An Evaluation of Multiple Regression Analysis, Comparable Sales Analysis and Artificial Neural Networks for the Mass Appraisal of Residential Properties in Northern Ireland

Richard A. Borst, Cole Layer Trumble, USA
&
William J. McCluskey, University of Ulster, Northern Ireland

Abstract

For property tax assessment the use of mass appraisal techniques have become widespread throughout the world. For residential properties, such techniques tend to rely on a variety of multivariate models. This paper applies three techniques of mass appraisal, namely multiple regression analysis, comparable sales analysis and artificial neural networks to a data set of residential sales from the suburbs of Londonderry, Northern Ireland. The objective is to analyze the performance of the models in terms of such criteria as predictive ability, explainability and defenseability. The results of this research demonstrate the consistency of all three models in terms of predictive accuracy.

The Residential Property Tax in Northern Ireland

The present system of property taxation in Northern Ireland involves the assessment of both commercial and residential property. The current basis of assessment is the Net Annual Value (NAV), which can best be described as an open market rental value, as of a predesignated date, on the assumption that the tenant is responsible for all repairs and outgoings. Traditionally, as most properties were occupied under leases there was ample rental evidence upon which to determine NAVs. As the occupation of commercial property remains primarily leasehold, there is currently sufficient market rents to establish objectively the rating assessment, and indeed the 1997 General Revaluation of commercial property will be based upon this approach.

Residential property on the other hand is predominately owner occupied, with properties being sold rather than rented. Therefore to establish NAVs based upon a weak and almost non-existent rental market could prove quite complex if not an impossible task. One would expect that any future revaluation of residential property should be based upon open market selling prices. Given, that commercial property is being revalued for the first time since 1976, there are no immediate plans as yet to revalue the residential sector. One however, would expect some form of residential revaluation to take place to ensure parity with the commercial sector. The alternative options would appear to be;

1. abolish the residential property tax. However the revenue foregone would need to be replaced by an alternative revenue source. None of the alternatives including a poll tax would have any real advantage over the present property tax.

2. to 'factor-up' the existing residential NAVs to a level broadly equivalent to the increase in the commercial sector. This broad brush approach having the advantage of simplicity has the disadvantage of exacerbating the value anomalies inherent within the present NAVs.

3. to revalue all residential property to a NAV. As stated earlier this would prove extremely difficult given the absolute scarcity of open market rental transactions.

4. to undertake a revaluation on the basis of capital values.

The most realistic option would be to maintain a residential property tax but, based on capital values. This approach has a number of distinct advantages including sufficient market evidence, enhanced taxpayer understanding of the system and the ability to apply mass appraisal technologies. In 1993 England, Scotland and Wales introduced a new residential property tax, based on capital values.

Mass Appraisal

Description

As the property tax is an ad valorem based tax it is imperative that to meet the dual requirements of equity and fairness the assessments need to be accurate. This would tend to suggest a manual approach given that each property is individually considered and valued. However, given the absence of statistics on the accuracy of manually derived assessments it could be argued that mass appraisal is the only discipline that holds itself out to the rigours of statistical verification.
Mass appraisal is a process in which a universe of properties is appraised using standardized techniques. Eckert (1990) has defined mass appraisal as the systematic appraisal of groups of homogeneous properties as of a given date using standardized procedures and statistical testing. Early writers such as Renshaw, (1959), Pendelton, (1965), Eisenlauer, (1968) and Stenehjem, (1974), argued that mass appraisal as opposed to single property appraisal requires the development of robust models capable of replicating the components of value. Mass appraisal is distinguished from single property appraisal in that it lends itself to statistical validation of the results, and is usually performed by teams of people with specialized skills. For example, data collection need not be performed by an appraiser. Rather, persons trained in data collection can cost efficiently gather necessary descriptive information about a property including its measurements, room counts and architectural style. This permits the skilled appraiser to review large numbers of properties for judgmental factors such as condition, quality of construction and ultimately a computer generated estimate of value.

The most predominant method for the mass appraisal of residential properties is the sales comparison approach. This is so primarily because the comparable sales analysis report developed for each property is easier to explain and defend to the general public than is almost any other method, e.g. an equation calibrated by multiple regression analysis.

Using computer based techniques, each subject property is valued by selecting several comparable properties which have recently sold. The selling prices are adjusted for differences in characteristics, location and sale date between each comparable and the subject. A final estimate

of value is computed using the several (usually three to five) estimates obtained in this process. The method for selecting comparable sale properties, adjusting their selling prices and computing a final value estimate may vary among mass appraisal systems, but multiple regression analysis is the most common method for determining the adjustments between a subject property and its comparable sales

Benefits Of Mass Appraisal

There are a large number of residential properties in Northern Ireland as indicated by Table 1:

Year	Residential Properties[1]
1991	583,628
1992	589,937
1993	597,676
1994	606,753
1995	607,223

Table 1: Residential Property Figures 1991 - 1995

With in excess of 600,000 properties the reality of how to value this number of properties needs to be considered. The basic question is whether to adopt a scientific approach or the traditional manual approach. A number of aspects need to be considered, firstly, from the theoretical property tax perspective, the elements of equity and fairness to taxpayers within individual property sectors and across sectors and secondly, from the practical view point, resource implications, costs and timescale.

The Database

Data for this research was supplied by the Valuation & Lands Agency. This government agency has the responsibility for the assessment of all real property in Northern Ireland for property tax purposes. The data comprised all open market sales for residential property during the period October 1993 to September 1995 for the suburbs of Londonderry. The variables captured are described in Table 2:

[1] Source: DoE for Northern Ireland; Rating Division, Statistics

Variables	Description
Selling price	actual price in £
Transaction date	converted to a reverse date of sale (RDOS) in Days from 1 Jan., 1996
Floor area	gross external area - square meters
Bedrooms	number
Age	date built expressed in five age categories, 1 is oldest, 5 is newest
Type	house, bungalow, chalet, terrace
Class	semi-detached, detached, terrace
Heating	full, part, none
Garage	single, double, none
Ward	political boundary

Table 2: Description of Variables

Several factors considered critical to developing accurate estimates of capital value were not available for the analysis. Most notable are the absence of land size, quality of construction, property condition, and indicators of remodeling or effective age.

After the elimination of obvious outliers the data set was comprised of 1495 sales. The continuous variables have the following statistics as described in Table 3.

	Price	Area	Beds	RDOS	AGE
Mean	44277	113	3.3	486	3.5
Median	40000	104	3.0	509	4.0
Standard Deviation	15256	35	0.8	212	1.3
Minimum	25250	51	0.0	94	1.0
Maximum	123000	334	8.0	822	5.0
Count	1495	1495	1495	1495	1495

Table 3: Statistics On Continuous Variables

After combining 30 Wards into 5 Ward groups based on similar age, and selling price per square meter the categorical variables had the following distributions as shown in Table 4.

Description	Code	Count
Building Type		
Single Story	BU	449
Chalet	CH	185
Cottage	CO	19
Two Story	HO	842
Building Class		
Detached	DET	454
Semi-Detached	SDT	608
Terrace	TER	433
Heating		
Full central heating	FCH	895
Part central heating	PCH	256
No Central Heating	NCH	344
Garage Type		
Double garage	MHD	20
Single garage	MHS	483
Outbuilding	OTB	342
No Garage	ABS	650
Ward Groups		
Group 1	W1	172
Group 2	W2	46
Group 3	W3	554
Group 4	W4	83
Group 5	W5	640

Table 4: Categorical Variables

Even after eliminating obvious outliers, the data set that remained had some obvious inconsistencies in it which have the effect of limiting the statistical accuracy of any value estimates which would be developed by any of the techniques subsequently applied and described herein. Consider Table 5. It contains a small subset properties which are identical in description except for sale date, but have widely different selling prices. This condition can be found extensively in the data set. The implication is that the statistical results will be limited by this inherent variability. It is believed that knowledge of land size, construction quality, condition and effective age would provide the ability to discriminate among these properties, but this is a limitation of the data that is considered a constraint of the analysis which follows. With the data presented in the table the minimum Coefficient of Variation for *Actual-Predicted* that could be achieved obtained by using the mean selling price as the estimate for all properties in the table is 14.3%. It is possible that by adjusting for Date of Sale the variability would be reduced. The ADJPRICE in the table was derived by adjusting the selling price for Date of Sale using the coefficient for RDOS from a MRA formulation to be presented subsequently. Even after adjusting for Date of Sales the COV of *Actual-Predicted* using the mean of the ADJPRICE as the predicted is 11.5%. This result is an indicator of the inherent variability within the data set.

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