GIS-BASED MASS APPRAISAL MODEL FOR EQUITY AND UNIFORMITY OF RATING ASSESSMENT

Ibrahim Sipan, HishamuddinMohd Ali, Suriatini Ismail, Shahabudin Abdullah and Shazmin Shareena Abd Aziz

Faculty of Geoinformation and Real Estate (FGRE)
University TeknologiMalysia,
81300 Skudai, Johor DarulTakzim
Email :ibrahimsipan@utm.my

Abstract

Rating is a major source of income for local authorities. The basis of rating is the assessed values of property holdings from which property tax can be charged. The traditional single valuation method contributes to the inconsistency of assessed values because locational factors are not considered objectively. The traditional method is also unable to produce equity and uniformity of the assessment values consistently. The main objective of this study was to develop a mass appraisal model incorporating spatial analysis and geographic information system (GIS) to produce more accurate predictions of property values and, thus, to achieve an overall equity and uniformity of property rating assessment. In order to achieve the objective, Majlis Perbandaran Kulai was chosen as a study area. The study involved 1,500 property holdings transacted between 2004 and 2006 representing 86 housing areas. The variable components for locational factors, namely accessibility, neighborhood and environment were generated using GIS spatial analysis which included buffering, overlaying, and network analysis. The outputs from the analyses consisted of variable components which were derived objectively and they can assist in the process of forming mass appraisal model. Four mass appraisal models were used as alternative choices to the traditional single valuation method. They were ordinary least squares (OLS), spatial hedonic model (SHM), geographically weighted regression (GWR), and kriging. The outcomes of the models showed that the assessed values were statistically significant. The performance of mass appraisal models from equity and uniformity perspectives was measured using ratio study technique. The four models were compared on the basis of their accuracy in terms of equity and uniformity. It was discovered that the spatial hedonic model (SHM) was the best choice followed by the ordinary least square model (OLS) as the second best choice.

Keywords: *property rating, mass appraisal model, equity, uniformity, ratio study, geographic information system (GIS), spatial analysis, OLS, SHM, GWR, kriging*

1.0 INTRODUCTION

The rating system in Malaysia is still traditionally performed in relation to property tax assessment process to generate assessment values. Developed countries like USA and Australia have long used mass appraisal system which requires the formation of statistical models for property tax purposes within the Local Authority administration area (Eckert, 1990). Mass appraisal is a systematic process to estimate property values in the scale and scope that are greater than a single assessment (IAAO, 1978). Mass appraisal system is divided into four main components, namely data management, valuation process, capability analysis, and tax administration. The adoption of Geographic Information Systems (GIS) and spatial analysis in appraisal has helped to produce more accurate assessment values.

In this study, GIS is used to generate variable component of the location for the formation of a mass appraisal model. Spatial element is included in the GIS data base and analyzed using GIS spatial analysis techniques such as buffering, overlaying and network analysis to generate the variable components of location that affect the assessed values of rateable holdings.

The resulting variables are included in the mass appraisal model that is designed to generate the estimated values. The accuracy of property assessments with respect to fairness and uniformity is measured using ratio study

The aim of this study is to form a mass appraisal model aided by spatial analysis and geographic information systems to produce equity and uniformity of assessment values by measuring them using ratio study. This paper comprises five sections. Section 1 states the study objectives, namely: (1) to generate variables of locational factors using GIS spatial analysis; and (2) to measure the ability of mass appraisal model on the basis of equity and uniformity using ratio study. Section 2 presents the theoretical background of the study. Section 3 outlines the study area, data and methods. Section 4 discusses the results and findings. Finally, section 5 concludes the paper.

2.0 THEORETICAL BACKGROUND

2.1 Concepts

Similar properties should have similar assessment values and should be taxed equally (Bowman &Mikesell, 1990; Smith, 2000; Mikesell, 2004). They emphasize the equity and uniformity concept in property assessment. Equity refers to the overall way in which a property is assessed at the same level to determine its market value. Uniformity refers to the degree to which different properties are assessed at equal percentages of market value, that is, the degree to which property tax burdens are distributed uniformly and according to the market value (IAAO, 1978).

A mass appraisal model is a statistical based valuation model to estimate the assessment value systematically at a greater scale and scope compared to a single valuation (IAAO, 1978). Assessment ratio study is a statistical method to measure the relationship between properties' assessed values and their sale prices by grouping individual sales according to property type and geographic area. Assessment ratio study can also be referred to as a statistical analysis of the degree of assessment accuracy.

2.2 Mass appraisal model

Hedonic models are essentially mathematically and statistically based regression models that have expanded in their applications in various fields of research (Hens, 1920; Count, 1939; Griclies, 1961; Lancester, 1966) as commented by Hamid (2001) and Suriatini (2005).

The Ordinary Least Square (OLS) model has been widely used in mass appraisal to estimate values of properties in the U.S.A., the U.K., and Australia (Dunse and Jones, 1998). The OLS technique in hedonic modelling has been improved to produce superior alternative models such as the spatial hedonic models (SHM).

The OLS model uses transaction price as the dependent variable while the property attributes and locational factors are used as independent variables. The OLS model is most commonly applied in mass appraisal because it is easy to use and does not require high skills and knowledge in the field of statistics. The OLS can also explain the factors that influence the assessment value.

In the initial stage, the OLS model only takes into account the physical attributes alone. Locational attributes are included in the OLS model as additional improvements to form SHM. SHM model improvements are added to the OLS model because it can reduce the problem of spatial autocorrelation. There are three models of SHM namely, spatial autoregression model (SAR), spatial error model (SEM), and general spatial model (SAC)

Geographically Weighted Regression (GWR) model is based on the traditional OLS model with spatial coordinates entered to take into account the weight factors of location. GWR uses the locational X and Y coordinates as a basis for calculating local weights for the dependent and independent variables. The values of X and Y are derived from GIS spatial database. The advantages of GWR include taking into account the influence of locality using latitude and longitude coordinates weights.

Ibrahim and Oliver (2005) used OLS and GWR for shop-lot rental analysis in the Johor Bahru City. This GWR model showed the significance of locational factors such as property distance from shops to banks, taxi and bus stops, and shopping complex. Brunsdon (1999) compared the GWR model with the traditional OLS model to estimate property prices. The dependent variable was sales price while the independent variables were property's physical factors such as floor area, number of rooms, and land area. The GWR model was found to have overcome the problem of spatial autocorrelation and reduced the residual sum of squares from 22,152 to 3,895. The OLS model is generally used for global analysis while the GWR model is used for local analysis.

Kriging model basically uses the concept of the traditional comparative method whereby best comparison is the nearest comparable property to the subject property. Spatial structure element exists in the form of the distance between the properties. This gives room for kriging application in interpolating property values. Kriging can reduce the subjective or arbitrary element (valuer's opinion) by using weights computed based on the variogram and the configuration of spatial data. Kriging also has a greater ability to produce the expected value than other interpolation methods (Isaaks, 1989andBurrough, 1998).

Kriging is a local trend analysis that generates the expected value at the global level (Bigrne, 1973). Kriging has the ability to make assessment based on the interpolation of sample data. Kriging treats property price as the Z-value while the coordinates X and Y are used as the basis for interpolation in a three dimensional relationship to generate the estimated value of the surface (Z-value) at points of no transaction prices. Z-values are obtained from the valuation database while X-Y coordinates from the GIS spatial database. Ordinary kriging method is developed using three semi-variogam models which commonly are spherical, exponential, and Gaussian (NaoumandTsanis, 2004).

2.3 Concept of Ratio Study

The principle of ratio study is that an estimated value should be the same level as a market price in order to create equity and uniformity in property tax assessment (IAAO, 1990, Birch, Sunderman and Hamilton, 1992; Cornia and Slade, 2005). Therefore, an assessment ratio is a ratio of a property's assessed value to its sales price (IAAO, 1987).

Numerous property assessment divisions in municipalities all over the world have adopted the ratio study for upgrading and enhancing their assessment quality and services. In the United States, for example, the ratio study is adopted by Utah State Commission (1997-2008), Kansas Department of Revenue (1998-2008), Nevada Tax Commission (2000-2010), and Idaho Tax Commission (2003-2008).

Ratio study has been widely used as a primary tool for measuring the ability of a mass appraisal model (IAAO, 1990), especially in terms of equity and uniformity of assessment in a particular sub-market (Sirmans *et al*., 2008). The results of ratio study can indicate sub-markets with good model ability and those requiring increased capacity in model ability (Smith, 2008).

The level of justice in the assessment of property holdings is said to have been achieved as a whole if the properties are valued exactly at the same level as their current market prices or where the assessed value to price ratio is 1.0 (IAAO, 1990, Guilfoyle, 2000; Smith, 2008). The measures of central tendency used are the mean, median, weighted mean, and the geometric mean. In addition, the size of the confidence interval is also computed. IAAO (1990) has set an overall level of justice at 90% with a range of ratios between 0.9 to1.10. In this study, the measurement of justice is done for the whole market as well as for the sub-markets.

Horizontal equity occurs when similar properties have similar market values but have different assessment values. This occurs because the distribution of sub-market segments is such a way to cause differences in the estimated values between sub-markets (Spahr and Sunderman, 1998).

Vertical inequity occurs when expensive properties are judged to be at difference levels with cheap properties (IAAO, 1990; and Sirman, 2008). Measurement of vertical uniformity is based on property prices that are divided into sub-markets.

2.5 Geographic Information System (GIS) and Spatial Analysis

Geographic Information System is used for modeling the real world to help solve problems that are associated with geography in the world's space (Taher, 2005). In rating assessment, GIS-aided mass appraisal models are designed to produce a more objective assessment of values (Ibrahim, 2003).

Spatial analysis is a quantitative study involving spatial data for a phenomenon that is associated with location in the world's space (Bailey and Gatrell, 1995). The objective of a spatial analysis is to find patterns in spatial distribution of a phenomenon and the possibility of identifying the reasons for its occurrence and to be able to make assessment of the expected values of areas that do not have evidence of the occurrences of the said phenomenon (Bailey and Gatrell, 1995; Fisher, 1999). For areas that do not have proof of purchase transactions, for instance, the expected values of the areas can be generated through the formation of the mass appraisal model (Ibrahim, 2004).

In this study, the discussion is focused on the generation of locational factors using GIS spatial analysis techniques such as buffering, overlaying, and network analysis. Ratio study is then used to measure the equity and uniformity of mass appraisal employing OLS, SHM, GWR and kriging.

3.0 STUDY AREA, DATA AND METHODOLOGY

3.1 Study Area

This study focused on properties located within Kulai Municipality Council's area (MPKu) with an area of 747 sq km and with a total number of taxable property holdings of 85,000 units comprising residential, commercial, and industrial properties as well as vacant lands. Single-storey terraced (1T) houses in MPKu were selected as the appropriate property type since they present in the highest number of units and active transactions.

3.2 Data and Methodology

The data employed in this study were valuation attribute data, purchase transaction data, GIS spatial data, and qualitative data derived from questionnaire.

Attribute data and property assessment information were used to explain the physical elements of properties. Information relating to ownership of holdings comprised proprietary, ownership status, and location. Details of the physical information were related to land and buildings, such as land and floor area, type of construction, the building, packaging, surrounding areas and accessibility. The information was derived from property attribute database generated from the MPKu's re-valuation exercise in 2006.

Property transaction data from 2004 to 2006 were obtained from theValuation and Property Services Department (JPPH), Johor Bahru. The data included information such as price, location, and details of houses.

The spatial data that have geographic references and displayed on maps included cadastral lots, roads, rivers, boundaries, land use, topography, and so forth. Cadastral lots with geographical references

were obtained from the Department of Survey and Mapping Malaysia (JUPEM) and were used as a base layer. The qualitative data included information obtained through site visits, review of instrumentation, fieldwork, literature, and empirical studies.

The process of achieving study objectives were divided into three stages. The first stage was a description of the mass appraisal model for rating purposes. Literature review was conducted to select the best and appropriate mass appraisal model that can generate accurate assessment values. The literature review shows that the Ordinary Least Square (OLS) was the most common model used in assessment ratings. Spatial hedonic model (SHM) was considered as an improvement to the OLS by taking into account spatial autocorrelation. Geographically Weighted Regression (GWR) and kriging technique were also considered to produce accurate assessment values.

The second stage involved a brief assessment relating to property rating tax, locational components, and the technique to generate these variables. The identification of variable components was based on locational factors to be included in the mass appraisal model and was based on the literature review. The process of generating locational variable components was aided by GIS data and spatial analysis. The variables representing locational components were accessibility, neighborhood, and environment that were generated using GIS spatial analysis such as buffering, overlaying and network analysis.

The third stage involved the measurement accuracy of the assessment values according to the date of the tone of the list. The assessment values derived from these models were compared with the market prices to assess the fairness and uniformity of using ratio study.

4.0 RESULTS AND DISCUSSION

4.1 Generation of Locational Variables

As mentioned earlier, the GIS spatial analysis techniques used were buffering, overlaying, and the network analysis. Neighborhood attributes were generally generated through buffering tehnique. Meanwhile, accessibility was assessed using network analysis. The integration of these techniques ware also used to generate the more complex locational variable components. The list of variables and spatial analysis techniques used in deriving the mass appraisal model is shown in Table 1.0.

Areas many as 29 locational variables were generated with the aid of GIS spatial analysis in Table1.0. Thirteen variables were generated through buffering, 12 overlays, and 4 network analyses.

Table 1.0: Locational variables and spatial analysis techniques

NO.	VARIABEL NAME	LOCATIONAL FACTORS	SPATIAL ANALYSIS TECHNIQUE
1	TANAH smp	Dependent –Land value per square feet	
2	Luas Lot	Neighbourhood - lot taman area	
3	KodKomposisi	Neighbourhood – composition of the commercial type of land use, housing and industry.	Overlay
4	KodBilPegangan	Neighborhood-the total number of taxable property holdings in the taman. More properties show the better taman.	Overlay
5	KodBKerjaKulai	Accessibility-close to work place at Kulai town	Buffer
6	KodBKerjaSenai	Accessibility-close to work place at Senai town	Buffer
7	KodBKerjaPejabat	Accessibility-close towork place at office area	Buffer
8	KodBKerjaIndustri	Accessibility-close to work place at industrial area	Buffer
9	KodBKerjaAirport	Accessibility-close to work place at Senai airport	Buffer
10	KodBsekolah	Accessibility-tamannear theschool. Toreducethe costof children transportationtoschool	Buffer
11	Gerai	Neighborhood–taman with MPKu stalls	Overlay
12	PamMinyak	Neighborhood–taman with petrol station	Overlay
13	Masjid	Neighborhood–taman with masjid	Overlay
14	KawLapang	Neighborhood–taman with open land area	Overlay
15	Klinik	Neighborhood–taman with clinic	Overlay
16	Bank	Neighborhood–taman with bank	Overlay

Table 1.0: Locational variables and spatial analysis techniques (con't)

NO.	VARIABEL NAME	LOCATIONAL FACTORS	SPATIAL ANALYSIS TECHNIQUE
17	Bbelibelah	Neighborhood–ctaman with shopping complex	Overlay
18	Bkedai	Neighborhood–taman with shop lot	Overlay
19	Dewan	Neighborhood–taman with public hall	Overlay
20	Pasar	Neighborhood–taman with market	Overlay
21	BjlnutamaUdara	Environment-taman in front of the main road. Air pollution occurs.	Buffer
22	BoksidasiBau	Environment-taman near oxidation pond. Odor pollution occurs.	Buffer
23	BketapiBunyi	Environment-taman near railway station. Noise pollution occurs.	Buffer
24	BlebuhrayaBunyi	Environment-taman near highway. Noise pollution occurs.	Buffer
25	JarakJ B	Accessibility-the distance from taman to Johor Bahru	Network
26	Jarak Senai	Accessibility-distance taman to Senai	Network
27	Jarak Kulai	Accessibility-distance taman to Kulai	Network
28	Btol	Accessibility-distance taman to highway plus tol	Network
29	Kod Jln Masuk Utama	Accessibility–taman near to main road entrance	Buffer
30	SkalaTaman	Neighborhood-the scale of taman according to questionnaire respondents.	Buffer
31	Kod Kawasan	Neighborhood-the socio-economic status based on demographic characteristics	Buffer

4.2 Comparison between Mass Appraisal Models

As mentioned earlier, locational attributes generated from GIS spatial analysis were used in the formation of selected mass appraisal models. The literature review shows that the models which can be used in the mass appraisal were based the Ordinary Least Square (OLS), Spatial Hedonic Models (SHM), Geographically Weighted Regression (GWR), and Kriging.

Table 2.0: Comparisons between OLS and SHM models

Model	OLS	SEM	SAR	SAC
Model Design	Linear	Linear	Linear	Linear
R^2	0.8539	0.8616	0.8700	0.8750
Adjusted R^2	**0.8214**	**0.8409**	**0.8411**	**0.8473**
SEE	1046	798	735	721
Log-Likelihood	-	-296	-293	-255
Dependent (TANAHsmp)	Nilai Tanah smp	Nilai Tanah smp	Nilai Tanah smp	Nilai Tanah smp
Independent variables:	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**
(Constant)	40.846 (0.237)	50.104 (0.338)	-121.68 (-0.78)	-161.40 (-1.01)
JarakKulai	31.734 (0.915)	32.155 (1.07)	45.49 (1.54)	49.96 (1.69)
Btol	49.037 (3.314)	40.69 (3.00)	34.711 (2.65)	34.41 (2.61)
KodJlnMasukUtama	31.715 (2.644)	30.82 (2.93)	31.88 (3.17)	31.25 (3.13)
BlebuhrayaBunyi	-13.010 (-0.870)	-12.62 (-0.93)	-13.37 (-1.06)	-12.71 (-1.05)
BketapiBunyi	-18.933 (-1.578)	-21.58 (-2.04)	-21.60 (-2.15)	-19.68 (-1.98)
Bbelibelah	42.793 (2.039)	40.78 (2.00)	25.08 (1.35)	22.51 (1.24)
KawLapang	27.60 (2.543)	25.79 2.82	31.15 (3.37)	33.12 3.53
Klinik	32.579 (2.332)	31.67 2.64	30.10 2.56	30.00 2.56
Gerai	44.465 (2.493)	40.71 2.55	41.98 2.81	42.38 2.89
KodBkerjaSenai	24.998 (3.387)	25.22 3.45	22.75 3.63	21.74 3.67
KodBkerjaKulai	60.461 (1.766)	58.44 2.00	70.17 2.42	74.17 2.56
SkalaTaman	5.902 (4.357)	6.04 4.80	5.47 4.75	5.22 4.71
Lambda (λ)		**0.34** (2.00)		0.33 (1.97)
Rho (ρ)			0.28 (1.91)	-0.21 (-0.82)
Number of significant variables (t value> 2.0)	8	**10**	9	8

Previous studies have shown that the SHM model which has the most number of significant parameters was considered the best model for property value assessment. Table 2 shows that the SEM model produced a lambda value of 0.34 (t-value = 2.00). SAR models produced a rho value of 0.28 (t-value = 1.91). SAC model also produced a lambda value of 0.33 (t-value = 1.97) and a rho value of -0.21(t-value = -0.82). The number of significant variables with t-values above 2.0 was also used as a guide for selecting the best model. In Table 2.0, the SEM model has 10 statistically significant variables, the SAR model has 9 while the SAC model has 8.

Although the adjusted R^2 for the SEM model (0.8409) was lower than that of the SAR model (0.8411) and the SAC model (0.8473), the difference was not considered significant. Therefore, SEM was considered to be a more effective model to represent the SHM.

The comparison between OLS and SEM models showed no significant differences between them. However, the SEM model was considered better as the adjusted R^2 square and significant t-values for the independent variables were higher. The SEE of the SEM was also lower than that of the OLS.

```
*****************************************************************************
*                          GWR ESTIMATION                                   *
*****************************************************************************
 Fitting Geographically Weighted Regression Model...
 Number of observations............ 67
 Number of independent variables... 13
  (Intercept is variable 1)
 Bandwidth (in data units)......... 8367.62483
 Number of locations to fit model.. 67

Diagnostic information...
Residual sum of squares.........         48656.083575
Effective number of parameters..            15.831414
Sigma...........................            30.836627
Akaike Information Criterion....           677.393953
Coefficient of Determination....             0.874158
Adjusted r-square...............             0.834447
```

Figure 3.0: The results of GWR statistical tests

Figure 3.0 shows the results of the diagnostic statistics of the GWR model, the residual sum of squares (RSS), the number of parameters, SEE, AIC, COD, and adjusted R^2. The GWR model has increased model explanatory power from 80% to84% based on the adjusted R^2. The RSS declined from 56.497 to 48.656 in the global model indicating the local GWR model to be better than the OLS model.

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*************************************************************
*                        ANOVA                              *
*************************************************************
       Source              SS        DF          MS          F
OLS Residuals         56497.8     13.00
GWR Improvement        7841.7      2.83   2769.5458
GWR Residuals         48656.1     51.17    950.8976     2.9126
```

Figure 4.0: ANOVA Result

Figure 4.0 shows the ANOVA for the global OLS model and GWR local model. The F value = 2.9126 proves that the GWR model was more significant than the OLS model. The total sum of squares (SS) was also reduced to 7841.7.

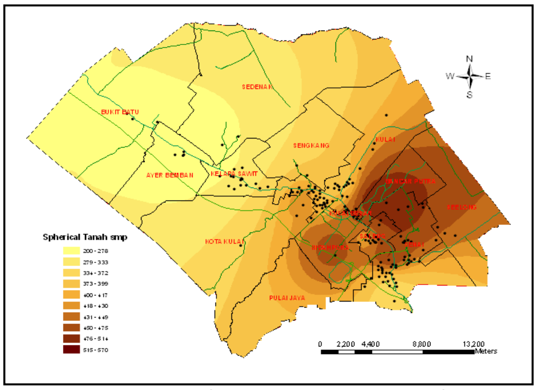

Figure 5.0: Map of the expected value of the land from spherical kriging model

Figure 5 shows the expected values of the land per square meter for spherical kriging model. The pattern shows the market where property values were getting higher towards Johor Bahru starting from Bandar Putra but were declining towards the north-western area (e.g. Bukit Batu). Therefore, an appropriate model to generate property assessment values has to be based on spherical-regression based maps.

Table 3.0: Cross-validation result

Prediction Model	Spherical
Mean	1.00
Root-mean-square	40.49
Average standard error	57.27
Mean standardized	0.01936
Root-mean-square standardized	0.8626
Model equation	227+0.462X

Statistically, a model that is considered good is one with the average expectation approaching 1.0 (mean prediction), low value of root-mean-square, and root- mean-square standardized approaching zero. Table3.0 shows the result of the spherical model with a mean of 1.00, root-mean-square of 40.49, and root-mean-square standardized of 0.8626. The spherical model has a mean value equals the market value of the land of RM415.00 per square meter.

4.3 Measurement of Mass Appraisal Model Accuracy

The ability of mass appraisal models was measured using the ratio study. The measurements were made on two main aspects, namely the level of equity and uniformity.

4.3.1 Measurement of Equity

Table 4.0: Measurement of overall equity

Model / Equity Measurement	OLS	SHM	GWR	KRIGING
Mean	1.0027	.9975	1.0006	1.0110
Median	1.0000	1.0000	.9900	1.0200
Weighted Mean	1.0008	.9957	.9986	1.0036
Geometric Mean	1.0018	.9966	.9996	1.0073

The ratio study found that the assessment value overall equity for OLS, SHM, GWR and kriging was about 1.0. The analysis followed was the view of equity in accordance with sub-market level.

Table 5.0 shows the results of measuring the level of equity in accordance with sub-market. GWR and kriging were considered not to have the level of equity because their values were outside the range of equitable ratio value, especially in the Kelapa Sawit area. The results showed that the OLS model and the SHM have a better level of equity with a ratio of 0.99-1.05.

Table 5.0: Measurement of sub market equity

Model	Sub market	Mean	Median	Weighted Mean	Equity level
OLS	KelapaSawit	1.05	1.05	1.05	yes
	Senai	1.00	0.99	0.99	yes
	Kulai	1.00	1.00	1.00	yes
	Bandar Putra	1.01	1.01	1.01	yes
	Overall	1.00	1.00	1.00	yes
SHM	KelapaSawit	0.99	0.99	0.99	yes
	Senai	0.99	0.99	0.99	yes
	Kulai	1.00	1.00	1.00	yes
	Bandar Putra	1.04	1.03	1.04	yes
	Overall	1.00	1.00	1.00	yes
GWR	KelapaSawit	**1.10**	**1.08**	**1.08**	**no**
	Senai	0.99	0.98	0.99	yes
	Kulai	0.99	0.99	0.99	yes
	Bandar Putra	1.00	1.00	1.00	yes
	Overall	1.00	0.99	1.00	yes
Kriging	KelapaSawit	**1.09**	**1.10**	**1.08**	**no**
	Senai	1.03	1.02	1.01	yes
	Kulai	1.01	1.02	1.01	yes
	Bandar Putra	**0.91**	**0.92**	**0.91**	**no**
	Overall	1.01	1.02	1.00	yes

Table 6.0: Mean rank based on Kruskal-Wallis test

Model group	KelapaSawit	Senai	Kulai	Bandar Putra	Range of Average Number of Sequence
OLS	57.25	30.09	33.47	38.75	27
SHM	29.75	31.02	33.47	52.92	**23**
GWR	62.13	29.81	33.37	37.25	33
Kriging	49.88	36.91	33.88	10.92	39

Table 6.0 shows the average results of the sequence of the Kruskal-Wallis test. Each model produced a sequence of events. The OLS model produced the average number of sequences of 27 (from 30-57); SHM model of 23 (from 29-52); GWR model of 33 (from 29-62) and kriging model of 39 (from 10-49). This was an early indicator of possible existence of an inequitable assessment of the sub-markets. The SHM model was considered the best because of the resulting lowest range it produced. Kulai areas showed a more uniform average sequence for each model. It shows that each model was suitable to be adopted in

Table 7.0: Results of Chi-Square test

Model	OLS	SHM	GWR	Kriging
Chi-Square	**7.831**	**6.548**	9.913	11.704
Degree of freedom	3	3	3	3
Asymp. Sig.	.065	.088	.019	.008

4.3.2 Measurement of Uniformity

Table 8.0: Measurement of overall horizontal uniformity

	MEASUREMENT OF UNIFORMITY	OLS	SHM	GWR	Kriging
1	Range - Low	0.22	0.23	0.25	0.42
2	COC - High	97%	99%	97%	78%
3	AAD - Low	0.032	0.032	0.032	0.069
4	COD - Low	3.24	3.23	3.37	6.82
5	STD - Low	0.044	0.042	0.046	0.088
6	COV - Low	4.35	4.19	4.59	8.74
	No of significant items	2	5	1	0

Table 8.0 shows the results from measuring the level of horizontal uniformity on the mass appraisal models, whereby the low range represents the uniformity of a particular model. The OLS model, SHM, and GWR model have almost the same low range of about 0.2. Larger COC was found in the OLS model, SHM, and GWR model with a value of about 97%. The OLS, SHM, and GWR models have a low value of AAD (0.03). Low COD values (3.3) were found in the OLS, SHM and GWR models. STD values were found to be as low as 0.04 in the OLS, SHM and GWR models. Low COV value around 4 was shown in the OLS, SHM and GWR models.

In general, the OLS, SHM and GWR models were able to generate uniform assessment values. Based on a significant number of items in Table 8.0, the most appropriate model in terms of overall horizontal uniformity was the SHM.

Table 9.0: Measurement of SHM horizontal uniformity

SUB MARKET	STD	Range	AAD	COD	COV	COC	No of significant item
KelapaSawit	.036	.187	.022	.022	3.6%	100.0 %	3
Senai	.049	.230	.037	.038	4.9%	96.3 %	0
Kulai	.035	.156	.026	.026	3.5%	100.0 %	1
Bandar Putra	.034	.099	.024	.024	3.4%	100.0 %	4

The results of measurement of SHM horizontal uniformity are shown in Table 9.0. The SHM was able to produce a horizontal uniform assessment in four sub- markets. In particular, property assessments in Bandar Putra and Kelapa Sawit were more uniform than those in Senai and Kulai.

Table 10.0: Vertical uniformity of assessments by sub-market and model type

SUB MARKET	OLS	SHM	GWR	Kriging	Vertical Uniformity
KelapaSawit	1.002	1.001	1.002	1.001	uniform
Senai	1.003	.999	1.003	1.015	uniform
Kulai	1.000	.999	1.000	1.004	uniform
Bandar Putra	1.001	1.001	1.001	1.001	uniform
Keseluruhan	1.002	.998	1.003	1.011	uniform

Table 10.0 shows the results of the vertical uniformity with price related differential (PRD) value for each model was in the range of 0.98–1.03. This indicates that each model has produced a uniform assessment value as a whole and also according to the sub-market whereby a property with a high market value was assessed at the same level of a property with a lower market value. Thus, there was no problem of regressive and progressive aspects in the mass appraisal models.

5.0 CONCLUSION

Overall measurements showed that all of the mass appraisal models (OLS, SHM, GWR and kriging) have produced equitable assessment values. Besides, the measurements according to sub-markets (Bandar Putra, Kulai, Senai and Kelapa Sawit) also found that the best model was the SHM followed by the OLS model. The measurement of equity level using the Kruskal-Wallis test by sub-market showed that the SHM model has produced more wquitable property assessments than the others. Overall measurements also showed that the SHM has produced horizontal uniformity in assessment values followed by the OLS model. The measurements according to the sub-market for the SHM and the OLS model found that Bandar Putra has the most uniform assessment values. Meanwhile, the measurements for vertical uniformity using PRD (with range of between 0.98–1.03) have indicated that each model has achieved vertical uniformity.

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