

Real property valuation using sales comparison method and multiple regression analysis

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Abstract- Valuation method using multiple regression analysis is widely used across the globe and is seldom used in India. The aim of present study is to find the advantages and disadvantages of using Multiple Regression Analysis (MRA) in valuation compared to the application of traditional approach of sales comparison. The procedure of application of MRA involves identifying and listing the factors that influence the value of a house. It is done through literature review of previous researches, published articles, questionnaire survey and interviews of experts in the field. From these attributes, critical house value influencing factors are chosen after thorough statistical analysis of questionnaire survey. In total, samples of fifty three valuation reports have been used & regression has been carried out. The advantage of using MRA method is that it can model the relationship between sale price of a house and housing attributes. MRA regresses each attribute to show how change in each attribute affects the house price. Results obtained from sales comparison method & multiple regression analysis show that, regression gives better accuracy & efficiency in predicting value of property as compared with the traditional approach.

Keywords: Real property, property valuation, sales comparison method, multiple regression analysis.

I. INTRODUCTION

Real property valuation is a topic of interest for stakeholders for various purposes. Investors are interested to know the purchase price of the property in which they are going to invest. Developers seek to find out the feasibility of selling price for their decision-making. There are risks and uncertainties in property valuation as it could be subjective [1]. Real estate appraisal, property valuation or land valuation is the practice of developing an opinion of the value of real property. There are no two properties that are exactly identical and have same characteristics. Based on these different characteristics, the appraisal process is important to determine the market value of property [2]. The valuation of properties can be conducted using various methods like comparison method, cost method, residual method, investment method and profit method. The market comparison approach suggests that the indicated value of the subject property equals sales prices of similar properties that have been sold recently and are in close proximity to the subject property with due consideration to adjustments for dissimilar characteristics. MRA improves over the comparison approach by using many recent sales versus just a few. This statistical analysis decreases the likelihood of human error and the problems of small samples [3]. The present study validates the above statement by predicting value of property by both these approaches of sales comparison & MRA.

1.1 Valuation of real property

Valuation of property is required by a number of players in the marketplace such as real estate agents, appraisers, brokers, property developers, investors, market researchers, analysts, other specialists and consultants [4]. Market value is estimated through the application of valuation methods and procedures. Out of various methods of valuation, sales comparison is the most basic method. In the study of [5], the various adjustment techniques in sales comparison methods such as

summative percentage, base percentage and dollar adjustment are considered. Opinion on comparison method by valuers from public sector and private sector shows that the analysis on sequence of elements for adjustment process in comparison method should be tenure, date of transaction, location, physical characteristics, economy condition, zoning, land size, topography and financial term. It states that the comparison method is the best method in determining the market value of property and summative percentage is the best adjustment technique in applying the comparison method. According to [6], appraisers prefer using very few comparable properties in order to sell their expert judgments regarding adjustment and weighting factors. The task of appraisers could be made much easier if they use the academicians' one-price assumption. This helps to reduce the number of adjustment factors and most academicians prefer MRA technique.

1.2 Use of MRA in valuation

MRA has been implemented by many researchers to study valuation of real property. [7] cite that MRA is possible for coefficient estimates and factor weightings using a large number of actual sale cases. It offers a very reliable tool to get accurate value for any property. In the study of [3], there are benefits such as less human bias and error when making adjustments for property differences, and easily updated assessment figures. MRA method is most popular because of their established methodology, long history of application, and acceptance among both practitioners and academicians [8]. The problem with MRA method is that it involves human judgment because it relies on functional assumptions to fit the relationships of the variables [9]. Also, multiple regressions have often produced serious problems for real estate appraisal that primarily result from multicollinearity issues in the independent variables. Absolute error is found out from actual sold price and resulting estimated price by MRA techniques and compare with coefficient of determination (R^2) and Mean Square Error (MSE) values [10].

MRA relies on econometric modelling i.e. fluctuation in market value which reproduces the market behaviour based on probability framework. Rough Set Theory (RST) is not based on behaviour modelling. MRA has less Mean Absolute Percentage Error (MAPE) and hence shows better performance than RST and MRA is better if small data sets are run. While results also depend on the functional specification of MRA, MRA still performs better when small samples are used [11].

II. IDENTIFICATION OF FACTORS

There are two categories of variables involved in regression modeling namely dependent and independent variables. The dependent variable is a market value, which can be represented by rents, sale price or owner's estimated price. The second category consists of the independent variables namely locational, structural and environmental factors. In structural attributes, variables such as size of plot, floor area, age of building, number of rooms, number of storeys, level of unit and housing fixtures are often used. Variables such as accessibility to amenities or facilities and other public facilities represent the locational traits. Neighborhood traits can be explained by variables such as quality of amenities and/or facilities, road quality, environment quality and view from property [12]. Study by [13] measured the effect of location on residential house prices. The attributes considered in their multiple regression model were sale price, date of sale, age of property, size, number of bedrooms and bathrooms, number of garages, type of central heating, condition. The finding was that location and structural characteristics are the key determinants of residential property values. [14], concluded that the contribution of housing characteristics have not changed over time. Only the age coefficient was affected by time and the effect was negative. [1] & [15] cite that the number of bedrooms has the highest weight in their study and helps to create a good quality of life that command on higher prices. More rooms mean higher construction costs, thus the higher the value of the property. According to [1], the bigger the land size, higher the value of a property and the bigger land size implies a potential for further improvement & land subdivision and generally households pay more for a property close to a school, particularly one with a high reputation. The access to schools is an important determinant [16].

Based on the literature survey and discussion with experts located across India, a total of fourteen variables have been finalized for further analysis. These seventeen variables are as shown in Table 1 below.

Table 1.Variables identified for the study

SrNo.	Variable	Variable code	Value
1	Built up area	X1	Quantitative
2	Plot shape	X2	Qualitative
3	Location	X3	Qualitative
4	Zoning	X4	Qualitative
5	Age of building /property as on the date of valuation	X5	Quantitative
6	Number of storey in building	X6	Quantitative
7	Condition of property	X7	Qualitative
8	Type of construction	X8	Qualitative
9	View from property	X9	Qualitative
10	Access road width	X10	Qualitative
11	Parking facilities	X11	Qualitative
12	Nearness to amenities	X12	Qualitative
13	Nearness to facilities	X13	Qualitative
14	Internal transport facilities	X14	Qualitative

2.1 Data conversion

Valuation report is usually a written statement of the valuer’s opinion about fair market value of a subject property as on the specified date. It is a conclusion which results from the process of research and analysis of actual and relevant data. It contains general information namely purpose of valuation, date of valuation, name of owner, street & ward no, zoning of property, classification of locality and proximity to civic amenities, like school, hospitals, offices, cinema etc. and means & proximity to surface communication. It also focuses on technical details of property namely built up area, number of floors & height of each floor, year of construction, condition of property, view from property, parking facility, estimated future life, type of construction, number of lifts, and specifications of doors & windows, flooring, finishing, internal wiring, plumbing and painting etc. For analysis of these factors through MRA, the factors should be converted in quantitative manner. The variables are identified by classifying factors and their corresponding meaning in numerical value in such a fashion that, built up area is defined as a measure of floor area. It is measured quantitatively in square metres. For regular and irregular plot shape the value given is 1 and 2 respectively as location is classified as superior, good and poor with poor as areas of low income, good as areas of middle class and superior as areas of high income group. House in superior location is referred as 1, good awarded a 2 and poor location is represented by a 3. Likewise all the variables have been given quantitative value as per possible situations.

III.APPLICATION OF MULTIPLE REGRESSION ANALYSIS

Regression analysis is defined as a statistical tool for the investigation of relationships between variables. It is used to find casual effect of one variable upon another. For example, in real estate appraisal the price of property depends on the location and the question is what the relationship between them is and how to quantify it [7]. MRA is a technique that allows additional factors to enter the analysis separately so that the effect of each can be estimated. It is valuable for quantifying the impact of various simultaneous influences upon a single dependent variable [17]. MRA is a statistical methodology that utilizes the relationship between two or more independent variables and a dependent variable. The dependent and independent variables are regressed using properties of known prices to determine the established relationships (coefficients) between the two types of

variables [18;19]. The determined coefficients are then used for the prediction of prices of unsold properties in the same stock. MRA determines the coefficients with the least possible error [20]. Multiple regression is carried out to establish the effect of all independent variables working together on sale price. The regression equation proposed is as follows [12]:

$$P = a_0 + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n + e$$

P is the dependent variable i.e. house price/value (dependent variable –P), a_0 is the regression constant, $X_1, X_2, X_3 \dots X_n$ are predictor or independent variables, $b_1, b_2, b_3 \dots b_n$ = are regression coefficients and e is the error term. The regression constant (a_0) is the Y intercept (i.e. value of Y when $X=0$). The regression coefficients (b_1-b_n) are value of each independent variable. They indicate how much value will change for a unit change in each characteristic, where other characteristics are constant. The error term (e) indicates the difference between the observed value and the predicted value of the depended variable. It is used for accuracy and reliability of the MRA model [12].

Regression is carried out in Microsoft Excel (version 2010) using trial and error method. Converted data of total fifty three valuation reports are fed to the software in transposed form in such a way that the first column contains the observations on the dependent variable i.e market value and then the other, adjoining columns contain the observations on all the seventeen independent variables.

Table2. Regression Statistics

Regression Statistics	
Multiple R	0.998
R Square	0.997
Adjusted R Square	0.995
Standard Error	2.269
Observations	53.000

Table 3. ANOVA table

	df	SS	MS	F	Significance F
Regression	14	58824.08	4201.71984	816.0478	1.34728E-42
Residual	38	195.6569	5.148864588		
Total	52	59019.73			

As shown in table 2, the multiple regression is 0.998. This indicates that the correlation among the independent and dependent variables is positive. The coefficient of determination, from the regression results is 0.997, showing that the combined influence of fourteen variables explains 99.7% of all house price variations. The R^2 range should be within $0 < R^2 < 1$. The adjusted R-square, a measure of explanatory power, is 0.995. This statistic is not generally interpreted because it is neither a percentage (like the R^2), nor a test of significance (such as the F-statistic). The standard error of the regression is 2.269, which is an estimate of the variation of the observed home prices.

Table 3 shows ANOVA analysis of variance information which provides the breakdown of the total variation of the dependent variable i.e. house prices. The F-statistic is calculated using the ratio of the Mean Square regression (MS Regression) to the Mean Square residual (MS Residual). If the value of significance F is lower than that of value F then the test is said to be significant. In above case, the significance F value is very small as compared to value F hence test is said to be significant.

Table 4. Final Regression Table

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	72.80	4.07	17.88	0.00	64.56	81.04
Built up area in Sq.ft	0.02	0.00	60.18	0.00	0.02	0.02
Plot shape	-9.08	2.08	-4.37	0.00	-13.29	-4.87
Location	-7.39	0.73	-10.18	0.00	-8.85	-5.92
Zoning	6.17	0.49	12.58	0.00	5.18	7.16
Age of building /property as on the date of valuation	0.08	0.03	2.50	0.02	0.01	0.14
Number of storey in building	-4.16	0.31	-13.55	0.00	-4.78	-3.54
Condition of property	-7.32	0.61	-12.10	0.00	-8.55	-6.10
Type of construction	-13.96	1.08	-12.89	0.00	-16.16	-11.77
View from property	-5.00	0.33	-14.99	0.00	-5.68	-4.33
Access road width	8.41	0.35	24.38	0.00	7.72	9.11
Parking facilities	-3.74	0.17	-22.00	0.00	-4.09	-3.40
Nearness to amenities	-3.55	0.29	-12.18	0.00	-4.15	-2.96
Nearness to facilities	-8.42	0.43	-19.59	0.00	-9.30	-7.55
Internal transport facilities	15.15	0.52	28.96	0.00	14.10	16.21

Table 4 shows the coefficients of each independent variable. The T-statistic is calculated using the ratio of the coefficients of variable to the standard error of variables. The intercept value 72.80 is the value of Y when values of all the independent variables are zero. For hypothesis testing, if we consider 95% of confidence level then P should be less than 0.05 of output variable. If output variable has $P > 0.05$ then the intercept value is not significant showing that these variables are not going to affect dependent variable. If the P-values of output variables have 95% of confidence level then only these variables are accepted for further regression analysis. For present study, all variables are having $P < 0.05$ values (table 4), all 14 variables are significant in regression analysis.

Table5. Data conversion of valuation reports

Valuation Reports	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Market value (in Lac.)	33.85	16.11	41.28	31.77	28.38	28.67	102.67	171.54	15.14	80.61
Built up area in Sq.ft	1687.16	827.42	2500	1644	1215	882.16	2373	4210	1594	4433
Plot shape	1	1	1	1	1	1	1	1	1	1
Location	1	1	2	2	1	2	2	1	2	2
Zoning	3	5	3	3	3	3	5	3	3	3
Age of building /property as on the date of valuation	0	6	23	17	5	1	2	10	2	16
Number of storey in building	2	5	2	1	1	3	2	2	2	2
Condition of property	1	1	2	1	1	1	1	1	2	1

Type of construction	2	2	2	2	2	2	2	2	2	2
View from property	2	3	3	3	2	3	1	1	3	1
Access road width	2	1	2	4	1	2	4	3	3	1
Parking facilities	7	2	7	8	3	3	2	1	7	2
Nearness to amenities	1	2	2	4	2	5	1	1	2	2
Nearness to facilities	2	3	1	4	3	3	1	1	3	4
Internal transport facilities	1	1	1	2	1	3	1	3	1	1

Conversion of data from valuation reports has been carried out and it is used for regression model. The same for ten valuation reports is shown in table 5. Value is calculated using the estimated model factors and respective characteristics of the subject property. Using the coefficients (table 4) model obtained is as follows:

$$Y = b_0 + b_1 * X_1 + b_2 * X_2 + b_3 * X_3 + b_4 * X_4 + b_5 * X_5 + b_6 * X_6 + b_7 * X_7 + b_8 * X_8 + b_9 * X_9 + b_{10} * X_{10} + b_{11} * X_{11} + b_{12} * X_{12} + b_{13} * X_{13} + b_{14} * X_{14}$$

Based on this standard equation, for the present study, the model used would be:

$$Y = 72.80 + 0.02 * X_1 - 9.08 * X_2 - 7.39 * X_3 + 6.17 * X_4 + 0.008 * X_5 - 4.16 * X_6 - 7.32 * X_7 - 13.96 * X_8 - 5.00 * X_9 + 8.41 * X_{10} - 3.74 * X_{11} - 3.55 * X_{12} - 8.42 * X_{13} + 15.15 * X_{14}$$

Where Y= Market value

72.80= the regression constant (a₀) is the Y intercept (i.e value of Y when X=0).

X₁= Built up area, X₂= Plot shape, X₃= Location, X₄= Zoning, X₅= Age of building, X₆= No of story, X₇= Condition of property, X₈= Type of construction, X₉= View from property, X₁₀= Access road width, X₁₁= Parking facility, X₁₂= Nearness to amenities, X₁₃= Nearness to facilities and X₁₄= Internal transport facility.

3.1 Results of MRA

The accuracy of the above valuation model is tested by comparing the actual sale values of fifty three valuation reports with the predicted market values from MRA. The predicted values for the sampled houses are calculated using the house value model above and their results are shown in Table 6.

Table6. Comparing actual versus predicted value for MRA

Valuation Reports	Actual Market value (In Lac.)	Predicted Market value (In Lac.)	Valuation Reports	Actual Market value (In Lac.)	Predicted Market value (In Lac.)
R1	33.85	34.99	R27	29.08	27.26
R2	16.11	16.20	R28	107.03	112.48
R3	41.28	41.72	R29	15.84	15.50
R4	31.77	32.11	R30	14.85	12.71
R5	28.38	29.17	R31	13.2	13.17
R6	28.67	29.80	R32	16.14	16.75
R7	102.67	106.43	R33	4.35	3.95
R8	171.54	163.12	R34	10.21	9.04
R9	15.14	14.24	R35	10	10.03
R10	80.61	80.78	R36	18.18	20.44
R11	17.92	17.57	R37	20.47	20.21
R12	30.75	30.01	R38	8.45	7.22
R13	29.65	28.91	R39	11.61	12.25
R14	83.45	84.31	R40	19.31	17.38
R15	88.34	88.91	R41	30.67	31.92
R16	93.75	97.07	R42	14.06	15.02
R17	105.09	106.00	R43	22.14	24.24
R18	58.87	56.84	R44	9.63	10.88
R19	20.27	19.88	R45	30.49	30.83
R20	19.37	20.80	R46	19.27	21.01
R21	52.93	52.12	R47	29.57	28.90
R22	17.55	17.67	R48	11.35	11.69
R23	60.27	58.71	R49	10.22	10.36
R24	12.55	13.19	R50	9.65	7.18
R25	43.82	42.59	R51	9.6	10.61
R26	21.78	21.38	R52	14.12	12.86
			R53	14.12	15.11

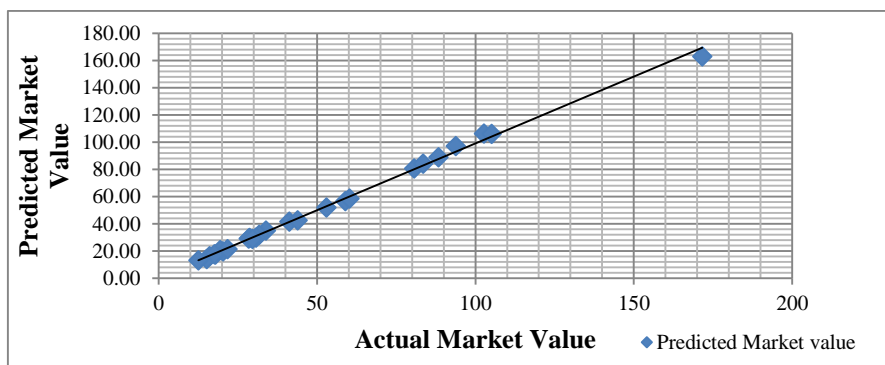


Figure1. Comparison of actual and predicted market value

Results of MRA for 14 factors show that predicted market values are within $\pm 5\%$ of actual market value. From table 6 and the line graph shown in Fig.1 above, it can be seen that the predicted values are very close to the actual values.

IV. APPLICATION OF SALES COMPARISON METHOD

The sales comparison approach is of interest because it is widely regarded by most appraisers as the approach that produces the most reliable estimate of the value of a subject property, especially when there are many recently sold properties comparable to the subject property. But, appraisers do not make use of a particularly large number of these comparable properties. Usually, appraisers combine their expert judgment with a relatively small number of comparable sales to arrive at a final estimate of value [6]. The sales comparison approach is dependent upon the availability, accuracy and period of sale transaction data. Information sources include government records and appraiser's local contacts [21]. The comparison method is the most common approach used by the professionals. The data consists of the actual transaction prices of residential buildings having market period of two years, covering 2013 to 2014. Total 53 valuation reports of residential buildings have been collected from practicing government valuers. These valuation reports are considered for studying sales comparison method.

4.1 Results of sales comparison method

Out of 53 properties, 10 properties namely R1, R2, R3, R5, R17, R47, R26, R14, R19, and R45 have been considered for application of sales comparison approach. Choice of property from the dataset is on the basis of location and each of the selected properties have been chosen from different locations to cover larger area. Table 7 shows comparison of actual versus predicted market value of selected properties that have been assessed by sales comparison method.

Table7. Comparing actual versus predicted value for sales comparison method

Valuation Reports	Actual Market value (In Lac.)	Market Value by Sales comparison (In Lac.)
R1	33.85	35.45
R2	16.11	16.35
R3	41.28	46
R5	28.38	33.45
R17	105.09	115.6
R47	29.57	35.28
R26	21.78	30.62
R14	83.45	88.58
R19	20.27	35.07
R45	30.49	30.9

Market value by sales comparison of properties under consideration show more value as compared to actual market value (Table 7).

4.2 Property value by ready reckoner rates

Ready reckoner is an official document prepared by government authorities in India which has rates for land and property mentioned in it for different parts of a city for a particular financial year. Stamp duty calculation is generally done on the basis of ready reckoner rates. The rate given in ready reckoner can be the least rate a particular property can have. There are ready reckoner rates for the year 2014 taken from Department of Registration & Stamps, Government of Maharashtra, India [22] to derive value. Table 8 gives rates and corresponding value of property if ready reckoner rate is considered.

Table8. Property value by ready reckoner rates (Index: 2014)

Valuation Reports	Property area (in Sq.m)	Actual Market value (In Lac.)	Ready reckoner rates of properties (Year 2014)			Property value by ready reckoner rates (In Lac.)
			Land Cost (Rs/Sq.m)	Construction cost (Rs/ Sq.m)	Total cost (Rs/Sq.m)	
R1	156.80	33.85	1140	13,557	14,697	23.04
R2	76.89	16.11	3443	10,000	13,443	10.34
R3	232.34	41.28	2216	9684	11,900	27.64
R5	112.91	28.38	3228	8608	11,836	13.36
R17	477.32	105.09	1291	10,760	12,051	57.52
R47	121.18	29.57	3873	16,140	20,013	24.25
R26	73.18	21.78	4660	20,982	25,652	18.76
R14	362.82	83.45	1721	16,678	18,400	66.75
R19	177.72	20.27	1140	6456	7596	13.50
R45	65.93	30.49	2216	14,526	16,742	11.04

V. RESULTS AND CONCLUSION

Actual market value of property, predicted market value from MRA and market value by sales comparison are considered for the comparison. The difference between actual market value & predicted market value from MRA of properties R1, R2, R3, R5, R17, R47, R26, R14, R19, R45 shows less difference as compared with the difference between actual market value & predicted market value by sales comparison method. Table 9 shows comparison of results of MRA, sales comparison method and value by ready reckoner. Observing the difference between actual and predicted values by all methods (table 9), it can be concluded that the results obtained from MRA method shows small variation as compared to results obtained from sales comparison method. Also, ready reckoner value is on lower side as compared with values by all other methods. Ready reckoner value can be considered as basic value of a property as decided by government which forms the basis for calculating stamp duty.

Table9. Comparison of results of MRA & sales comparison method

Valuation Reports	Actual Market value (In Lac.)	Property value by ready reckoner rates (In Lac.)	Predicted Market value by MRA (In Lac.)	Market Value by Sales comparison (In Lac.)	Difference bet Actual MV & value by ready reckoner rates (In Lac.)	Difference bet Actual MV & Predicted MV by MRA (In Lac.)	Difference bet Actual MV & Market value by Sales comparison (In Lac.)
R1	33.85	23.04	34.99	35.45	10.81	1.14	1.6
R2	16.11	10.34	16.20	16.35	5.77	0.09	0.24
R3	41.28	27.64	41.72	46	13.64	0.44	4.72
R5	28.38	13.36	29.17	33.45	15.02	0.79	5.07
R17	105.09	57.52	106.00	115.6	47.57	0.91	10.51
R47	29.57	24.25	28.90	35.28	5.32	-0.67	5.71
R26	21.78	18.76	21.38	30.62	3.02	-0.40	8.84
R14	83.45	66.75	84.31	88.58	16.7	0.86	5.13
R19	20.27	13.50	19.88	35.07	6.77	-0.39	14.8
R45	30.49	11.04	30.83	30.9	19.45	0.34	0.41

It can be thus concluded that qualitative characteristics of property are difficult to identify and measure. To overcome this problem MRA method is very accurate method. MRA allows more factors to enter the analysis separately and to estimate effect of one variable upon another. Sales comparison being traditional approach can be used for properties with lesser value or it can be used to have a quick judgment of range of value for a property. It can be used for approximate valuation. Ready reckoner rate gives a basic value of property and it is generally not considered as the actual value of any property.

MRA makes possible the coefficient estimates and factor weightings using a large number of realized sales. It offers a very reliable tool to get accurate assessment value for any property. Sales comparison method is dependent on the basis of judgmental values. MRA requires proper identification of variables affecting property value & data conversion. Reliability of results of MRA can improve with more number of cases as input. Results of sales comparison can improve with more number of sales instances with higher degree of similarity. Also, experience of valuer affects results of sales comparison. MRA when compared with sales comparison method, gives results with lesser error thus is more acceptable.

REFERENCES

- [1] Dr. Ge, Xin Janet and Du, Yue' Main variables influencing residential property values using the Entropy Method – the case of Auckland', School of the Built Environment, UTS, Sydney (2007), xinjanet.ge@uts.edu.au .
- [2] Muhammad Hanafi Bin Ahmad," A study between multiple regression analysis and traditional method of valuation (rating) case study: kuantan local authority", (2012) Department of estate management, Universititeknologimara.
- [3] John D. Benjamin, Randall S. Guttery and C. F. Sirmans "Mass Appraisal: An Introduction to Multiple Regression Analysis for Real Estate Valuation" Journal of Real Estate Practice and Education Vol. 7, No.1, (2004).
- [4] SibelSelim, "Determinants of house prices in Turkey: A hedonic regression model" Dogus University Dergisi, 9 (1) 2008, 65-76
- [5] Anuar Alias, Noor Hana, Asyikin Nor Hanapi "Comparison Method - Preference Of Adjustment Techniques Among Valuers" research paper of centre for Studies of Urban and Regional Real Estate (SURE) University of Malaysia.
- [6] Hans R. Isakson "The linear algebra of the sales comparison approach" Journal of real estate research (JRER) Vol.24, No.2-2002
- [7] BrankoBonzic, DraganaMiilicevic, Marko Pejic and StevanMarosan "The use of multiple linear regression in property valuation" Geonauka Vol. 1, No.1 (2013).
- [8] JozefZurada, Alan S. Levitan, and Jian Guan,"A comparison of regression and Artificial intelligence methods in a mass appraisal context", Journal of real estate research (JRER), (2011), Vol.33, No.3
- [9] Lai Pi-ying "Analysis of the Mass Appraisal Model by Using Artificial Neural Network in Kaohsiung City" Journal of Modern Accounting and Auditing, Vol. 7, No. 10, 1080-1089, (2011).
- [10] Larry G. Perry, Timothy P. Cronan and Donald P. Epley "Ranking comparable properties prior to their use in regression on a large or small sample" The appraisal journal, (January -1986) : 57-65.
- [11] Maurizio Damato "A comparison between mra and rough set theory for mass appraisal. A case in Bari", International Journal of Strategic Property Management, 8:4, 205-217.(2004).
- [12] MusiliKioko Joseph,' Real estate valuation based on hedonic price model: Case study of residential housing in Nairobi', University of Nairobi department of real estate and construction management school of built environment (2010).
- [13] McCluskey, W. J., Deddis, W. G., Lamont, I. G., &Borst, R. A, "The application of surface generated interpolation models for the prediction of residential property values".Journal of Property Investment & Finance, (2000),18(2), 162-176.
- [14] G. Stacy Sirmans, Lynn MacDonald, David A. Macpherson and Emily Norman Zietz," The value of housing characteristics: a meta analysis', American Real Estate and Urban Economics Association (2005).
- [15] Joslin, A. "An investigation into the expression of uncertainty in property valuation". Journal of Property Investment & Finance, (2005), 23(3), 269-285.
- [16] Han, S. S., Yu, S. M., Malone-Lee, L. C., &Basuki, A. "Dynamics of property valuedistribution in an Asian metropolis - the case of landed housing in Singapore", 1991-2000.Journal of Property Investment & Finance, (2002), 20(3), 254-276.
- [17] BaharBulut, Novruz Allahverdd, Humar Kahramanli and SukranYalpir "A Residential Real-Estate Valuation Model with Reduced Attributes" International journal of mathematical models and methods in applied sciences, Issue 3, Volume 5, (2011), PP. 586-593
- [18] Adair, A., &McGreal, S. "The application of multiple regression analysis in property valuation". Journal of Property Valuation and Investment,(1988),6, 57-67.

- [19]EbrahimJahanshiri, TaherBuyong and Abdul Rashid Mohd.Shariff, “A Review of Property Mass Valuation Models”, *Pertanika J. Sci. & Technol.* (2011), 19 (S): 23 – 30.
- [20] Benjamin, J. D., Guttery, R. S., &Sirmans, C. F. “Mass appraisal: An introduction to multiple regression analysis for real estate valuation”. *Journal of Real Estate Practice and Education*, (2004),7, 65-77.
- [21] Elli Pagourtzi,Vassils, Thomas, Nick French,” Real estate appraisal: a review of valuation methods”, *Journal of property investment & Finance*, (2003), Vol. 2, No.4,pp-383-401.
- [22] Department of Registration & Stamps by Government of Maharashtra, India.
igrmaharashtra.gov.in:8080/frmMap.aspx

