EVALUATING THE CONTRIBUTION OF INFRASTRUCTURE EFFECTS ON RESIDENTIAL PROPERTY

Naruson Romkaew
Post Graduate Student, RMIT
phai23@hotmail.com

This paper is based on a minor thesis completed in partial fulfillment of the requirements for a masters degree.

Abstract

Property value is dependent upon many characteristics associated with that property such as physical characteristics of property; location of the site in relation to employment centers and other recreational facilities (accessibility). In addition the social and economic characteristics of neighborhood, including the presence of such amenities as view, parks, schools and community services affect value. Those attributes are usually provided by the State and Local governments through their various policies and services. Thus property price will be suburb (or locational) dependent due to the attributes with respect to specific desirable services.

This paper is concerned with the effect of the established infrastructure as well as social and culture services on property values in Camberwell.

The results of analysis indicates that the presence of physical attributes of property and transportation are important housing attributes in determining price. This suggests that different attributes are valued differently when combined with other attributes. Key locational factors are fundamental in the determination on house prices.

EVALUATING THE CONTRIBUTION OF INFRASTRUCTURE EFFECTS ON RESIDENTIAL PROPERTY

Introduction

Property is a multidimensional product. The number and nature of influences on the perceived value of property are large and various. The value of property in an urban area is strongly effected by location.

Physical location refers to the position of one site relative to that of another. The term physical location is often used interchangeably with proximity and accessibility (Fanning and Stephen, 1994). Location influences on the value of residential property may arise from any number of sources, such as accessibility to shopping centre, educational and leisure facilities.

Pollakowski (1982) indicates that house prices are not determined only by accessibility but also by the environmental attributes of the location. The environmental factors, such as neighbourhood amenity, parks, and levels of neighbourhood security have to be taken into account. Moreover, the analyzed location is also relevant to the overall urban structure. To consolidate urban structure and the cost of providing urban infrastructure, existing infrastructure is more effectively utilised in the built-up urban areas. The infrastructure includes services such as sewerage and drains, roads, and public transport, as well as social infrastructure such as health care facilities, education facilities and other community services. These attributes are usually provided by the State government and by the municipal council through its' policies and services.

The effects and influence of those factors exert a complex interaction that will affect the value of properties. This leads to households that will respond to differential public service levels by migrating between communities to meet their needs.

In Australia sale prices of properties vary for different suburbs due to the attributes. For people who live in Melbourne, location decisions may be influenced by the balancing of desires and the environments. Therefore, location is discussed as a key influence in explaining house price dynamics.

The suburb of Camberwell was chosen to evaluate the effect of established infrastructure and locational amenities on property values.

Purpose and Setting

The aim of this research is to investigate the effect of established infrastructure as well as social and culture services on property values in Camberwell.

This will be achieved by looking at the demographic relationship and structure in Camberwell and the critical drivers of development of the infrastructure plans for the future. This will affect the price gradient of the residential property and type of housing required in the area.

To assess the affects of this, a hedonic analysis will be used to investigate the relationship between established infrastructure and social services on the house prices.

A brief overview of the relevant literature is provided in the Section II. The next section describes the overview of the Camberwell profile and infrastructure expenditure within the area, followed by a discussion of methodology and an analysis of the result and interpretation. The last section is the summary and conclusions.

II REVIEW THE RELEVANT LITERATURE

The effects of neighborhood and location factors on the value of properties have been systematically examined by a number of researchers. For instance, *Modelling The Influence of Location on Value* (Gallimore, *et al*, 1996); *Empirical Study of the Relationship between Residential Lot Price, Size and View* (Marvin, 1997); and *The Value Impact of New Residential Construction and Neighbourhood Disinvestment on Residential Sales Price* (Simons, Quercia, and Maric, 1998) have been analyzed. It is generally accepted that locational housing choice is largely the result of the effects of various neighborhood and government externalities on households.

Methods

In general, hedonic price methodology has been used to assess the effect of variations in housing characteristics that may influence price changes during the sample period.

Hedonic price analysis is a technique in which the values of independent variables are determined implicitly through regression analysis. Hedonic regression analysis is a statistical technique, which may be applied to a series of property values, together with their associated characteristics, to identify and quantify the significant determinants of value (Neil and Colin, 1998)

Goodman (1978) states “A general hedonic form of analysis may be expressed as a function of housing in a given sub-market at a given time”.

These hedonic prices are not necessarily long run equilibrium supply prices, in other words market prices may not have been stable throughout the time period of the study. However, a set of market prices reflects the composition and location of existing of

residences and the neighbourhood component. Therefore, hedonic analysis has been widely applied to housing market analysis and has become a well-established technique.

The current analysis involves a dependent variable (House price) and several independent variables (such as physical attributes of a property and locational influences). Property values consist of a bundle of attributes, each of which is integral to house prices. Each property owner is assumed to derive value directly from the property characteristics.

The physical attributes and locational influences may be described as "the fundamental factors" of property value, in that all individuals receive utility or disutility from these influences over their entire expected tenure (Norman, G.M., 1982).

Physical attributes may be described as building area, type of structure and so on. Locational influences pertain to off- site neighborhood attributes such as parks, health care facilities and so on.

A problem associated with the application of the ordinary least squares technique is generally a violation of one or more of the classical assumptions[1]. Moreover, with hedonic modeling methods, problems include variable selection, functional form, the instability of housing characteristic coefficients over time and sample selection bias (Marvin L.W. and Jimmy S., 2000).

Property value structure has been much subjected to hedonic analysis. Work by John (1998) collected the data on the transaction prices value, which were based on valuations by professional valuers and advertised asking prices. If sufficient data is to be assembled then transaction prices spanning significant periods have to be used.

A study of the influence of transport on house prices was examined by So *et al.* (1997). He notes that the major risk of using hedonic price regression is the presence of the multicollinearity between housing attributes and the consequent instability of estimates.

Another study by Marvin (1997) studied the sales of 56 residential, mountainside view lots located in Tucson, Arizona, occurring over the 1989 to 1991 period. He used the data that was restricted to a relatively small geographic area with little variation in household income to investigate the relationship between residential lot price, and the amount of view amenity and lot size. All the sale properties were located within the same public school area, and were subject to the same government jurisdiction, property tax rates, and were equally distant from major employment nodes. This suggests that the character and quality of the data, which underpinned the hedonic analyses varied markedly.

A study by James, R. L. and Wesley, H. J. (1979) analyzed that the use of proxy measures of neighborhood amenities may degrade the accuracy of hedonic valuation models. The result showed that direct subjective measures yield only modest improvements in price prediction. Careful use of proxy measures for neighborhood

[1]The classical assumptions are described in Flaherty, et al., pp. 319-321.

amenities appears to be too costly for efficient large-scale appraisal work. However, the use of proxy variables provides valuable additional information in the absence of data obtained by direct measurement.

Results

Many researchers suggest that the characteristics of the local neighborhood, transport system and environment quality be of great importance in the determination of residential property prices. Sirman (1994) analyze sale of 194 residential properties in Fairfax County, Virginia, occurring over the 1985 to 1991 time period. He found that homes with good views sold for prices approximately 8 per cent more than homes without views. However, there is no attempt to account for differing types or qualities of views.

A study by John (1998) examined how new transport infrastructure influenced property values in the South Yorkshire (UK). John found that anticipation of the construction of a super tram acted to reduce house prices. This is possibly because of expectations of disruption during the building of the system. However, on completion of the super tram, the negative impact has disappeared. Moreover, this study has also shown that the type of neighborhood was a major influence on house price, which was statistically significant at a rate less than 1 percent.

Further evidence on the influence of infrastructure and environmental attributes is provided by So *et al.* (1997). They demonstrate that the presences of shopping centers and sports facilities are important factors in determining house prices. However, the most striking feature of the results of this research is that the coefficient, probably indicating that park are highly valued as a part of the environmental quality. In this case, accessibility to transport is an important determinant of house prices, based on residential income class in Hong Kong.

With similar approach, Simons, Quercia and Maric (1998) in the study of value impact of new residential construction and neighborhood disinvestment on residential sales price also found that the neighborhood variables included demographic, locational and economic attributes have the expected sign and are statistically significant.

On the other hand, Chau and Ng (1998) found evidence to suggest that constructed public transport such as a railway line may have negative effect on the prices of some residential property. They assessed the net change in the price gradient before and after the improvement in public transportation.

This was apparent for a house located along a railway line in Hong Kong and transaction prices were affected at varying distances from the railway line. When the railway line was completed the property prices actually improved provided they were not located on the railway line. This is because there was no precedence for people to judge the full effect accurately of the proposed construction. When the railway line became fully functional and the staff familiar with the smooth operation of the system, relative prices in the area near the railway station remained stable. However, their study do not indicate

how widespread the changes are in relative prices in the area near the railway station since only one building has been from each location.

III FACTORS INFLUENCING RESIDENTIAL PROPERTY VALUE

The house price is not only determined by the demand for the attributes of the dwelling units themselves, but also the area in which the properties are located. Location is the time-distance relationships, or linkages, between a property or neighborhood and all other possible origins and destinations of people going to or coming from the property or neighborhood. In other words, location is the relationship between the property and its surroundings.

Harold, W. E., and Leonard, V. Z. (1991) suggest that more distant locations may have more attractive features and amenities, despite their longer commute. Usually, all neighborhood properties have the same or highly similar locational relationships with common origins and destination.

The neighborhood is influenced by the surrounding community or metropolitan area. Each suburb responds to its own local demands for urban space. Many metropolitan areas include upper income households and they tend to live outside the center of the city, while lower income families continue to reside in the cities, close to employment centers. However in Melbourne a trend seems to be occurring where by lower income families are now living further away from the city center and the city is increasingly in demand with new expensive apartments being constructed.

To analyze the impact of location in a neighborhood, the valuer must identify the important linkages and measure their time-distances or distance to and from properties (Fanning and Stephen, 1994). The linkage relationship such as the movement between, or proximity of, associated activities may be judged in terms of how well they serve the typical users of real estate in the neighborhood. For instance, single family residential neighborhoods, linkages with schools, grocery stores, and employment centers are usually the most important. Therefore, it is to identify and discuss neighborhood conditions and trends that enhance or detract from property values.

Public transportation is crucial for the numerous people who do not own cars or prefer not to use them during the day or week. Distance from public transportation is considered in relation to the people who are to be served by it.

For instance, urban apartment residents usually prefer to be within convenient walking distance of public transportation. Several studies on the relationship between transportation and property values can be found such as in the study by Chau (1998), the effects of improvement in public transportation capacity on a residential price gradient in Hong Kong and the study by John (1998), Transport investment and house prices.

On the other hand, income levels, profitability of business, inflation and interest rates are also important factors in determining general level of value at any given point in time (Gallimore, Fletcher and Carter, 1996). Households, which have the same tastes and income, tend to live within the same area. Therefore, the factors such as the size of households, their age, income and education levels and the availability and cost of mortgage financing have to be incorporated in affecting the types of housing and the values. High-income residents will seek out a part of city that may offer leisure facilities, parks, amenities and the most convenient form of transportation and infrastructure. This also reveals that the proximate and relevant influences on the property are related to the same influences operating on other properties in the neighborhood.

Moreover, social considerations in neighborhood analysis involve characteristics of neighborhood occupants. They may affect real estate value. Relevant characteristics may be the availability and quality of services, including recreation facilities and shopping. Residents are attracted to a location because of status, physical environment, and availability of services, affordability, and convenience. However, residential groups generally socialize with those of a similar educational, cultural or social level.

The important social characteristics include;

- Quality of educational, social, recreational, cultural and commercial services.
- Community or neighbourhood organisations (e.g. neighbourhood watching area).
- Occupant age levels, particularly important in residential neighbourhoods.

In addition, it is difficult to attempt to relate the preferences to an effect on property values. An appraiser should not place too much reliance on social influences when arriving at a value conclusion. Mann (1982) analyzed the effects in the housing values of altering school boundaries in an urban area. He found that changing the school boundaries associated with a house affected the value of the house. This finding of Mann (1982) may not be so applicable to the Melbourne housing markets.

Another consideration is to environmental attributes that consist of any natural or man-made features that are contained in or affect the neighborhood and the neighborhood's graphic location. The important environmental considerations include open space, nuisances, hazards emanating from nearby facilities such as shopping centers, factories, and schools; adequacy of public utilities such as street lights, sewers and electricity; general maintenance; street pattern, width, and maintenance. An excessive volume of vehicular traffic or odours, dusts, and noises from commercial or manufacturing enterprises restrict a residential neighbourhood's desirability.

IV PROFILE OF CAMBERWELL

The chosen study area is Camberwell. The suburb of Camberwell is within the City of Boroondara, which is located, approximately 8 kms from the CBD of Melbourne.

Exhibit 1. Camberwell Region Map

The area is well preserved with numerous examples of Victorian, Edwardian and interwar architecture and the infrastructure is highly developed. There is an abundance of gardens, park and open spaces. The suburb has a high concentration of educational institutions allowing for a large choice of primary and secondary institutions within the area. There are numerous prestigious schools within the area. Residents have access to key shopping and commercial centres at Camberwell junction as well as neighbourhood shopping areas. This area also offers extensive community facilities to residents.

Demographic Content

According to a local statistic sheet, produced by the Department of Infrastructure, in January 2000, the population size was 14,826. The City of Camberwell is an affluent suburb. Income levels in the City of Boroondara area are amongst the highest in the State. Boroondara City recorded the highest median income ($401), extracted from the ABS web-site, 1996 Census of Population and Housing.

Exhibit 2. Nature of Occupancy (Top 3)

Nature of Occupancy	Camberwell	Melbourne
Fully Owned	1	1
Purchasing	2	2
Rented	3	3

Source: APM Web-site, Australian Postcode Snapshot, at 9 November,2000

Exhibit 3. Type of Dwelling (Top 3)

Type of Dwelling	Camberwell	Melbourne
Separate House	1	1
Flat	2	2
Semi/Terrace	3	3

Source: APM Web-site, Australian Postcode Snapshot, at 9 November,2000

As can be seen from exhibit 2 and 3, the number and composition of household sizes in Camberwell average 2.62 per household and most residents own their own home. Separate houses followed by flats or apartments, and Semi/Terrace house; respectively dominate Camberwell's housing.

House prices in Camberwell have risen steadily and the medium price is now $446,000. This median price figure is based on auctions and private sales of houses reported to the REIV. The median price is obtained by listing a suburb's sales from highest to lowest value, and choosing the middle figure. These statistics help to confirm that Camberwell is an affluent suburb with a strong demand for housing.

In addition the statistics confirm a profile of a well-educated residents with a high proportion of people with bachelor or higher degree qualifications. The Camberwell workforce is mainly in "white-collar" jobs and has a few residents working as trade-persons, labourers or in the clerical and sales and services. This is consistent with its household income level. "Upwardly mobile" people live in Camberwell and there is a continuing demand of new residents, seeking the lifestyle it has to offer.

Exhibit 4. Family Statistics (Top 5)

Family Statistics	Camberwell	Melbourne
Couple with Kids	1	1
Lone Person	2	2
Couple No Kids	3	3
Single Parent	4	4
Group	5	5

Source: APM Web-site, Australian Postcode Snapshot, at 9 November,2000

Camberwell has also a significantly different household and family structure. As can be seen from exhibit 4, there are substantial numbers of family households with children and single person households. The family households usually have children that use the local pre-school, primary and secondary school facilities and other infrastructure within the suburb.

Camberwell has good access to public transport facilities several tram routes to the CBD and other areas throughout Melbourne. The Camberwell railway station was one of the first railway stations established in Melbourne and express trains run regularly to the CBD and many of the residents use theses services to go to work and school.

Infrastructure Expenditure

In general, the local government is committed to providing both residents and businesses with the highest standard of services and a quality managed natural environment. Many services are provided by council, such as aged care, economic development, waste collection, urban planning and neighborhood amenity, gardens, the provision of recreation centres, maintaining drains, the upkeep of some roads and the libraries services. It is the quality of these services and the environment around the area that makes living in Camberwell so enjoyable. Furthermore, the implementation of public policy in the local area will generate relative price changes in property.

Rate revenue helps fund the services that council provides, and is the major source of funds for the council's budget. Under State rating guidelines, Councils charge ratepayers equitably by using residential and commercial property values to distribute rate charges. The Rate bill is calculated by multiplying the rate in dollar (which is set by Council) by the annual value of property. The value of properties is calculated by analysing recent sales and leasing in surrounding areas, and takes into account the individual characteristics of each property.

Total budget expenditure in City of Boroondara in 2000/2001 is $90.82 million. Capital works accounts for about 17 per cent of the total expenditure in budget 2000, or nearly $13 million. More than $2.1 million will be spent on community facilities, $3.8 million on infrastructure and $4.9 million on municipal operations.

Other significant projects outside capital works programs include $1.5 million for cultural activities, $5.3 million for park maintenance and horticultural services, $1.6million for street and amenity cleaning, $1.2 million for health promotion and protection, $900,000 for maternal, child and health services and $890,000 for youth and specialist services.

These services will protect and improve natural environs and enjoyment of community life in Camberwell and sustains the civic environment and infrastructure. A budget for a city of nearly 100 million dollars is most substantial and not all municipalities would enjoy this level of infrastructure and service.

Exhibit 5. Total Budgeted Sources of Income 2000/2001

V MEASUREMENT OF HOUSE PRICE IN CAMBERWELL

The Study Area and Data

The data used in this research was obtained from the Valuation Department at the City of Boroondara in Camberwell. This research is based on actual transaction prices and adequate descriptions of property characteristics, which are relating to the sale of 192 houses. The sample data included all of the houses sold for the period January 1999 to May 2000 within Camberwell, which is often referred to as an inner-eastern suburb.

Data collection and recording was carried by using spreadsheets to satisfy the database requirements and simplify the statistical analysis. However, gathering of the data has proved to be difficult due to insufficient information in recording relevant details at the Valuation Department.

Exhibit 6. Descriptive Statistics

Descriptive statistic of selling price	
Mean	500971.7
Standard Error	15073.46
Median	450000
Mode	310000
Standard Deviation	208319.3
Sample Variance	4.34E+10
Kurtosis	8.598383
Skewness	2.394908
Range	1432500
Minimum	190000
Maximum	1622500
Sum	96185600
Count	192
Confidence Level(95.0%)	29732.85

The transaction range is from $190,000 to $1,622,500. The median house price is $450,000. The first and third quartile values are $370,00 and $586,000 respectively. The standard deviation is $208,319, indicating a relatively large spread of prices. When expressed as a coefficient of variation (Std dev/mean), 0.42, it can be seen that there is a very large range in the variance of the selling prices. The skewness and kurtosis for these distributions confirm both positive skewness and kurtosis in the distribution of selling prices. This would conclude that few properties sold at very high prices and most sales were concentrated about the median price. However, an important issue in using

transaction data is the structure of the data and the characteristics of the variables available for analysis.

Methodology and Variable Definitions

The model assumes that house prices may be described by an equation of the form:

Selling price = f (Building area, Age, Construction, Garage, Swimming Pool, distance to major shopping center, distance to schools, distance to parks, distance to tram stop, distance to train station)

Six types of physical characteristics of the property variables were used which include age of building, building area, garage, swimming pool, types of construction, and number of bedrooms. Type of construction had a large number of alternatives, which were typically difficult to rank in any particular order due to the number of choices. Type of construction was grouped into non-brick construction and brick construction.

The locational amenities, including locally provided public services, are alike for families within geographically distinct locations. Many locational amenities are difficult to quantify. In this research locational amenities were measured by distance in meters to the nearest park, educational institution and transport.

There are 3 types of property variables chosen and these were:
- the physical character of the property
- the neighborhood amenities
- the location of the property relative to the transport infrastructure.

The exhibit 7 presents the exact definitions of variables, along with a more detailed description of the variables employed.

Exhibit 7. List of Variables and their Definitions

Short	Explanatory variables	Definition of variables
Age.	Age of Building (+)	Number of years since the house was constructed.
Area.	Building Area (+)	Total number of square meters in the house.
Garage.	Garage (+)	Number of parking spaces available in the garage.
Pool.	Swimming Pool (+)	1, if property has an in-ground pool, or 0, otherwise
Const.	Type of Construction (+)	0 or 1 variable indicating whether the construction is non-brick (1) or brick (0)

BedRm.	Number of Bedroom (+)	Number of bedrooms in the house
Dist_Sh.	Distance to Major shopping center (-)	Distances in meters to closest major shopping center.
Dist_Edu.	Distance to education (+)	Distances in meters to closest educational institution regardless of size, small or large.
Dist_Pk.	Distance to park & leisure (+) facilities	Distances in meters to closest leisure facilities
Dist_Tm	Distance to tram stop (+)	Distances in meters to tram stop.
Dist_Tr	Distance to Train station (+)	Distances in meters to train station.

The variables and their values are listed in Exhibit 8.

Exhibit 8 List of Variables with their Means and Ranges

NAME	MEAN	ST. DEV	VAR	MIN	MAX
AGE	61.167	29.985	899.11	1	120
AREA	175.36	64.835	4203.6	84	398
GARAGE	1.2396	0.61	0.37162	0	2
POOL	0.11458	0.32	0.10199	0	1
CONST	0.33854	0.47	0.2251	0	1
BEDRM	3.1979	0.80	0.64125	2	5
DIST_SH	1708.5	1010.40	1.02E+06	0	4300
DIST_EDU	729.53	375.11	1.41E+05	0	1500
DIST_Pk	391.92	256.40	65743.0	0	1300
DIST_TM	343.93	270.10	72953.0	0	1250
DIST_TR	996.12	626.03	3.92E+05	0	2900

From the outset it was expected that building area or size of the property would be the most dominant variable in the explanation of the expected price of the property. Price should be positively associated with building area, garage, and swimming pool. Furthermore, there was an expectation that all neighbourhood variables and transportation variable would contribute positively to price. Expected signs for variables, which are consistent with expectations, are presented in exhibit 7.

Non-brick construction is expected to have a negative sign. Brick, the preferred construction, is defined as a house with two layers of brick or brick veneer. Brick construction also tends to serve as a proxy for other non-measured price-affecting variables such as, how modern is the house.

Some of the variables selected will have more impact upon property values than other variables.

The key variables selected are:

- Age of building
- Building area
- Number of Bedrooms
- Distance to tram and train

Before the data can be adequately used to justify the prediction of values. A number of tests must be carried out to ensure that the regression equation is consistent with the underlying theory. Multicollinearity and heteroskedasticity are common problems with this type of data.

Multicollinearity occurs when independent variables are closely correlated with each other or some variables duplicate the information contained in other variables. Building size and number of bedrooms is a prime example. Many studies into housing markets display this problem and it is particularly problematic when attempting to explain the determinants price. If severe multicollinearity exists the model is likely to be seriously distorted. Therefore, when deciding which variables to include in the model, care must be taken to minimize this problem.

Heteroskedasticity is present when the error variance is not constant. This could arise if the dependent variable is functionally related to one of the explanatory variables. It often occurs in data sets having a wide disparity between the largest and smallest observations. The choice of variables to include in the equation is tempered by consideration for these problems (Renwick and Flaherty, 1996).

Several diagnostic tests were performed on the data, including univariate analysis and functional form, influential outliers, multicollinearity and scatter plots for heteroskedasticity. Where necessary, the appropriate action was carried out.

Result and Interpretations

This section presents the overall results of the models, and reports the findings concerning physical attributes, neighborhood attributes, and transports infrastructure attributes. The inclusion of all variables in the regression to begin with produced the results given in exhibit 9.

Exhibit 9. Regression Equation Containing All Variables

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 180 DF	P-VALUE	PARTIAL CORR.	STANDARDIZED COEFFICIENT	VIF
AGE	1377.5	317.1	4.344	0.000	.308	.1988	1.466418
AREA	2125.5	203.1	10.46	0.000	.615	.6632	2.814400
GARAGE	24462.	0.1682E+05	1.454	.148	.108	.0718	1.707849
POOL	61594.	0.2767E+05	2.226	.027	.164	.0947	1.266305
CONST	9995.9	0.2008E+05	.4978	.619	.037	.0228	1.481434
BEDRM	35959.	0.1447E+05	2.486	.014	.182	.1386	2.190075
DIST_SH	-26.346	9.763	-2.699	.008	-.197	-.1281	1.592498
DIST_EDU	27.183	22.15	1.227	.221	.091	.0491	1.124145

```
DIST_Pk     41.887       32.94        1.272       .205  .094       .0517      1.155182
DIST_TM     46.195       32.93        1.403       .162  .104       .0601      1.272719
DIST_TR     .63241       13.61      0.4645E-01    .963  .003       .0019      1.177300
CONSTANT -0.11957E+06 0.5425E+05   -2.204        .029 -.162      -.0000

R-SQUARE =    .7430     R-SQUARE ADJUSTED =    .7273
VARIANCE OF THE ESTIMATE-SIGMA**2 =  0.11774E+11
STANDARD ERROR OF THE ESTIMATE-SIGMA =  0.10851E+06
SUM OF SQUARED ERRORS-SSE=  0.21193E+13
F- STAT = 47.016
MEAN OF DEPENDENT VARIABLE =  0.50091E+06
LOG OF THE LIKELIHOOD FUNCTION = -2492.40
```

A number of Regression analysis were undertaken with the data from the Valuer's Department in the City of Boroondara. After careful analysis of these models Model 1 was undertaken with all eleven variables. Model 1 has a slightly superior adjusted R^2 value, explaining approximately 73% of variation in the sale price (Y), and a very acceptable F-statistic of 47.01.

These measures enable a statistical judgement to be made of the quality and relevance of the model. It is equally important that its structure should appear to make intuitive sense as a representation of the influences on price, although, as explained below, interpretation of this must be performed with caution. In addition, it is necessary to test for the presence of multicollinearity. Evidence of multicollinearity may be identified by examination of the pairwaise correlation matrix given in exhibit 10.

Exhibit 10. Correlation Matrix

								Distance to:			
	Price	Age	B.area	Garage	Pool	Const	BedRm	Shop	Edu	Lei	Tram
Price	1										
Age	0.023	1									
B.area	0.795	-0.273	1								
Garage	0.465	-0.366	0.56	1							
Pool	0.445	0.07	0.396	0.208	1						
Const.	-0.305	0.296	-0.397	-0.391	-0.154	1					
BedRm.	0.668	-0.055	**0.697**	0.449	0.259	-0.315	1				
Dist_Sh	-0.326	-0.143	-0.209	-0.108	-0.145	0.319	-0.264	1			
Dist_Edu	-0.032	-0.034	-0.12	0	0.016	-0.018	-0.118	-0.021	1		
Dist_Pk	0.222	0.121	0.102	0.113	0.092	-0.165	0.175	-0.243	0.161	1	
Dist_Tm	-0.018	0.045	-0.069	0.042	0.053	0.19	-0.106	0.385	0.119	0.011	1
Dist_Tr	-0.046	-0.091	0.042	-0.012	-0.041	-0.031	-0.089	0.278	-0.191	-0.121	0.046

The correlation matrix contains one value that is relatively large (close to 1 or –1).

$$\text{CORR}\ (X_2, X_6) = 0.697$$

The high positive correlation between building area and number of bedrooms is to be expected as the larger the building area the more rooms. However, a value of 0.697 is unlikely to give rise to severe multicollinearity. It is also due to its theoretical importance, and these variables have a highly significant t-ratio suggesting that it is

important in the equation. Therefore, these results do not suggest that the use of any of the independent variables will result in significant multicollinearity.

In addition, a more reliable method of identifying the presence of multicollinearity is by means of the variance inflation factor (VIF). The VIF- value is a measure of the linear dependence between a particular predictor and all other predictors. The results, appearing in the rihht hand column of Exhibit 9, are consistent with the correlation matrix, multicollinearity is unlikely to pesent a problem.

The Breush-Pegan statistic is employed to test for the presence of heteroscedasticity. It is to test for the possibility that more than one proportionality factor is involved simultaneously. The computed value from Breush-Pegan test (164.23) is greater than the critical value from the Chi-square distribution, indicating that heteroscedasticity is present.

Heteroscedasticity distorts the standard errors of the coefficients rendering t-tests invalid. Some of the t-ratios in Model 1 indicates that some variables are insignificant (Type of Construction and Distance to Train Station).

For instance, the coefficient for X_5 (type of construction) is insignificant, compared with the others. This indicates that there is a slight effect associated with selling price. The t-ratio for X_5 is also insignificant (-0.0464). It is reasonable to exclude type of construction variable from the model.

The best model for the hedonic equation is provided in Exhibit 11. *White's Heteroscedasticity Consistent Covariance Matrix*[2] is used to obtain the correct estimates of the standard errors. Model 4 (Exhibit 11) excludes construction type, garage, swimming pool, Distance to parks, Distance to educational institution and Distance to train stop variables.

Exhibit 11 Regression Equations - Model 4

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 186 DF	PARTIAL P-VALUE	CORR.	STANDARDIZED COEFFICIENT
AGE	1402.3	425.8	3.293	.001	.235	.2024
AREA	2322.0	388.3	5.980	0.000	.402	.7246
BEDRM	38149.	0.2029E+05	1.880	.062	.137	.1470
DIST_SH	-31.201	7.909	-3.945	0.000	-.278	-.1517
DIST_TM	72.205	31.26	2.309	.022	.167	.0939
CONSTANT	-85570.	0.5981E+05	-1.431	.154	-.104	-.0000

R-SQUARE = .7260 R-SQUARE ADJUSTED = .7186
VARIANCE OF THE ESTIMATE-SIGMA**2 = 0.12147E+11
STANDARD ERROR OF THE ESTIMATE-SIGMA = 0.11021E+06
SUM OF SQUARED ERRORS-SSE= 0.22593E+13

[2] White, H., 1980, "A heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct test for Heteroskedasticity", ***Econometrica***, Vol. 48, pp.817-838.

```
F-STAT = 97.623
MEAN OF DEPENDENT VARIABLE =  0.50091E+06
LOG OF THE LIKELIHOOD FUNCTION = -2498.54
```

Coefficient signs are as expected in the Model 4. The F-statistic provides us with a determination of the significance of the model. It is interesting to note the value of the F-statistic in this Model (97.623) it is greater than Model 1 (47.016) and this is due to the large number of degree of freedom associated with this Model. A higher T-stat is preferred as shown in the Model so that Model 4 becomes the preferred Model.

The chosen model – Model 4 has a reduction in the variables that has not significantly reduced the explanatory power of the Model. The Adjusted R- Square has decreased a little, explaining 72 per cent of variation in property values. It was decided that a number of variables were found to be insignificant and were disregarded from the best model. In this model all variables are significant at the 95 per cent level and they have plausible signs and magnitudes.

The coefficients of the variables generated in the hedonic model represent an implicit value of buying that attribute which is not included in the constant term. In this study the constant term represents the amount of "fixed costs", on average. Those costs correspond to those expenses, such as stamp duty and registration fees.

An examination of the regression coefficients in the model 4 emphasizes the importance that age of building, building area and number of bedrooms have in explaining the variation in property values. The technique enables one to quantify the variation.

The positive sign on the age of building coefficient is consistent with expectations for Camberwell, a suburb where period architecture is valued. It means that the older a house is the higher will be the price. In this case prices of old houses may be higher than those of new houses. This may be because the older houses are likely to be in better condition when they are sold and this may also indicate some people desire to live in period homes. Victorian and Edwardian style homes are stolidly constructed and offer attractive period features that are increasingly in demand. It can also reflect the feeling of richness.

The Garages variable has been excluded from the Model as it may not significantly affect the selling prices of houses. However logic would indicate that if there is no garage or off street parking available this may affect the price of a house. In the data given no distinction was made between a garage and off street parking.

The Neighborhood variable such as distance to major shopping center and distance to tram stop were also important. The result reveals that distance to a shopping center is negatively significant in the determination of house prices. There are several possible reasons for these results.

Firstly, Residents desire to live in a tranquil area and prefer a quiet lifestyle. Living close to a major shopping centers that are crowded and noisy with heavy traffic has a negative

impact upon property prices. Secondly, Camberwell has a well-established shopping precinct at the Junction and several other smaller strip shopping areas so residents are well serviced with a wide variety of shopping facilities available. Thirdly, the public transport and road system allow residents to travel within 10 minutes to several other shopping centres such as Malvern central and Toorak/South Yarra complexes.

Model 4, t-stat ratio shows –3.945 for distance to major shopping center, which indicates the negative effect.

In Model 4, the results also reveals that the presence of parks is not an important factor in determining house prices. The t-stat is not significant and although proximity to a park is probably highly desirable Melbourne has earned a reputation as a park city. Camberwell and the environs are noted for their many tress and parklands so residents have a wide choice of parks so that the proximity to a park is not a concern.

The variable Distance to a Tramstop suggests this variable has a positive effect on the property values in Camberwell. This would seem to agree with the demographic composition of the population travelling to schools and the CBD.

The Variable Distance to Educational Institutions does not appear to be relevant. Camberwell is well served with many types of schools and a great choice of public transport which is frequent and reliable. A possible explanation for the apparent insignificance of Distance to Educational institution is that distance to the closest educational institution may be inappropriate for measurement. The most frequently used forms for educational institution is cost (expenditures per pupil) measures (Bruce, 1982). However, in the area of Camberwell many residents have moved into this area because of the convenience and reputation of the many educational institutions

The overall result suggest that important in public transport infrastructure and social services have an effect on the house price in Camberwell. In addition, high home price are found in high income areas (in this case Camberwell). This is consistent with the proposition that higher-income families pay more for a good.

VI CONCLUSIONS

The primary objective of this research is to apply hedonic regression techniques to investigate house prices in Camberwell in order to identify the significant contribution of the different attributes to house prices. The research analyses a sample of 192 selling prices, together with a series of physical attributes, neighbourhood attributes, and distances to transportation. The hedonic analysis explains housing prices reasonably well, though not perfectly. The basic variables have appropriate signs and are almost always both statistically significant and important.

The overall pattern of estimated prices is essentially consistent with prior expectations. The results emphasise the importance of physical attributes as principal determinants of selling prices. In addition, the result also shows that the presence of transportation,

particularly a tramline is an important housing attribute in determining housing prices. This suggests that different attributes are valued differently when combined with other attributes.

It may be concluded that a variety of locational factors are also fundamental to determining the housing prices.

In researching hedonic analysis and other forms of statistical analysis it is a useful guide to analysing data but it is only one method and may not be relied upon solely. Statistical results must only be applied when they are consistent with uderlying theory and plausible in a practical sense.

Analysing data for a single suburb, or neighbourhood, makes it difficult to disconer many of the underlying characteristics affecting price. A multivariate study could examine data for several suburbs simultaneously and identify key factors impacting on price.

REFERENCES

Bruce, D.M., (1982), " The Influence of School Busing on House Values", *Research in Real Estate*, Vol 2, pp. 85-110.

Chau, K.W. and Ng, F.F. (1998), "The effects of improvement in public transportation capacity on residential price gradient in Hong Kong", *Journal of Property Valuation & Investment*, Vol. 16 No. 4, pp. 397-410.

Fanning, Stephen, F. (1994), *Market analysis for Valuation appraisals*, Appraisal Institute.

Flaherty, J., Lombardo, R., Morgan, P., DeSilva, B., and Wilson, D., (1999), *A Spreadsheet Aproach to Business Quantitative Method*, RMIT University, Melbourne.

Gallimore, P., Fletcher, M., and Carter, M. (1996), "Modelling the influence of location on value", *Journal of Property Valuation & Investment*, Vol. 14 No. 1, pp. 6-19.

George, F.B., Arthur, M.W., and Jeffrey, D.F. (1982), *Real Estate*, 8th edition, United States.

Goodman, A.C., (1978), " Hedonic Prices, Price Indices and Housing Markets" *Journal of Urban Economics"* Vol 5, pp. 471-484.

Herold, W.E., and Leonard, V.Z. (1991), "Tenure Choice, Housing Demand and Residential Location", *Journal of Real Estate Research*, Vol. 6, No.3,pp. 341-356.

James, R.L., and Wesley, H.J., (1979), " Hedonic Property Valuation Models: Are Subjective Measures of Neighborhood Amenities Needed?", *Journal of American Real Estate and Urban Economics Association*, Vol. 7, Issue 4.

John, C. W., and Hartzell, D., (1982), " Hedonic Analysis of Home; result for 59 metropolitan areas", *Journal of Research in Real Estate,* Vol. 2, pp. 267-291.

John, H. (1998), "Transport investment and house prices", *Journal of Property Valuation & Investment,* Vol. 16 No. 2, pp. 144-158.

Marvin, L.W. (1997), "Empirical study of the relationship between residential lot price, size and view", *Journal of Property Valuation & Investment,* Vol. 15 No. 1, pp. 48-57.

Marvin, L.W., and Jimmy, S., (2000), " Hedonic Estimate of Regional Constant Quality Housing Prices", *Journal of Real Estate Research*, Vol 19, No 3, pp. 235-253.

Neil, D and Jones, C. (1998), "A hedonic price model of office rents", *Journal of Property Valuation & Investment,* Vol. 16 No. 3, pp. 297-312.

Norman G.M, (1982), "Residential property hedonic pricing models", *Research in Real Estate,* Vol. 2, pp. 31-35.

Pollakowski, H.O., (1982), *Urban Housing Markets and Residential Location,* D.C. Heath and Company, Lexington, MA.

Renwick, R., and Flaherty, J., (1996), " Developing an Appraisal Model for theCity of Melbourne Residential Units Project 1995", *Journal of Property Tax Assessment and Administration*, Vol 2, No 3.

Rodriguez, M. and Sirmans, C.F. (1994), " Quantifying the value of a view in single-family housing market", *The appraisal Journal,* Vol. 62, No. 4.

Simons, R.A., Quercia, R.G., and Maric, I. (1998), "The Value Impact of New Residential Construction and Neighborhood Disinvestment on Residential Sales Price", *Journal of Real Estate Research,* Vol.15 No. 2 pp. 147-161.

So, H.M., Tse, R.Y.C. and Ganesan, S. (1997), "Estimating the influence of transport on house price: evidence from Hong Kong", *Journal of Property Valuation & Investment*, Vol. 15 No.1, pp. 40-47.