely on the conventional sales comparison approach, with a small set of comparable sales, and why this method seems to continue performing modestly well. That is to say, as far as property valuation is concerned, a small sample may not merely be a cost-minimizing expedient, but it could also be a sensible choice.

Despite the potential advantages of introducing regression analysis and other methods, such as the nearest neighbours approach, the extent of their practical improvements certainly demands more empirical study, particularly outside the U.S. and in different types of markets. This belief leads the authors to undertake an additional empirical piece that compares regression analysis and nearest neighbours methods.

The authors understand that other techniques in addition to conventional regression, grid-adjustment regression, and the nearest neighbours approach have been developed and applied to property valuation, such as spatial econometrics, notably spatial autoregression and spatial error models (Anselin 1988 and Wilhelmsson 2008), and geographically weighted regression (Fotheringham et al. 2002), among others. Employment of those techniques requires advanced statistical knowledge and specific software aptitude. In addition, unlike the methods reviewed in this article, neither spatial econometrics nor geographically weighted regression was developed alongside the thinking of property valuation. In this regard, this study only focuses on the methods whose development is closely associated with the theories of property valuation.

3 An additional investigation in a suburban residential area

Review of previous studies reveals a series of efforts to make valuation more objective, and the need for additional empirical work becomes evident. This article thus investigates a suburban residential area of Taipei City in Taiwan to compare the accuracy and reliability of regression and nearest neighbours methods when applied to multi-story condominiums. Taipei is among the most crowded cities worldwide, with 9,650 residents per square mile and an average living area per person of 31.67 square metres (Essential Statistics of Taipei City, Department of Budget, Accounting and Statistics, Taipei City Government 2010). Its housing price is also considered high by international standards. The ratio of the median housing price to the median yearly income has been on the rise from 5.5 in the early 1970s up to 9.06 in 2010 (Chen et al. 2007 and Housing Statistics Quarterly

Report, Construction and Planning Agency, Ministry of the Interior 2010). These figures suggest that real property takes up a substantial proportion of equity from Taipei's households, and has noticeable effects in many ways.

The study area is the Wen-Sun district of Taipei City, a suburban area dominated by residential activities. Selection of such a relatively homogeneous residential area enables us to concentrate on the comparisons between regression analysis and the nearest neighbours method. The data set of 1,468 low-rise condominiums and 926 high-rise condominiums that were sold in the market from January 2001 through January 2005 is supplied by the Land Administration Department of the Taipei City Government. A low-rise condominium refers to residential buildings of or less than five storeys without elevators and a high-rise condominium refers to residential buildings over five storeys, usually with elevators. As the data obtained includes addresses for individual properties, all properties are located in space through an address-matching function. In addition, their distances to major public facilities are calculated through networking analysis, both through a geographical information system. We also keep 50 low-rise condominiums and 50 high-rise condominiums as the hold-out samples for later examination of prediction ability. In order to maintain a thorough examination in space, we adopt the quadrat analysis (Lee and Wong 2001: 62–72) to delineate the Wen-Sun district into 50 quadrats and select one low-rise condominium and one high-rise condominium from each as the hold-out samples.

Distances to the nearest park, junior high school, public garage, electrical substation, mass rapid transit (MRT), and the regional public hospital are calculated. We use the spatially coded map provided by the Department of Urban Development, Taipei City Government. This map indicates locations of all public facilities; however, unfortunately, locations that provide private services, such as private clinics, private schools, etc, are not indicated. A number of dummy variables are also included, such as whether a property fronts onto a main road. Furthermore, a series of variables presenting the time trend as year 1999 being the base year, and a series of floor variables that present the effects of different floors on price are included. In Taiwan, ground-floor properties are normally more expensive than properties on other floors because ground floor locations have their own entrances, and therefore, have a greater degree of privacy. Top-floor properties are expected to command a price premium because they have better access to common areas on top of buildings. In contrast, fourth-floor properties are usually cheaper because in Taiwan the number 4 is often regarded as bad luck (similar to number 13 in western culture), as it has a similar pronunciation as the word death. These variables are consistently found to significantly affect property values in Taipei City (for two recent pieces, Lin and Ma 2007; Lin and Ko 2010). Table 1 shows the summary of selected variables.

No multicollinerity is found in any of the regressions with a variance inflation factor (VIF) test. Heterodasticity is found in some regressions, and where it is found, original standard error is replaced by White's corrected standard error (Gujarati 2003: 417–8). In addition, the Dubin-Watson test shows no autocorrelation problem in any of the regressions. Table 2 summarizes the regression results for

***Table 1.** Statistical Summary of Selected Variables.*

	Low-rise condominiums				**High-rise condominiums**			
	Mean	**Min.**	**Max.**	**S.D.**	**Mean**	**Min.**	**Max.**	**S.D.**
Sales price (New Taiwan Dollars)	5,244,346	2,220,000	22,000,000	1,707,418	6,428,456	1,600,000	17,500,000	2,681,682
Total floors (m^2)	101	37	304	25.6	108	21	345	43.2
Structure age (in years)	24	3	38	6.5	11	3	27	4.8
Distance to nearest park (m)	244	36	590	103.4	260	67	599	95.5
Distance to nearest school (m)	261	59	613	106.9	299	67	625	123.6
Distance to nearest public garage (m)	536	28	1,658	256.2	666	38	1,752	421.2
Distance to nearest substation (m)	691	52	1,877	324.9	672	80	2,731	398.9
Distance to nearest MRT (m)	1,146	66	2,946	659.1	1,134	123	3,033	692.8
Distance to nearest hospital (m)	1,850	55	2,326	703.3	1,887	363	4,573	702

both low-rise condominiums and high-rise condominiums in three functional forms.

The empirical results as a whole correspond to our prior expectation. Residential properties that front onto a main road are penalized, likely due to the noise and congestion. Properties with a better access to MRT command a premium in price. Besides, properties significantly depreciate with structure age. Properties on ground and top floors tend to be more expensive than those on other floors. In contrast, properties on the fourth floor are liable to suffer from price reduction. In addition, the series of time variables present a consistent price trend. However, low-rise condominiums seem to be more sensitive than high-rise condominiums in terms of the price effects of access to parks and public garages. This phenomenon is probably due to the fact that high-rise condominiums in Taiwan often have their own exclusive, although small, green areas and underground garages. The variable coefficients for access to electrical substations and hospitals are contrary to our prior expectation. The electrical substations included in the sample only serve the local neighbourhoods and are modest in size. Additionally, they have all been in place for years. Most likely due to the above reasons, the expected adverse price effects are absent. Also, only the regional hospital in this district is considered and those local private clinics are ignored in the models. This hospital is located in the major commercial area where traffic congestion has long been a problem. The disamenities around the hospital, we suspect, overshadow the benefits of approximation to the medical services. The Wen-Sun district is known for its relatively homogeneous neighbourhoods. Furthermore, it is probably because of this homogeneous neighbourhoods, it is noted

Table 2. *Regression Results for Low-rise Condominiums and High-rise Condominiums.*

Variables	**Low-rise condominium (linear)**	**Low-rise condominium (semi-log)**	**Low-rise condominium (double-log)**	**High-rise condominium (linear)**	**High-rise condominium (semi-log)**	**High-rise condominium (double-log)**
Intercept	1999006(10.03)	14.90744(411.09)	12.17265(83.05)	2584413(11.62)	14.975(406.62)	12.01025(81.8)
Total floor areas (m^2)	50320***(54.16)	0.00836***(49.46)	0.88838***(51.68)	53045***(61.08)	0.00826***(57.47)	0.87028***(71.48)
Structure age (in year)	–42161***(–11.17)	–0.00644***(–9.37)	–0.15043***(–12.83)	–66938***(–8.06)	–0.01098***(–7.99)	–0.15422***(–10.83)
Front onto main road (yes:1; no:0)	–33865(–0.55)	–0.01438(–1.29)	–0.00969(–0.62)	–30840(–0.35)	–0.01719(–1.18)	–0.03683**(–2.12)
Distance to park (m)	–1460.95536**(–2.54)	–0.00022292**(–2.13)	–0.03787***(–1.9)	454.0666(0.48)	0.00004171(0.26)	–0.01582(–0.48)
Distance to school (m)	300.12282(0.55)	–0.00004251(–0.43)	0.00915(0.44)	–307.6866(–0.37)	0.00003588(0.26)	0.013(0.42)
Distance to public garage (m)	–325.95376***(–3.34)	–0.00008089***(–4.55)	–0.04262***(–5.49)	–10.30846(–0.07)	0.00001449(0.62)	0.02734***(2.93)
Distance to substation (m)	–189.54542**(–2.29)	–0.00002378(–1.58)	0.03419***(4.24)	–399.10291***(–3.44)	–0.00003996**(–2.08)	–0.01076(–1.22)
Distance to MRT (m)	–571.63997***(–11.85)	–0.00010728***(–12.22)	–0.10838***(–15.07)	–398.78172***(–6.02)	–0.00005018***(–4.57)	–0.06531***(–7.13)
Distance to hospital (m)	200.74544***(2.83)	0.00003400***(2.64)	0.05379***(3.72)	–183.56893**(–1.84)	–0.00004432***(–2.68)	–0.0816***(–4.23)
Sold in 2000 (yes:1; no:0)	–399682***(–5.49)	–0.06248***(–4.72)	–0.11514***(–6.19)	–1005213***(–7.65)	–0.1512***(–6.95)	–0.25072***(–9.61)
Sold in 2001 (yes:1;no:0)	–955716***(–13.38)	–0.15959***(–12.28)	–0.24452***(–13.37)	–1553443***(–12.83)	–0.21588***(–10.77)	–0.38205***(–15.86)
Sold in 2002 (yes:1; no:0)	–816455***(–10.16)	–0.13878***(–9.49)	–0.21893***(–10.64)	–1640428***(–12.65)	–0.21445***(–9.99)	–0.3852***(–14.93)
Sold in 2003 (yes:1; no:0)	–673895***(–9.09)	–0.13541***(–10.04)	–0.20076***(–10.59)	–1433558***(–11.78)	–0.21181***(–10.52)	–0.372***(–15.37)
Sold in 2004 (yes:1; no:0)	–333319***(–3.06)	–0.04954***(–2.5)	–0.08255***(–2.96)	–1696303***(–8.61)	–0.22193***(–6.81)	–0.3893***(–9.95)
On ground floor (yes: 1; no: 0)	1298541***(18.53)	0.22250***(17.46)	0.34737***(19.4)	1396174***(9.41)	0.18919***(7.7)	0.30094***(10.25)
On fourth floor (yes:1; no:0)	–235599***(–3.33)	–0.02108(–1.64)	–0.02412(–1.33)	–247498**(–2.06)	–0.04172**(–2.1)	–0.0545**(–2.29)
On top floor (yes:1; no:0)	88178***(1.54)	0.01074(1.03)	0.02736**(1.87)	221427(1.35)	0.05187***(1.91)	0.06292*(1.93)
adj R^2	0.7391	0.7064	0.7205	0.8249	0.7064	0.8631
D-W value	1.965	2.041	1.786	1.865	1.977	2.014

***: Significant at 0.01 significance level.
**: Significant at 0.05 significance level.
*: Significant at 0.1 significance level.
Numbers in parentheses are t-values.

that the price effects of external attributes, such as distances to parks, schools, public garages among others are small, compared to the attributes of buildings; such as floor areas, structure age, storeys, and the price trend over time. After all, the primary purposes of this paper do not focus on the price effects of individual attributes; the focus is on the comparison of price prediction between methods. The two variables are therefore retained for later analysis, as regression models perform better with inclusion of distances to electrical substations and the regional hospital.

The variable coefficients derived in Table 2 are then employed to estimate prices for the hold-out samples of 50 low-rise condominiums and 50 high-rise condominiums. They are first used to directly arrive at the estimated property prices, as the conventional regression analysis does. As previously argued, the conventional regression method, while performing reasonably well, is not in full conformation with the principle of the sales comparison approach. Selection of comparable properties, price adjustments, and weight allocation are absent in the process of determining the final price of the subject property. Therefore, in addition to the conventional regression method, the nearest neighbours method is also undertaken for comparison.

In compliance with the property valuation standards published by the Taiwanese government, three comparables for each low-rise condominium and high-rise condominium in the hold-out sample are chosen. These comparables are those with the three shortest Mahalanobis distances to the subject property. The weights allocated to these three properties are determined and the weighted average price, namely the indicated price, is derived. The Mahalanobis distances and weights allocated to comparable properties are derived by formulas 1 and 2.

$$D^2_{ij} = (X_i - X_j)\, E^{-1}\, (X_i - X_j)' \tag{1}$$

$$W_{ij} = (1/D^2_{ij}) \,/ \sum_{i=1}^{3} (1/D^2_{ij}) \tag{2}$$

where D^2_{ij}: Mahalanobis distance between property i and j
X: a vector of the factor-coordinates of the property
E: the factor-coordinate covariance matrix of all properties,

4 Evaluation of accuracy and reliability in predicting property prices

In order to examine the accuracy of price prediction between the conventional regression and the nearest neighbours methods, Table 3 illustrates the results for the properties in the hold-out sample in terms of average prediction errors.

With regards to low-rise condominiums, the average errors for the nearest neighbours method are lower in all functional forms than for the regression method, although not by a significant margin. It seems that the nearest neighbours method performs better in predicting property prices. However, the standard deviations of prediction errors for the nearest neighbours method are clearly higher than those of the regression method. Thus, the reliability of prediction using the nearest neighbours method appears to be more unstable. As for high-rise condominiums, except for double-log function, the nearest neighbours method predicts price

Table 3. *Average Prediction Errors for Hold-out Sample.*

Low-rise condominiums					
NN linear	**NN semi-log**	**NN double-log**	**Regression linear**	**Regression semi-log**	**Regression double-log**
10.22% (13.09%)	10.41 (12.64%)	11.12% (11.82%)	12.18% (9.96%)	11.78% (10.83%)	11.27% (9.56%)
High-rise condominiums					
NN linear	**NN semi-log**	**NN double-log**	**Regression linear**	**Regression semi-log**	**Regression double-log**
10.15% (10.3%)	10.52% (10.68%)	13.92% (15.4%)	11.91% (10.7%)	13.75% (11.65%)	12.11% (12.01%)

Note: Numbers in the parentheses are standard deviation.

Table 4. *Coefficient of Variations for Hold-out Samples.*

Low-rise condominiums					
NN-linear	**NN semi-log**	**NN double-log**	**Regression-linear**	**Regression semi-log**	**Regression double-log**
14.58%	14.11%	13.3%	11.34%	12.27%	10.77%
High-rise condominiums					
NN-linear	**NN semi-log**	**NN double-log**	**Regression-linear**	**Regression semi-log**	**Regression double-log**
11.47%	11.94%	17.89%	12.15%	13.5%	13.67%

better than the regression method in both accuracy and reliability. Overall, we cannot conclude definitively which method is better. We further calculate the coefficient of variation (Eckert 1990: 539) for prediction errors. This coefficient expresses the standard deviation as a percentage of average errors and thus makes comparison between groups easier. Table 4 details the results of coefficient of variations for both low-rise condominiums and high-rise condominiums in the hold-out samples.

Table 5. *Accumulated Prediction Errors – Low-rise Condominiums (linear).*

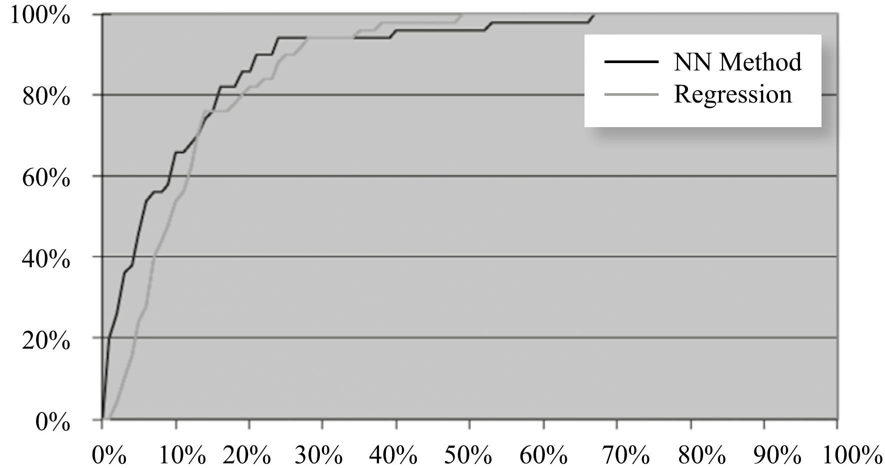


Table 6. *Accumulated Prediction Errors – Low-rise Condominiums (semi-log).*

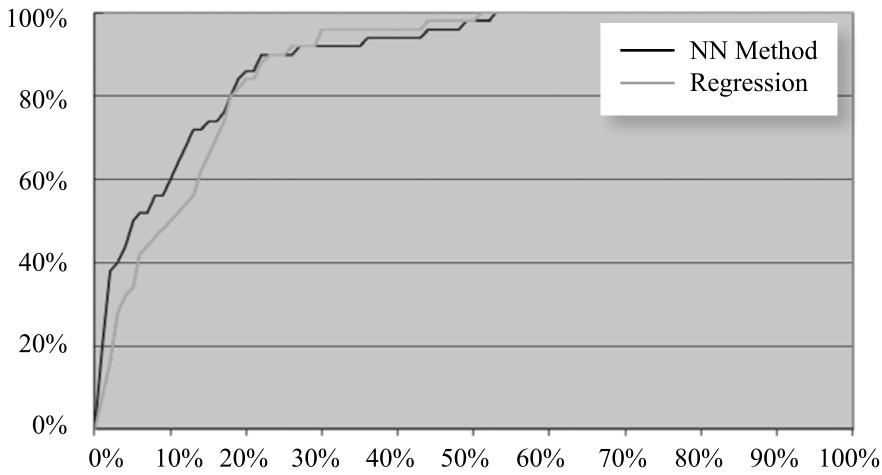


Table 7. *Accumulated Prediction Errors – Low-rise Condominiums (double-log).*

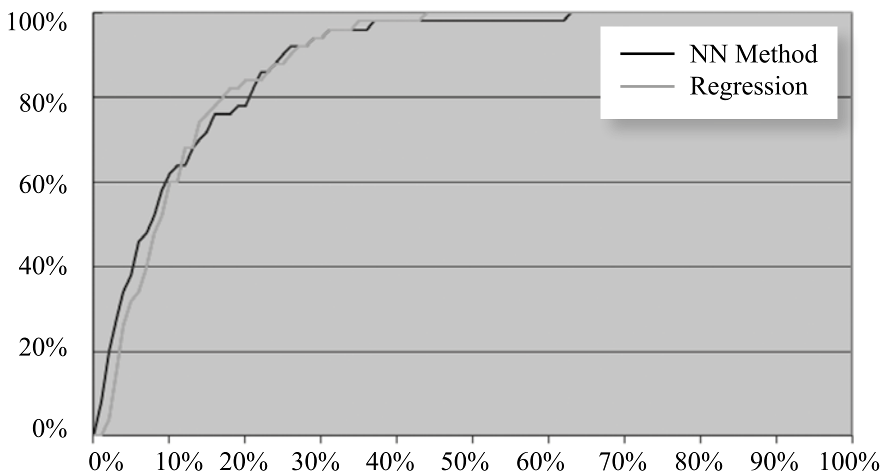


Table 8. *Accumulated Prediction Errors – High-rise Condominiums (linear).*

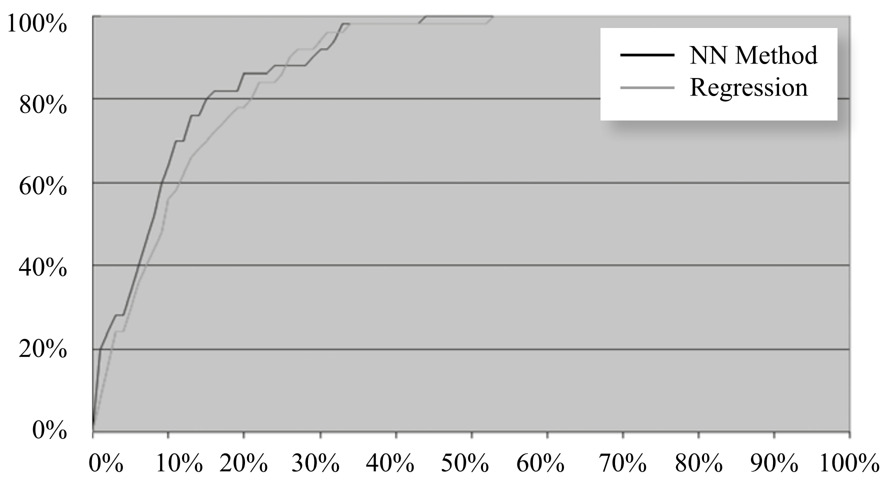


Table 9. *Accumulated Prediction Errors – High-rise Condominiums (semi-log).*

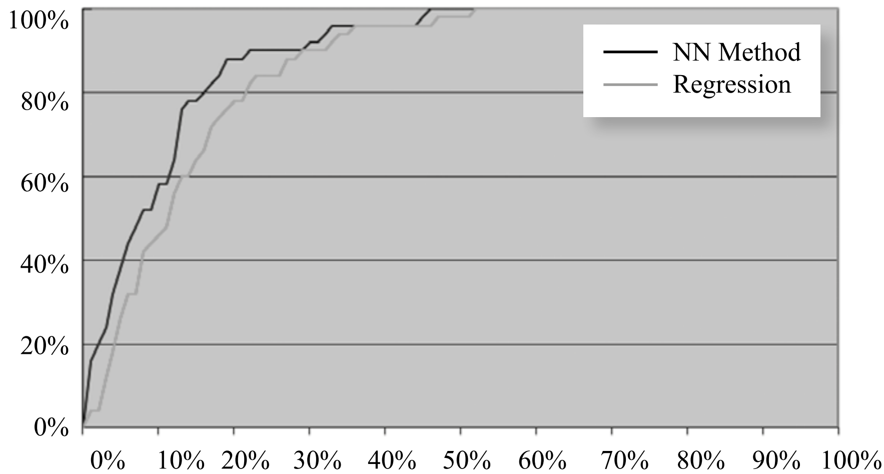
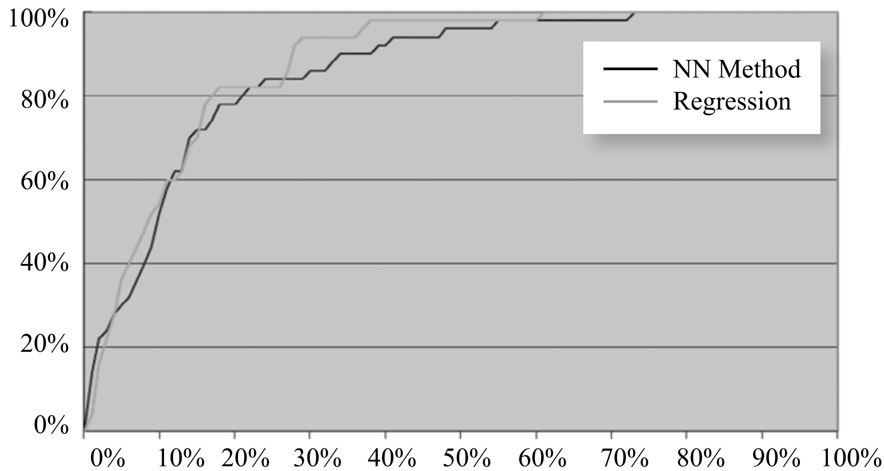


Table 10. *Accumulated Prediction Errors – High-rise Condominiums (double-log).*



The smaller the coefficient of variations, the better a model performs. It is clear that in terms of coefficient of variations, the conventional regression method performs better than the nearest neighbours method on low-rise condominiums. Overall, in contrast, the nearest neighbours method seems to outperform the regression method (except for double-log model) on high-rise condominiums.

Despite that the average and variation figures are useful measures, the accumulation of prediction errors provides deeper insights into the prediction accuracy of models. The prediction error is defined as the difference of predicted value and true value divided by true value in a percentage term. The samples with prediction errors below a given level can be considered as well-predicted samples. Accumulated prediction errors look at the average and variation of prediction errors in addition to their distribution. Prediction errors are decomposed, thus a more comprehensive evaluation of models is possible. The prediction error is on the X-axis and the accumulation percentage is on the Y-axis in Tables 5 through

Table 11. *Distances of the Comparable Properties from the Subject Property.*

	Low-rise condominiums		High-rise condominiums	
Distances	**No. of comparables**	**Accumulated percentage**	**No. of comparables**	**Accumulated percentage**
0–100 m	164	65.6 %	171	68.4 %
100–200 m	32	78.4 %	27	79.2 %
200–300 m	11	82.8 %	18	86.4 %
300–400 m	9	86.4 %	8	89.6 %
400–500 m	4	88 %	7	92.4 %
500–600 m	5	90 %	0	92.4 %
600–700 m	5	92 %	0	92.4 %
700–800 m	5	94 %	2	93.2 %
800–900 m	4	95.6 %	0	93.2 %
900–1000 m	1	96 %	3	94.4 %
1000–1500 m	1	96.4 %	0	94.4 %
1500–2000 m	2	97.2 %	2	95.2 %
2000–2500 m	5	99.2 %	3	96.4 %
2500–3000 m	2	100 %	8	99.6 %
>3000 m			1	100 %

10. A model can be evaluated by the proportion of the well-predicted samples with respect to the prediction error (Gao et al. 2006). The smaller the area between the curve and the vertical axis, the better (the higher degree of prediction accuracy) the model is. All figures, other than those in Table 10, indicate that the nearest neighbours method outperforms the conventional regression method. Taking 10 percent of prediction error as an example, apart from the double-log function for high-rise condominiums, the accumulative proportion of prediction errors using the nearest neighbours method is substantially higher than the regression method. As far as the accumulative prediction errors are concerned, the nearest neighbours method is superior to the conventional regression model.

Another related issue in practice is the geographical areas within which the comparable properties are likely to be found. In other words, what is the possible distance from the subject property within which an appraiser might pick the comparables? Table 11 illustrates the results in our study.

Possibly because Taipei is a very high-density city, respectively 65.6 and 68.4 percent of the three comparables for low-rise condominiums and high-rise condominiums in the hold-out samples are found within 100 metres of the subject property. Ninety percent of the comparables are within 600 metres of the subject property. Moreover, except for one case, comparables are no more than 3,000 metres away from the subject property. A practical implication might be that in this district a comparable with a distance of over 3,000 metres from its subject property demands more examination and explanation. Finally, 31 comparable low-rise condominiums are in the same building with the subject low-rise condominiums. Also, 28 comparable high-rise condominiums are in the same building with the subject high-rise condominiums. The evidence suggests that the nearest neighbours method seems able to find comparables with very similar attributes. This result is based on this particular set of data and used only to demonstrate one possibility of how the nearest neighbours method might help appraisers. In this case, this result provides appraisers with an educated guess or a more reliable rule of thumb. Different sets of data or places will certainly lead to different suggested searching areas.

5 Concluding remarks

Sales comparison is probably the most frequently used method in property valuation. The application of the regression method with a large number of sales data enables a more objective estimate of attribute values. However, when the regression method is applied, some essential elements of sales comparison method are missing, such as selection of comparable properties and weight allocation.

The present study, after reviewing the incorporation of the regression method with the sales comparison approach, extends the application of the nearest neighbours method to high-density residential properties that have previously not been examined. In terms of both average and coefficient of variations for prediction errors, neither the conventional regression nor the nearest neighbours method outperforms the other. Nevertheless, the distribution of accumulated prediction errors suggests the superiority of the nearest neighbours method over regression analysis. What is more, the process of selecting comparables with the nearest neighbours method uncovers useful information for valuation. Through the comparable selection process, we can understand which properties are similar to the subject property, and to what extent. The measurement of similarity also serves to construct the weighting scheme. All the processes retain the spirit of the sales comparison approach, and provide information with which appraisers can make use. For example, the appraisers will be able to explain to clients, or even to the court, how the comparables are chosen, based on what criterion, and to what extent they are similar to the subject property, and also how they are related to the later weight allocation.

The sales comparison method can be thought of as a small sample method. The pieces cited in this paper, in which the grid-adjustment regression and nearest neighbours methods have been pursued, share the belief that property value is best inferred from a small sample of fairly similar comparables. As the correct or best form of regression model is unknown and its results are largely data-dependent, an appropriate comparison of different valuation methods is based on the prediction errors. Our empirical study of a homogeneous residential district is in favour of further pursuit along the small sample (comparables) methods. We agree that regressions can provide an objective value estimation of individual attributes that would otherwise demand a highly suggestive guess. However, we also believe that concentration on a small sample of comparables can help avoid the inclusion of properties with which buyers simply will not find worthy of comparison.

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