TEMPORAL AGGREGATE EFFECTS IN HEDONIC PRICE ANALYSIS

BURHAIDA BURHAN[1], HOKAO KAZUNORI[2] and MOHD LIZAM MOHD DIAH[3]

[1]Saga University, Japan

[2]Saga University, Japan

[3]University Tun Hussein Onn Malaysia

burhaida@uthm.edu.my

ABSTRACT

Housing units are commodities made up from significant aspects. These aspects could be valuable in terms of predicting its value, or they may just be part of insignificant characteristics. Housing markets which are significantly related to both supply and demand are best reflected by hedonic method. A regularly reported house price index normally predicted by a set of suitable temporal aggregation. This paper attempts to discover the temporal aggregation effects on the price index. The results showed the percentage of variance explained by the factors involved towards the house price index. The differences of R squared value in different temporal aggregate shows the importance of choosing the right level in terms of analyzing the housing market. Our empirical analysis is based on Johor Bahru housing transaction data, sold between the years of 1998 to 2007. The results indicate clear importance of disaggregation in the estimation of housing prices and volatility.

Keywords: hedonic analysis, temporal aggregation, price index, multiple regression analysis, mass appraisal

INTRODUCTION

House price indexes are important for numerous reasons. In order to gain a better understanding of housing markets (such as analyses of the determinants of house prices and of the efficiency of housing markets), and also to identify issues related to social (such as analyses of housing affordability or whether or not housing bubbles exist), house price indexes are crucial information. Englund et al., (2002) and Shiller, (2003) discussed the benefits of hedging housing risk, which in order to execute that, needs a price index. Given the importance of housing in households' wealth, the measurement of house price movements is a vital topic from both academic and practical perspectives.

The normal median house price indexes are widely used in several countries (Prasad and Richards, 2007). On the other hand, distinguished movements in prices and change of dwelling sold composition between one period to another are not available. It is suggested that methods involved quality control should be used. Two very well known methods are hedonic and repeat sales techniques. In the hedonic method, quality is usually controlled by using multiple regression models with the properties' characteristics as independent variables. While with the repeat sales method, in theory, quality control is normally achieved by considering subset of properties which have sold repeatedly for a certain given or selected period.

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[1]Burhaida Burhan is currently pursuing doctoral degree in Saga University, Japan. She is currently serving as a lecturer in University Tun Hussein Onn Malaysia. She can be easily reached by her personal email, b.burhaida@gmail.com.

It is always a question in further research that by using only medians of sale prices could generate a more appropriate price indexes. Much has criticized that such indexes could be prone to further bias. A few considerations has been made, first, the spread between list prices (median price) and transaction prices might vary according to the state of the housing market. Second, if the samples of the properties are collected from advertisements, they may not be a good substitute of the whole population of the transacted properties. Third, there are possibilities that the same property might appear in several different advertisements across different time periods in case the property took too much time before being sold.

Englund (1999) mentioned that a considerable amount of literature exist on the price measurement for non-standard asset types such as housing. In constructing price index, two major problems should be overcome: the relative infrequency of housing unit sales; and the characteristics' heterogeneity across those units. Simple price indexes based on mean or median housing prices normally do not at all consider the housing characteristics sold. These are major reasons why movements of prices and composition differences of sold homes between periods cannot be distinguished more properly using these methods. Crude regression models (e.g., the U.S. Bureau of the Cencus C-27Index) are just crude. Strong assumptions on the constancy of quality of housing of any given dwelling are the basics of more sophisticated repeat sales models (for example, Bailey, Muth, and Nourse, 1963 and Case and Shiller, 1987).

Most of the time, research papers discussing issues on model selection, but the measurement of time itself in analyzing trends and volatilities is more important. This paper addresses the issues of implicating different aggregate of time towards changes of housing prices by combining housing sales observed in continuous time into detached time periods for statistical analysis. The differences of model fitness in each time period are observed. The analysis is based on detailed model of house price determinants, using inputs on wide range of hedonic characteristics.

Calhoun et. al. (1995) mentioned that dwelling units are being transacted infrequently. The low level of liquidity restricts the capacity of valuing assets that regard more than half part of the household wealth. Temporal aggregations are normally being resorted in price indexes of these assets. Calhoun et. al. suggested that in order to secure the degrees of freedom, observations from several narrow time intervals are combined to estimate values for a wider time interval (e.g. monthly into quarterly indexes). As part of a temporal aggregation test, a quarterly index of real estate prices is constructed.

This paper has two main objectives. First, this paper aims to provide information of the key determinants or factors of real estate prices in Johor Bahru, Malaysia. At the same time, it attempts to examine how much the prediction of accuracy of real estate prices could be improved by applying hedonic equations at suitably defined disaggregate levels (time period).

It provides a test structure for temporal aggregation in house price indices. A quarterly index is compared with annual counterparts, providing information on the short-term behavior of house prices. The data are 9766 transactions of single and double storey house transactions, provided by the Valuation and Property Services Department (JPPH) in Malaysia. In the empirical analysis, quarterly and annually index of houses are constructed.

By relating to Calhoun et. al. (1995), the empirical application leads to one principal conclusion. There is an aggregation difference of hedonic model fitness in moving to longer time interval. In other circumstances, aggregation bias is positively correlated with the level and rate of change of house prices. The tendency is for the quarterly index, when monthly data are available, to understate house price increases in a rising market and to understate decreases in a falling market, effectively smoothing some of the volatility. As the time interval widens in aggregation, the variance of house prices declined. Temporal aggregation should smoothes prices variability across time because spot values are averaged over time (Calhoun et. al.,1995). Our results do confirm this behavior. In the real estate market for single storey and double storey houses, where there is relative liquidity in the perspective of Malaysian market, the wider the range of time interval, the lower the variance of house prices. Nevertheless, the results also showed the effective temporal period in terms of selecting the appropriate temporal segmentation.

CONCEPTUAL AND EMPIRICAL FRAMEWORK

Hedonic Analysis

Coulson, E. defined hedonic analysis as the study of relationship between the price of a product and the characteristics of that product. Through ownership or rental arrangements, people buy and employ residential real estate because they are able to obtain utility– that is, gratification, from the things that the housing unit has to offer, what will sometimes be generically referred to as "housing services". Every house or apartment or duplex has certain attributes, or characteristics (the terms can be used interchangeably), that could allow people to obtain utility from residing in it. These factors include the land, the amount of interior square feet, the age of the house, the number, size, and type of the various rooms of the house, and the existence (or lack of) other amenities such as a garage, air conditioning, source(s) of heat, and etc. Due to the importance of immobility characteristics of housing, the location is important too; more particularly, the attributes of that location will be experienced by residents as well, though, in this paper, the location attributes will not be considered as much.

The main purpose of hedonic analysis in real estate, according to Coulson, E., is to investigate the relationship between the existence and amount of all of these characteristics (structural and locational) and the price that people are willing to pay for the unit. The incorporating of the characteristics are done by combining through the actions of the participants, through the mechanism of supply and demand. Each housing unit has an apparent price, determined partly by the overall supply and demand conditions in the local housing market, and also by the obvious collection of attributes it represents. The combination method usually embodies the hedonic function which uses attributes related as inputs and develops the unit price of the market as its output.

Hedonic analysis assumes that each attribute is governed by supply and demand of its own, which in turn has their own 'market'. Supposedly, each characteristic therefore has their hedonic 'price'. By gaining knowledge of the hedonic price could allow one to create housing price indexes. These price indexes could allow one to examine the volatility of overall market conditions and may gain a few insights on a particular specific market.

The real origins of hedonic analysis occur when researchers proposed methods that systematically used data on existing products to derive a statistical relationship between real estate prices and real estate characteristics. One assumes a relationship of the following sort:

$$P = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_k X_k \qquad (1)$$

where X_1 through X_k represent the k attributes of a piece of real property (e.g., internal square feet, external square feet, number of bathrooms, etc.) and the a_j's are variously referred to as the weights, or coefficients for each of the X's, and P is the price of the property . This is a hedonic function. Equation (1) assumes that the hedonic function is linear. Hedonic analysis thus involves using statistical procedures to calculate values of the a_j's which obviously give the influence of each X on the price.

The linear function implies that if X_i goes up (e.g., internal square feet), the price of the property rises by a_i dollars. In the language of calculus, defined as:

$$\delta P / \delta X_i = \alpha_i$$

that the change in P due to a change in X is constant and equal to a_i.

In this research, P is being referred as housing sales price, with the addition of temporal variable in the equation. X is definitely the suggested housing attributes collected for each property (as mentioned in Table 3), while α is the

calculated coefficients for each derived variable. As in previous explanation, it is suggested that the change in P (housing sale price) will definitely involve changes in X (the housing attributes) accordingly, hence, the needs to understand the importance of using multiple regression analysis in later discussion.

As mentioned above, the most common use of hedonic prices is in the creation of price indexes. A price index is a measure of the "average" house price in a given location at a given time. The comparison of "average" housing prices in different cities, or in the same city at different time periods (or indeed for different cities in different time periods) is fraught with danger, again because the times and places one is comparing have different housing stocks (Coulson, E.). Hedonic analysis can help alleviate this problem because it provides a mean for comparing two houses with identical characteristics.

Hedonic Price Model

In this article we discuss regression-based methods for estimating hedonic prices. Hedonic regressions are a way of statistically estimating the relationship between a property's characteristic cs and its market value, and thus a way of determining the value of the property itself. The result of this regression estimation is a hedonic function like equation (1) that can solve the problem of appraisal.

In the literature, there are several statistical methods that empirically analyze real estate price. However, apparently, the most popular one is the hedonic framework that has been developed since Rosen (1974), which is now widely applied in both the academic community and industry (Malpezzi, 2005).

In Rosen (1974), housing is treated as a composite commodity in the sense that its market value is dependent on the vector of its characteristics (Lancaster, 1966). The theory of hedonic price functions laid down the theoretic foundation for the analysis of differentiated goods and each individual characteristic can be implicitly priced. Commonly, characteristics that are important to the market value of housing are classified into three categories: 1) structural attributes, i.e. building material, floor space, number of bedrooms and bathrooms, inner structure, age of dwelling, floor level, direction, and outside appearance; 2) neighbourhood attributes, i.e. dwelling maintenance and management service, parking, safety, surrounding parks and leisure facilities, composition of neighbours in terms of ethnic, racial, age, educational background; 3) locational attributes, i.e. distance to central business district (CBD), travel and shopping convenience, and accessibility to subway/underground and public transportation systems.

According to Chen and Hao (2010), although the economic theory outlined by Rosen (1974) provides a general framework for the analysis of housing prices through hedonic price functions, the theory has not yet provided standard guidelines on empirical issues, such as the choice of functional form and selection of particular housing characteristics to be included in the hedonic price function (Epple, 1987). A long list of functional forms has been proposed and tested, which include parametric and non-parametric approaches (Meese and Wallace, 1991). However, recent discussions on the identification of hedonic price functions show that this issue is still open for further discussion (Ekeland et al., 2004). Maybe the most exciting breakthrough in hedonic price work during the last few decades is the increasing interest and growing application of newly developed spatial econometric techniques (Wihelmsson, 2002). The question we address here is how to determine the hedonic prices for a particular housing market. Hedonic studies generally use a statistical tool called multiple regression analysis.

Temporal House Price Aggregation

According to Calhoun et. al. (1995), temporal aggregation may entail bias in the construction of real estate return and price indices. Geltner (1993) shows that temporal aggregation discovers a smoothing bias even if the data are based on purchase-money transactions. Temporal aggregation may impart bias in the estimation of repeat sales indices of house prices, Calhoun et. al mentioned that apart from systematic seasonality, temporal aggregation may smooth and defectively eliminate noise in house price movements. With this smoothing, houses appear to be less risky investments,

having an aggregation bias that under states volatility. The variance of housing and its covariance with other assets are understated. In this paper, we consider the implications of the aggregation of sales reported in quarters and years for the estimation of housing prices. The observations on model fitness of R squared value are being examined for each selected temporal aggregation.

THE EMPIRICAL ANALYSIS

The earlier stage of the analysis considers the whole transaction of both property types. Multiple regression analysis with the application of stepwise regression is applied across all temporal aggregation. This research focuses on the value of R square, as a key factor for the investigation of fitness of models across all periods. Since the R square definition could value the variation in the explaining factors of the house prices, it is at most important for this paper to understand the movement of this value in terms of indicating the origins of most important period aggregation.

The years of 2005 till 2007 are given extra attention in this research. Due to the fact that these the latest years in the database, and has the most and newest transactions. It is possible to say that the later years should encourage for more attempts of new transaction price accordingly with the market conditions. Since the motivation of the paper is to identify suitable aggregation for further examination of that particular period, it is an upmost important to include the later years (in this case, the most existing transactions) as well.

Table 1 shows the movements of model of fitness throughout the time selected. It is seems there is very small variance in terms of including the time dummy as part of independent variable. Although according to Calhoun et. al. (1995), As the time interval widens in aggregation, the variance of house prices declined. It is proven in our result as well, where in all cases of different aggregate, quarterly period shows the highest R square value in all regards. It relatively shows that the capability of quarter period to explain higher variations of the house prices. Although it is the highest, it does not show much significance, as the percentage of differences is less than 1 percent. Though it might triggers higher result for a far bigger area (considering Johor Bahru as part of small developing region in the south of Malaysia).

Table 1: Temporal aggregation of Johor Bahru House Prices between 1998 to 2007: R square value

	All Years	2005 - 2006	2005 - 2007	2006 - 2007
Without temporal aggregation	0.457	0.565	0.574	0.622
Annual	0.46	0.565	0.575	0.623
Quarterly	0.463	0.566	0.577	0.626

Most important indication extracted from Table 1 is the steady rise of R square movements towards the later years of the indexes. Periods of 2006 to 2007 are highest in value, and major climb of about 16.5% for overall index itself is a very interesting factor. It gives view of more significant variations of price is happening in the database in the latter years. Due to this finding, the paper intends to divide the aggregation of later period into independent years, so that the index could be viewed as independent hedonic model for each year. Table 2 proves that the raise in R square to round up at about 60.5% to 67.1% is highly related to the temporal segmentation. 2007 itself shows an increase of 4.5% of variations when it is standing on its own.

Table 2: Temporal aggregation of Johor Bahru House Prices between 2005 to 2007: R square value

	2005	2006	2007
Without temporal aggregation	0.605	0.618	0.667
Quarterly	0.606	0.618	0.671

Table 3: Variable Means By Selected Temporal Aggregate

Variables	All	2007	2006	2005	2005 - 2006	2005 - 2007	2006 - 2007
Selling Price	129848.00	123767.24	127933.10	128941.31	128479.99	127360.30	126245.38
Sub district	5.09	5.63	5.53	4.99	5.24	5.33	5.57
Tenure	.93	.95	.93	.89	.91	.92	.94
Location quality	.28	.24	.20	.20	.20	.21	.22
Lot area (meter square)	242.15185	165.84296	238.58586	157.30628	194.49714	187.68928	209.11533
Area category	.55	.58	.54	.51	.52	.54	.55
CBD Distance (km)	18.285	17.367	18.414	19.414	18.957	18.579	17.990
Lot type	.86	.86	.88	.85	.86	.86	.87
Building condition	.93	.92	.94	.90	.92	.92	.93
Building lot (meter square)	83.77149	83.80436	82.28167	85.21758	83.87420	83.85761	82.89856
Ancilliary	18.72904	18.14878	17.95547	18.58704	18.29806	18.26259	18.03379
Countour	.73	.89	.77	.73	.75	.78	.82
Valuation Category	2.17	2.29	2.23	2.15	2.19	2.21	2.25
Seller type	2.35	2.19	2.20	2.24	2.22	2.21	2.19
Buyer type	1.68	1.70	1.67	1.65	1.66	1.67	1.68
Transaction number	.44	.30	.29	.35	.32	.32	.30
Age	-9.3532	-13.0249	-11.7209	-10.3767	-10.9917	-11.4748	-12.2492
Floor number	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Bedroom number dummy	.9448	.9145	.9292	.9558	.9436	.9367	.9232

Table 3 shows variables selected for the hedonic models in this research. It shows the selected aggregation period. We estimated the model in the earlier stage by using the whole set of 9766 transaction on single and double storey terrace house in Johor Bahru, Malaysia. Table 3 also contains the means of the independent and dependent variables used in the regression analyses for the overall sample. These samples are divided into several temporal aggregate. The distribution of means for each variable shows little variance between each according time aggregate. It simply determines the evenness of each variable after being sorted accordingly. It is significant in order to determine reliable comparability of the model of fitness (R squared) in the later discussion. If the numbers fluctuate noticeably for any of the variable, it might suggest the needs to revise the affected parameters.

CONCLUSION

Applying hedonic method in this study, by implying multiple regression analysis is crucial. In this paper, we have considered the aggregation of housing sales reported in continuous time to discrete periods for the computation of indexes of house prices. We solely consider hedonic regression method for this study. The analysis strongly suggests that house price estimates ought to be undertaken using the finest (smallest) disaggregation of time available. On statistical view, price indices based on quarterly aggregations dominate those based on annual data.

We strongly reinforce what has been discussed by Calhoun, Chinloy and Megbolugbe by using Johor Bahru data. However, our results also suggest that for a consistently defined period, the movement of R square do not differ much. We also extract the period into pairing years in order to understand the variations represented by different holding period. The implicit assumption of constant quality is difficult to verify. Furthermore, with small differences in variances across the aggregate periods, it is suggested for future study to consider only the later years, or maybe the last year of the database and focus more on the characteristics of that holding period only, rather than the whole set of data, where bias might exists in the earlier years. The three latest aggregations (annual) show high value of R square which indicate very good base of segmentation characteristics in terms of temporal effects or factors.

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