A MICRO LEVEL ANALYSIS OF RENT PREMIUM, PRICE DETERMINANTS AND SUBMARKETS USING HEDONIC MODEL

Ismail Ojetunde, Abass Sule Iyanda , Foluke Fabunmi & Sekinat AbdulKareem[1]

Abstract

The malleability of the urban housing markets is an indication that price equalisation in the housing market would not hold, to the extent that, reliable housing price measurement would be a difficult task. This paper which is exploratory in nature attempts to examine house prices at a micro level by employing hedonic pricing model to empirically uncover the rent premium and price determinants of Federal University of Technology (FUT) residential staff housing units. The results of the market-wide hedonic model reveal a pecuniary advantage in form of rent premium (₦87533) which tenants of FUT owned housing units benefit over tenants who are FUT staff but living in identical units in the free sector. By disaggregating house rental prices, the results of the hedonic model provide insights into the variables which are significant determinants of FUT residential quarters specific rental prices. This paper also provide evidence of a posit FUT owned residential submarket based on significant differential implicit prices which exist between FUT owned residential quarters and those properties which are occupied by FUT staff, but not owned by FUT. This result is considered appropriate as it is further reinforced by comparing the weighted standard error of FUT owned model with the standard error of market-wide model and assessing the significance of the reduction in standard error using chow test.

Key Words: Autocorrelation, FUT, Hedonic model, Implicit price, Rent premium, Submarkets.

Introduction

A fundamental feature of housing is its heterogeneity which implies that housing attributes cannot be unbundled and repackaged such as to allow consumers to consume the same selected set of housing attributes at any desired location (Redfarn, 2009). This heterogeneous nature of housing which ensures a wide spectrum of degrees of substitutability among dwellings for consumers, together with other special characteristics, such as the structural durability and the spatial immobility of housing stock result in the imperfect nature of housing market, to the extent that price equalisation (single price) and hence a unitary housing market cannot hold. The imperfection of housing market also brings along with it the issue of submarkets. Submarkets are derived from the concept of substitution, which means an increase in price of a commodity results in an increase in demand for another. Intuitively, it is the interaction between dwellings which are substitutes (distinct product groups for those demanding them) and distinct consumer groups with similar tastes, preferences, household compositions and income levels that brought about quasi independent submarkets with housing price differentials within the market process (Maclennan, 1992; Feitelson, 1993; Tu and Goldfinch, 1996; Tu, 2003).

Insofar price equalisation is elusive within the housing market, changes in housing price movements are bound to have far- reaching implications on consumers' spending and saving patterns, as changes in housing price across different housing market segments create self- reinforcing effects on demand and supply and then back to housing price itself (Stein, 1995; Ortalo- Magne and Rady 2004; Sing *et al.* 2006). As such, real estate market actors are bound to generate considerable interests in housing price trends and link them back to some explicate factors which shape and determine their consumption and investment behaviour. In a narrow sense, accurate measurement of housing prices is of considerable importance in view of the fact that the housing market is further fraught with infrequent trading at odd intervals, to such extent that home buyers and sellers as well as renters negotiating transaction prices and rents are faced with asymmetric information problem of the

1 Department of Estate Management, School of Entrepreneurship and Management Technology, Federal University of Technology, Minna. Nigeria.

current market value of the various housing services embodied in a house and by extension the house itself (See, Geltner, 1993 and Geltner *et al.*, 2007 for details).

In disaggregating house prices and more importantly, understanding the dynamics of housing markets, a pragmatic approach of determining house prices is the use of hedonic pricing model- by regressing both physical and location attributes of an area's housing stock to estimates the regression coefficients (the characteristic prices) which can be summed up to give its aggregate price. Although, this pricing model has its drawbacks which stem from its choice of functional form and selection of independent variables (Fletcher *et al.* 2000; Malpezzi, 2003; Martins-Filho and Bin, 2005), with proper specification it can provide a useful insight into aggregation of housing demand and reduces asymmetric information in the property market - an informational less efficient market.

This paper empirically uncovers the rent premium and specific price determinants of Federal University of Technology (FUT) Minna residential staff quarters using hedonic approach. Specifically, this paper employs the concept of submarket as a working hypothesis to test for the existence of any potential submarket based on overall variability in housing prices with a priori expectation that all FUT Minna staff who are renters are classified as a consumer group within the housing market. It is pertinent to state that most assertions and findings in this paper are based on quantitative analysis though complemented with some qualitative arguments from literature in other to answer the research objectives. The remainder of this paper is organised as follows: In section 2, a review of previous literature on hedonic model and housing submarket is considered. Section 3 provides a description of the data variables used in the analysis and their operational definitions as well as the methodology aspect of this study. In section 4 the empirical results are presented. Lastly, conclusions are drawn on the basis of these results.

Previous Literature on Hedonic Model and the Housing Submarkets

Several authors have employed diverse parameters such as structural and spatial characteristics of dwellings, demander groups and price to provide evidence for submarkets existence within the housing markets (Watkins 1999, 2001; Rothenberg *et al.* 1991).

With respect to structural dimensions, Allen *et al.* (1995) uncover the presence of distinctive rental submarkets in Clemson, USA, by calculating separately a hedonic regression for apartments, condominiums and single-family dwellings and later testing for null hypothesis of parameter equality in the hedonic coefficients of these three property types. (See also, Dale-Johnson, 1982 and Watkins, 1999 who explore this structural dimension theme with minor variant by using factor analysis to test the presence of submarkets). In Nigeria, Megbolugbe (1989) estimates hedonic regressions for 186 single and 1124 multi-family units in Jos housing market and concludes that the individual hedonic coefficients of only the multi-family units are statistically different from the full sample. Arguably, Megbolugbe study seemingly does not acknowledge this result in terms of submarket, and the relatively small sample size of the single family units affects the predictive accuracy of the regression model and the findings.

Munro (1986) delineates submarkets on the basis of spatial characteristics. He employs a priori knowledge of the Glasgow housing market to define submarkets north and south of river Clyde axis and also in the inner and outer areas of Glasgow suburban. Michaels and Smith, (1990) examine the value of not locating near negative externalities such as landfills containing hazardous wastes by allowing real estate agents influence to define the submarkets. In both studies, attribute prices of housing are found to be statistically different across submarkets. On the contrary, Ball and Kirwan (1977) application of census boundaries to define households having common characteristics into compartments could not provide any evidence of submarkets existence in Bristol, UK.

Adair *et al.* (1996) combine structural and spatial dimensions to operationalise submarkets in Belfast urban area of UK. They estimate hedonic prices for 9 submarkets on the basis of geographical dimension (planning subareas of inner, middle and outer city) and property type (terraced, semi detached and detached housing) and conclude that the hedonic coefficients of the variables which predict value are statistically different from zero across these 9 submarkets. Though Adair *et al.* analysis show evidence of disaggregation of housing prices into component parts based on property types, it can be criticised for its inability to compare the estimated hedonic price coefficients across the models.

Jones *et al.* (2005) analyse intra urban migration patterns by examining the level of self containment within the city of Glasgow to provide evidence of submarket existence. They observe that the nature of submarkets is reflected in over 50% of new buyers from outside Glasgow who are interested in only city centre properties and more than 65% buyers originating from within the city itself but interested in properties located in the south-west part of the city.

Palm (1978) stratifies submarkets based on information constraints and search costs. She argues that submarkets resulting from exchange of information through real estate agents are statistically different from those defined by economic and racial-ethnic characteristics. Gabriel (1984) also examines the Beer Sheva housing market in Israel and demonstrates that there is no equality in the hedonic price coefficients across the ethnic submarkets.

Buchel and Hoesli (1995) evolve a useful methodology to discern the effect of rent premium in the housing market by estimating hedonic price function (with rent as the regressand) to analyse the difference in rent between a subsidised and an unsubsidised unit. By replicating Marks (1984) and Fallis and Smith (1985) approach, the authors included a dummy variable to capture the difference in rent between subsidised and unsubsidised housing. The results show that the coefficient estimate for the dummy variable is significantly positive and that a tenant in a subsidised housing unit pays 15% less than a tenant residing in an identical unit in the unsubsidised sector of the housing market.

Although, Stigler and Sherwin (1986) mention that economic theory gives little guidance as to the consistent approach in defining submarkets, literature and empirical testings however suggest a standard procedure to test for existence of housing submarkets (See, Schnare and Struyk, 1976; Dale-Johnson, 1982; Rothenberg *et al.*, 1991; Watkins, 2001; Dunse *et al.*, 2002 for elaborate details) The procedure which was developed by Schnare and Struyk, (1976) is a three stage approach. It involves decomposing housing prices into segments by estimating hedonic price coefficients for each submarket and then comparing the submarket price for a hypothetical property. Secondly, chow test is calculated to determine the presence or otherwise of price equality in the submarket specific prices. Lastly, weighted standard error is estimated to test for price differential across submarkets and to compare the predictive accuracy of different housing price models in defining different housing submarkets.

Data and Method

Data were randomly selected from 223 academic and non academic staff of Federal University of Technology, Minna who are renters in FUT owned residential quarters including those who are renters in private properties geographically located in different neigbourhoods of Minna urban as at 2010. Among the 148 questionnaire returned from these 223 staff, 24 were dropped due to missing information. As a result, the empirical results of the hedonic models presented in this paper are based on 124 complete observations drawn from Staff of which 68 reside in flats, 47 in bungalows and 11 occupying tenements properties.

The data extracted from the academic and non- academic staff of the university provide three variant sets of information alongside the annual house rents: structural and property attributes of the houses such as the building condition, numbers of room, presence or absence of bathroom and garage; details of location attributes as varied as the plot size and age and lastly socio-economic and neighbourhood characteristics such as distance of place of work from residence, distance of residence to CBD, household size, income, crime level and the quality of neighbouhood. The list of these attributes (dependent variable and explanatory variables) incorporated into the hedonic models as well as their operational definitions are presented in table 1. For the purpose of this study, the characteristics (descriptive statistics) of the 124 residential properties where the staff reside are reported in table 2 along with the sample means, standard deviations and range.

Table 1: Data Variables and Operational Definitions

Data Variables	Operational Definitions
RENT	Annual House Rent in Naira
HOUSEHLDSIZE	Size of household living in a dwelling
INCOME	Income of FUT staff who are renters

NOOFROOM	Number of rooms in a dwelling
PLOTSIZE	Plot size measured in square metres (m^2)
PPTYAGE	Age of the property (years)
WORKDIST	Distance of dwelling to place of work in kilometres (km)
CBDDIST	Distance of dwelling to central business district in kilometres (km)
BLDCOND	Dummy equal to 1 if building condition is good; otherwise 0
CRIMELEVEL	Dummy equal to 1 if the level of crime is low; otherwise 0
NEIGQUAL	Dummy equal to 1 if the quality of neighbourhood is good; otherwise 0
PRESGARAGE	Dummy equal 1 if garage is present; otherwise 0
*NONFUTSAMPLE	Dummy equal 1 if the property is not FUT quarters ; otherwise 0

* Included as a dichotomous dummy variable to capture the rent premium (difference in rent) between FUT owned and Non FUT housing occupied by staff.

Summarily, the average house in the sample has a rent of about ₦87,000 and an approximate plot size of 306 square metres with 2.45 bedrooms and a mean age of 9.4 years old and is occupied by a household of 4.32 people. 55% of the residential properties have good building condition. In addition, 59% of all these residential units are located in good quality neighbourhoods with 50% having garage spaces.

Table 2: Summary Descriptive Statistics for the Dependent and Independent Variables

Variable	Mean	Standard deviation	Range	
			Minimum	Maximum
RENT	87403	48343.1	24000	250000
Structural Property Attributes				
NOOFROOM	2.45	0.87	1	4
BLDCOND	0.55	0.50	0	1
PRESGARAGE	0.50	0.50	0	1
Location Specific Variables				
PLOTSIZE	305.94	287.09	225	1800
PPTYAGE	9.41	5.89	4	22
Neighbourhood and Socio- Economic Characteristics				
HOUSEHLDSIZE	4.32	1.81	1	7
INCOME	557186	1099134	312000	6000000
WORKDIST	7.06	7.68	0	30
CBDDIST	6.85	5.11	0	18
CRIMELEVEL	0.57	0.50	0	1
NEIGQUAL	0.59	0.49	0	1
NONFUTSAMPLE	0.61	0.49	0	1
OBSERVATIONS	124			

For the purpose of analysis, the data were subjected to various statistical techniques which include: multivariate analysis (hedonic regression), F-Test and weighted standard error test. First, in estimating a parsimonious hedonic regression model, a linear functional form was employed so as to avoid specification bias[i]. Typical model specification to estimate the coefficients in the hedonic model using ordinary least square (OLS) method takes the following functional form:

$$R = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \qquad (1)$$

Where house rent is expressed as R, α is a constant term, $\beta_1 \ldots \beta_n$ is the regression coefficients for housing variables, $X_1 \ldots X_n$ and ε is the uncorrelated residual term.

Subsequently the coefficients parameters of the estimated hedonic models were subjected to chow test - a parameter stability test to determine whether there is structural change or equality in the implicit values of the estimated hedonic models (Gujarati, 2003 and Brooks, 2006). For this analysis, the intent of the chow test which is also known as F- test is to determine based on the hedonic model, whether significant statistical differences exist between the implicit prices of FUT residential quarters occupied by FUT staff and those properties occupied by FUT staff who are renters outside FUT residential quarters[ii]. The F-test is derived based on the formula:

$$F = \frac{RSS - (RSS_1 + RSS_2)}{RSS_1 + RSS_2} \times \frac{T - 2k}{k} \sim F[k, T - 2k] \qquad (2)$$

Where RSS = residual sum of squared for the full sample, RSS_1 = residual sum of squared for FUT owned staff quarters, RSS_2 = residual sum of squared for Non FUT owned properties, T = number of observations, 2k = number of coefficients estimated for the two unrestricted regressions, k = number of coefficients in each unrestricted regression.

Finally, standard error (SE) is computed to give a measure of the degree of uncertainty in the estimated values of the coefficients in the hedonic models (Brooks, 2008). By comparing the weighted standard errors of the restricted and unrestricted regressions, one can further test for price differential in the two subsamples relative to the overall variability in the house rents from the full sample. The formula for deriving the weighted standard error for each of the submarket model is as follows:

$$SE^{u} = \frac{(N_i - k_i - 1)}{(N - k - 1)} \times SE_i \qquad (3)$$

Where N_i is the number of observations in the ith submarket and k_1 is the number of explanatory variables in the ith submarket. N is the number of observations in the whole market (full sample) and k is the number of explanatory variables in the whole market equations. The ratio of the standard error for the restricted and unrestricted regressions will therefore follow an F distribution with $(N_i - k_i - 1)$ and $(N - k - 1)$ degrees of freedom. The empirical results of the hedonic models are considered in the next section.

Empirical Results

Before examining any pecuniary advantage in form of rent premium due to renters of FUT residential quarters, a cursory look at the fit of the market-wide hedonic model (Table 3) suggests that the R^2 value has a fairly explanatory power of over 52% of the variation in house rents. The adjusted R^2 of 0.472 is outside the 0.60 to 0.80 range provided in Rothenberg *et al* (1991) review, but consistent with those reported in Bourassa *et al.* (1999) study. The null hypothesis of positive autocorrelation in the residuals of the estimated hedonic equation is rejected at 5% level of significance (computed Durbin-Watson statistic of 1.70 exceed the lower critical value, d_L, 1.56)[iii]. Furthermore, following Johnston and DiNardo (1997), the Durbin-Watson statistic of 1.70 which is close to 2.00 suggests that there is no first order autocorrelation in the residuals of the estimated hedonic equation. The F-statistic of 10.18 implies that at 5% level the hedonic equation is statistically significant.

More importantly, the results of the market wide hedonic model for the rent premium which occupiers of FUT residential quarters would benefit if those units were exposed to the open market is garnered from table 3. The coefficient estimate for the dummy variable which captures the rent premium is significantly positive with a t-statistic of 6.170 and is equal to ₦ 87533. By extension, this signifies that staff who are renters (occupiers) of FUT owned residential quarters pay ₦ 87533 less than staff who are tenants outside FUT residential quarters.

Furthermore, at a disaggregated level, the results of the hedonic model generated in table 4 provide some insights into the nature of the variables which are influential determinants of FUT residential quarters specific rental prices. The significant determinants (as shown in column 3 of table 4) are: the number of rooms in a house (NOOFROOM), condition of the building (BLDCOND), presence of garage (PRESGARAGE), the property age (PPTYAGE), income of FUT staff who are renters (INCOME) and the crime level within the neighbourhood where these residential units are located (CRIMELEVEL).

Turning to the interpretation of the implicit rental price coefficient of the significant individual housing characteristics, the number of rooms coefficient of -8638 as indicated by the NOOFROOM variable suggests that, *cetris paribus,* one additional room will decrease the annual rental price of a standard FUT residential staff housing unit by ₦8638 based on year 2010 prices. This negative but significant relationship between the rental price and the number of rooms was expected as the marginal price of property should decrease with additional increase in the number of rooms. The coefficient of the dummy variable which measures the condition of the building is increasingly positive and adds almost ₦139,000 to the rental price of an identical FUT residential unit. This shows that high premium in terms of higher rental price is attached to property in good condition.

A striking but not surprising result is that a FUT residential staff unit without a garage space has a rental price that is ₦11400 greater than the rent of similar unit with a garage. This holds sway as most garage spaces are not put to functional use, with others converted or modified to other residential use as varied as additional bedroom, storage room and study room. The coefficient of the age of property shows that, holding all variables constant, age has a positive significant impact on rental price. This can be explained by the fact that greater capital expenditure on maintenance of the FUT staff residential units more than offset the loss in use value due to depreciation and obsolescence (See, Baum 1993).

Table 3: Market -Wide Hedonic Price Estimates for All FUT Staff (Full Sample)

Independent Variables	Coefficients	t- statistics
CONSTANT	-23373	-1.039
NOOFROOM	5084	1.246
BLDCOND	28905	3.481*
PRESGARAGE	21452	2.091*
PLOTSIZE	10	0.899
PPTYAGE	-509	-0.809
HOUSEHLDSIZE	938	0.496
INCOME	0.006	2.085*
WORKDIST	327	0.738
CBDDIST	-1726	-2.349*
CRIMELEVEL	7605	0.790
NEIGQUAL	29486	3.053*
**RENTPREMIUM	87533	6.170*

R^2	0.523
Adjusted R^2	0.472
Standard Error(SE)	35116.26
RSS	1.37E+11
Durbin-Watson	1.70
F-Statistic	10.18
No of Observations	124

Note: * denotes that the coefficient estimates are significant at 5% level of significance. RSS - Residual Sum of Squares. ** included as a dichotomous dummy variable to capture the rent premium (difference in rent) between FUT owned and Non FUT housing occupied by staff.

Table 4: Hedonic Models Price Estimates for the Two Sub-Samples

Variables	Non FUT Owned Subsample	FUT Owned Staff Quarters Subsample
	Coefficients	**Coefficients**
CONSTANT	61983	-67137.69
	(2.860)	(-2.253)
NOOFROOM	9454	-8638
	(1.588)**	(-1.809)**
BLDCOND	14962	138737
	(1.354)	(8.173)*
PRESGARAGE	17750	-11369
	(1.379)	(-0.677)**
PLOTSIZE	3.7	-18
	(14.950)	(-0.78)
PPTYAGE	-1171	1275
	(-1.161)	(1.762)**
HOUSEHLDSIZE	-1061	867
	(-0.377)	(0.590)
INCOME	0.014	0.006
	(2.534)*	(3.689)*
WORKDIST	336	-637
	(0.479)	(-1.853)
CBDDIST	-1871	1073
	(-1.698)**	(0.682)
CRIMELEVEL	17232	98740
	(1.254)	(6.210)*
NEIGQUAL	32248	-
	(2.765)*	
R^2	0.441	0.713
Adjusted R^2	0.345	0.646
Standard Error(SE)	41206.32	14111.76
RSS	1.09E+11	7.37E+09
Durbin-Watson	1.65	2.41
F-Statistic	4.61	9.21
No of Observations	76	48

Note: * denotes that the coefficient estimates are significant at 5% level and ** denotes a 10% level of significance. The t-statistic for the individual coefficient is reported in ( ). NEIGQUAL was removed from the analysis as it is found to be correlated with CRIMELEVEL.

Both income of staff who are renters or occupiers and low crime level are also positively related with rental prices of the housing units. The coefficient of the crime level which is captured by the CRIMELEVEL dummy means that a standard staff residential unit in a low crime neighbourhood commands a rental price of ₦ 99,000 more than an identical unit in a high crime neighbourhood. It is pertinent to state that the signs and magnitude of the implicit price determinants have consistency with those reported in Sirmans *et.al.* (2005) review of 125 empirical hedonic pricing studies.

Although it is beyond the scope of this paper to reflect on the coefficients of the Non-FUT owned subsample, a diagnostic check of the robustness of the two hedonic models show some interesting findings. The R^2 for FUT owned staff quarters hedonic model has high explanatory power by explaining 71.3% of the variance in housing rental prices [iv]. This is hypothesized to the impact of the building condition variable, which is positively significant with a large rental price coefficient (₦ 139,000). The null hypothesis of autocorrelation in the residuals of the estimated hedonic equation is also rejected at 5% level of significance since computed Durbin-Watson statistic of 2.41 is less than 4 minus the lower critical value, d_L, 1.02 (See, Johnston and DiNardo (1997) for review of the significant points of Durbin-Watson test). In addition, the low standard error of the model (14111.76) compared to the market-wide model (35116.26) implies that the level of statistical variability is reduced at the subsample level. In contrast, the lower $\mathbf{R^2}$ value of 0.441 and the standard error (41206.32) for Non-FUT owned hedonic model show some high level of variability in the subsample when compared with the market-wide model. Although such results are rather not unusual in studies which have employed cross-sectional data, as they are attributable to the differential rental price structure resulting from the different property types (tenements, bungalows and flats) in the subsample.

By replicating Schnare and Struyk, (1976) approach, the chow test for price equality in the coefficients of the two pooled subsamples provides evidence of submarket existence. To this, the null hypothesis of price equality between the subsamples implicit price coefficients is rejected at 5% level of significance on the basis that, the F-test statistic of 1.77 is greater, when compared with a 5%, F(12, 110). By extension, the result shows evidence of submarkets based on significant differential implicit prices which exist between FUT owned residential quarters and those properties which are occupied by FUT staff but not owned by FUT.

Lastly, the weighted standard errors reported in table 5 provide additional test for price differential for the FUT owned residential submarket. By comparing the weighted standard error of FUT owned model with the standard error of market-wide model, substantial percentage (87%) reduction in standard error is achieved. A further use of F-test to assess the significance of this reduction shows that the null hypothesis of overall difference in house rental prices is rejected, since this reduction in standard error exceeds a 5%, F(36, 111). This implies that there is enough reason to assume that the posited FUT owned residential submarket is appropriate (See, Goodman and Thibodeau, 1998; 2003).

Table 5: Weighted Standard Error for the Hedonic Regression Models

	Standard Error	**Percentage reduction in Standard Error** $\left[\frac{\Delta SE}{SE} \times 100\right]$
Restricted Market- Wide Model	35116.26	
Unrestricted FUT Owned Subsample Model	4576.78	87
Degree of Freedom	F(36, 111)	

Conclusion

This paper is an attempt to examine house prices at a micro level of analysis by employing hedonic models to empirically uncover the rent premium and price determinants of Federal University of Technology staff housing units. The paper further adopts the concept of submarket as a working hypothesis to test for the existence of a submarket based on a priori expectation that all FUT Minna staff who are tenants are classified as a consumer group within the housing market. The results of the market-wide hedonic model reveal a pecuniary advantage in form of rent premium (₦87533) which tenants of FUT owned housing units benefit over tenants living in identical units in the free sector.

At a disaggregated level, the key determinants of FUT residential quarters rental prices are: the number of rooms, condition of the buildings, presence of garage, the property age, income of FUT staff who are occupiers of the units and the crime level within the neighbourhood where these residential units are located. The findings further highlights based on the hedonic model, that the significant building condition variable but with large implicit price coefficient means that high premium- in terms of higher rental price- is attached to property in good condition.

Finally, the results provide evidence of submarket existence by replicating Schnare and Struyk, (1976) approach. The chow test for price equality in the coefficients of the two pooled subsamples shows that significant differential implicit prices exist between FUT owned residential quarters and those properties which are occupied by FUT staff, but not owned by FUT. This result of a posited FUT owned residential submarket is considered appropriate as it is further reinforced by comparing the weighted standard error of FUT owned model with the standard error of market-wide model and assessing the significance of the reduction in standard error using chow test.

NOTES

[i] The use of wrong functional form would constitute specification bias and affect the model results (DiPasquale and Wheaton, 1996)

[ii] The steps involved in the chow test are: Estimate regression for the full sample (all FUT staff who are renters) and for the two subsamples (renters in FUT owned staff quarters and Non FUT owned) separately. The residual sum of squares (RSS) is equally obtained for each regression. The full sample is the *restricted regression* since the restriction is that the price coefficients are equal across the subsamples. The *unrestricted regression* in this case is each of the subsamples as restriction has not been imposed on both. If there is price equality, then the residual sum of squares (RSS) of the unrestricted and the restricted regressions should not be statistically different. This can be derived based on F-Test viz; If the value of the F test statistic exceed the critical value from the F- table distribution, which is an $F[k, T-2k]$, then reject the null hypothesis of price equality and that the price coefficient of the subsamples are different.

[iii] Autocorrelation arises when the standard assumption of regression model- that the residuals or error terms are not correlated with other residuals- is violated.

[iv] It has been rightly observed by Eckert (1990) that higher value of R^2 than that reported in the market wide hedonic model suggests that higher levels of explanation are likely as the market level becomes more homogeneous.

References

Adair, A., Berry, J.N., and McGreal, W.S. (1996). Hedonic modelling, housing sub-markets and residential valuation, *Journal of Property Research*, 13(1), pp. 67–84.

Allen, M. T., Springer T .M, and Waller, N. G. (1995). Implicit pricing across residential submarkets. *Journal of Real Estate Finance and Economics*, 11(2), pp. 137- 151.

Ball, M., and Kirwan, R. (1977). Accessibility and supply constraints in the urban housing market. *Urban Studies*, 14, pp.11- 32.

Baum, A. (1993), Quality, depreciation and property performance. Journal *of Real Estate Research*,8 (4),pp 541-566.

Bourassa, S.C., Hamelink, F., Hoesli, M., and MacGregor, B.D. (1999). Defining housing submarkets. *Journal of Housing Economics*, 8, pp. 160-183.

Brooks, C. (2008). Introductory econometrics for finance. 2nd ed. New York: Cambridge University Press.

Buchel, S., and Hoesli, M. (1995) A hedonic analysis of rent and rental revenue in subsidised and unsubsidised housing sectors in Geneva. *Urban Studies*, 32(7), pp 1199-1213.

Eckert, J.K. (1990) *Property Appraisal and Assessment Administration*. International Association of Assessing Officers, Chicago.

Dale-Johnson, D. (1982). An alternative to housing market segmentation using hedonic price data. *Journal of Urban Economics*, 18, pp. 135-147.

DiPasquale, D., and Wheaton, W.C. (1996).*Urban economics and real estate markets*. USA: Prentice Hall.

Dunse, N., Leishman, C., and Watkins, C. (2002). Testing for the existence of office submarkets: A comparison of evidence from two cities. *Urban Studies* 39, 3, pp. 483–506.

Fallis, G., and Smith, L.B. (1985). Price effects of rent control on controlled and uncontrolled rental housing in Toronto: a hedonic index approach, *Canadian Journal of Economics*, 18, pp. 652-659.

Feitelson, E, (1993). An hierarchical approach to the segmentation of residential demand: theory and application. *Environment and Planning*, A 25, pp. 553-569.

Fletcher, M., Gallimore, P., and Mangan, J. (2000). Heteroskedasticity in hedonic house price model. *Journal of Property Research*, 17(2), pp.93–108.

Gabriel, S. (1984). A note on housing market segmentation in an Israeli development town. *Urban Studies* 21, pp. 189 – 194.

Geltner, D. (1993), Estimating market values from appraised value without assuming an efficient market. *Journal of Real Estate Research*, 8(3), pp.325-345.

Geltner, D., Miller, N. G., Clayton, J., and Eichholtz, P. (2007), *Commercial real estate analysis and investments*, 2nd ed.Thomson South-Western.

Goodman, A. C., and Thibodeau, T. G. (1998). Housing market segmentation. *Journal of Housing Economics*, 7, pp.121–143.

Goodman, A. C., and Thibodeau, T. G. (2003). Housing market segmentation and hedonic prediction accuracy. *Journal of Housing Economics*, 12, pp. 181-201.

Gujarati, D. N. (2003). Basic econometrics. 4th ed. New York: McGraw-Hill

Johnston, J., and DiNardo, J.E. (1997). *Econometric Methods*, 4th Edition, New York: McGraw-Hill.

Jones, C., Leishman, C., and Watkins, C. (2005) Housing market processes, urban housing submarkets and planning policy, *Town Planning Review*, 76, pp. 215–233.

Maclennan, D. (1992). Housing search and choice in a regional housing system: new housing in Strathclyde. *Report to the Housing Research Foundation*, Centre for Housing Research, University of Glasgow, Glasgow.

Malpezzi, S. (2003). Hedonic pricing models: a selective and applied review. In: T. O'Sullivan and K. Gibb, (eds). *Housing economics and public policy*. Oxford: Blackwell Publishing Limited. pp. 67-89.

Martins-Filho, C., and Bin, O. (2005). Estimation of hedonic price functions via additive nonparametric regression. *Empirical Economics*, 30(1), pp. 93-114.

Marks, D. (1984). The effect of rent control on the price of rental housing: an hedonic approach, *Land Economics*, 60, pp. 81-94.

Megbolugbe, I.F. (1989). A hedonic index model: the housing market of Jos. Urban Studies, pp. 486-494.

Michaels, R., and Smith V. K. (1990). Market segmentation and valuing amenities with hedonic models: the case of hazardous waste sites. *Journal of Urban Economics*, 28, pp. 223-242.

Miller, N., Spivey, J., and Florance, A. (2008). Does Green Pay Off? *University of San Diego Working Paper*, final draft version: July 12, 2008.

Munro, M. (1986). Testing for segmentation in the private housing market in Glasgow. *Centre for Housing Research,Discussion Paper 8*, University of Glasgow, Glasgow.

Ortalo-Magne, F., and Rady, S. (2004). Housing transactions and macroeconomic fluctuations: a case study of England and Wales. *Journal of Housing Economics* 13(4), pp. 287–303.

Palm, R. (1978). Spatial segmentation of the urban housing market. *Economic Geography*, 54, pp. 210- 221.

Redfearn, C.L. (2009). How informative are average effects? hedonic regression and amenity capitalization in complex urban housing markets. *Regional Science and Urban Economics*, 39, pp. 297–306.

Rothenberg, J., Galster, G., Butler, R. and Pitkin, J. (1991). *The Maze of Urban Housing Markets*. Chicago and London: University of Chicago Press.

Schnare, A., and Struyk, R. (1976). Segmentation in urban housing markets. *Journal of Urban Economics*,3, pp. 146 – 166.

Stigler, J., and Sherwin, R. (1986). The extent of the market. *The Journal of Law and Economics* 28, pp.555 – 585.

Sing, T.F., Tsai, I.C., and Chen, M.C. (2006). Price dynamics in public and private housing markets in Singapore. *Journal of Housing Economics*, 15, pp.305–320.

Sirmans, G.S., Macpherson, D.A., and Zietz, E.N. (2005). The composition of hedonic pricing models. *Journal of Real Estate Literature*,13(1), pp.1-44.

Stein, J.C. (1995). Prices and trading volume in the housing market: a model with down-payment effects. *Quarterly Journal of Economics*, 110, pp.379–406.

Tu, Y. (2003). Segmentation, adjustment and equilibrium. In: T. O'Sullivan and K. Gibb, eds. *Housing economics and public policy*. Oxford: Blackwell publishing pp-39-41.

Tu, Y., and Goldfinch, J. (1996). A two stage housing choice forecasting model. *Urban Studies*, 33(3), pp 517-537.

Watkins, C. (1999). Property valuation and the structure of urban housing markets. *Journal of Property Investment and Finance*, 17(2),pp.157- 175.

Watkins, C.A. (2001). The definition and identification of housing submarkets. *Environment and Planning* A, 33, pp. 2235–2253.