Measuring and Evaluating Changes in Returns for Residential Property

by

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Abstract

Changes in home owners' wealth is measured by using an index of property prices constructed from sales transactions. Since only a very small proportion of the housing stock is offered to the market in any given time period, the index is a proxy for change in the price of all properties. The accuracy of the index determines its suitability as a 'good' proxy in reflecting price changes.

Several methods of index construction may be employed to measure price changes. A brief review of these methodologies and their shortcomings is presented. A hedonic regression analysis is employed to construct an index for ten Melbourne suburbs. The results are compared with the standard approach commonly employed by the property profession.

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Section I Introduction

The dynamics of the Australian residential property market have changed considerably since the period of the late 1980s. Evidence of these changes began to emerge with the deregulation of the financial markets in the mid-1980s, which removed controls over housing interest rates. In addition to the traditional housing finance lenders, consisting mainly of the major banks and building societies, new mortgage providers have dramatically increased the competition in the market. The environment for investing in residential property has become more attractive resulting in an increase in demand for this type of property as an investment asset. A significant and growing proportion of the market is now represented by those purchasing to invest as opposed to owner occupation.

Investors in the residential property market tend to be private individuals and not institutions, with such investments typically representing a major proportion of the investor's total wealth. Price movements in the various sub-markets therefore have important implications for investors' current and future wealth levels.

Information on prices in the residential property market is relatively inefficient when compared with other financial markets, such as the share or bond markets. Property is a heterogenous commodity making price determination more complex. There is a well established market for buying and selling property, however, a formal trading exchange does not exist. There is a significant time lag between the decision to buy or sell and the consummation of the transaction. Transaction costs are large making it uneconomical to reverse a position in a short period of time.

Due to the complex nature of the residential property market good quality information on price movements is essential for all market participants. The measurement of price changes is a key element in the provision of quality information.

Property prices are locationally dependent. The national average, or even a state average, does not usually provide a very accurate measure of what is happening in specific neighbourhoods or locations. Property represents a bundle of characteristics which include locational attributes. Two locations, each with schools, shops and other amenities, may each have properties that are very different in price. The desirability of one location over another is influenced by the perceived attractiveness of each to would-be purchasers. The price commanded in the market is the expression of buyers' willingness to own a property in a particular location. Faster rates of growth in prices in one location over another are the result of purchasers' preferences and the benefits they perceive from owning property in a specific location. The presence of *sub-markets* has implications for the approach taken in index formulation. The issue of sub-markets is considered more formally when analysis of the data is undertaken.

The heterogeneous nature of property makes it difficult to determine the value of a particular property. Property, while being heterogeneous to a large extent, possesses characteristics that make comparisons among properties meaningful. This is usually the province of an experienced valuer who takes his benchmark from recent sales in the local area. A local sales database should therefore provide a mechanism for the determination of property value. The professional valuer takes account of several factors to arrive at a value for a specific property. Some of these factors would include size of land and building, type of construction, age, condition and many others.

A survey of the literature dealing with the construction of indices for property prices is provided in the Section II. The most commonly used index in Australia is based on the median price. The simplicity of the median, together with its ease of calculation, has made it a popular measure to calculate price changes. A number of alternative measures to deal with the shortcomings of the median are discussed.

One of the alternative measures of property-price index construction is the hedonic regression model. This method is particularly suited for the estimation of prices for differentiated products, such as housing. The theoretical structure of the hedonic model is briefly discussed later.

In Section III the regression-based hedonic model is applied to transactions data for ten suburbs to formulate a price index. The models are evaluated based on theoretical and statistical criteria to establish their suitability for index construction. Consideration is given to the determination of an index, based on data combined from several locations, to determine whether the attribute coefficient estimates are constant across locations, that is, verify *locational dependence*. Section IV contains the conclusion.

Section II Overview of Property Price Index Literature

The Median Price

Property sales are the basis for establishing prices which are then used to establish benchmarks or indices. The most commonly used index of suburban property prices reported in the Australian media is the median. The median ranks all prices from lowest to highest and selects the centre-most price. The median is therefore that price below which fifty percent of sales lie. If the sales that have occurred for a given time period are truly representative of all properties in the area, then the median sale price will reflect the median property price for the area.

The attraction of the median stems from its apparent simplicity of calculation and from the fact that it is not influenced by extreme values either of a large or small magnitude. Since extreme values represent a relatively low proportion of sales in practice they should not be allowed to have undue influence in determining overall price movements. In contrast, since the arithmetic mean incorporates all sales it will be biased by such extreme values. Consequently, this measure is unsuitable for measuring property price changes.

Statistical theory may be relied upon to add some support to use of the median measure. If the sample is sufficiently large, then the sample of sales should be representative of the population of properties, and the median sale price will be a good estimate of the median property value. Assuming representative samples were drawn from the same population of houses at two different time periods, a change in the median price between the two time-periods would be meaningful if the underlying population remained stable across the two time periods.

Constant Quality Indices

Residential property is a highly differentiated product, requiring specialized skills to value an individual property. In addition to the property's intrinsic value, derived from its location, size, construction, views, etc., demand and supply conditions prevailing at a point in time influences market price and hence value. A property in a sought-after location will command a higher price if the supply of properties coming on to the market for sale is low. Buyers evaluate the many and varied characteristics of those properties that are available in the market based on their knowledge of what each of these characteristics or attributes are worth as a bundle.

Early literature on valuing differentiated products was undertaken by Houthakker (1952) and Lancaster (1966). A formal approach was later provided by Rosen (1974) who used observed product prices, and the specific quantity of characteristics associated with each good, to define a set of implicit or 'hedonic' prices. In Rosen's view a class of differentiated products may be described by its measured characteristics. Goods are valued for their utility-bearing attributes or characteristics. Hedonic or implicit prices of attributes are revealed to economic agents from observed prices of differentiated products and the specific amounts, or quantities, of characteristics associated with them. The theoretical framework established by Rosen (1974) is discussed in greater detail later.

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.

A hedonic model is one in which the price of a good is a function of the attributes of that good. Differentiated products of a given class, such as dwelling units (or automobiles) may be described by their measured attributes or characteristics. Goods and services are composed of a series of attributes, and relative quantities of these attributes contribute to the total value of any particular example of the good. Hedonic prices are thus implicit prices of attributes revealed to economic agents from observed prices of differentiated products and the specific quantities of characteristics associated with them. To use a housing analogy, the value of each attribute is implicit, or reflected in, the total house price.

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 residences and the neighborhood component. Hedonic analysis has been widely applied to housing market analysis and has become a well-established technique.

> "House price indices are typically estimated using either hedonic regression or repeat sales methods. Hedonic multivariate regression is a technique for measuring price while controlling quality of the heterogeneous commodity. The underlying rationale is that housing can be thought of as a bundle of separately measurable characteristics. The hedonic index application requires a sample of house sales from multiple time periods (or multiple locations). Transaction prices are regressed on structural and locational characteristics. The implied marginal contribution of each characteristic, relative to the composite price, is estimated by the vector of coefficients. Applying the implicit prices for each period to a standardized bundle of house characteristics yields an index of prices for the bundle. The index represents an estimate of the price that would have occurred if no variability existed in the included characteristics." (Gatzlaff and Ling, 1994, page 223)

Differentiation among properties arises due to the very large number of characteristics each house is actually or potentially endowed with. Such features may include land area, building area, number of rooms, number of bedrooms, number of bathrooms, type of construction, distance from a central location, quality of building, easements, and many others. Almy (1984) points out that in the early days of computer assisted mass valuation (CAMV), valuers tended to collect data on a significantly higher number of property characteristics and it was not uncommon for over one hundred possible variables to be collected. In time, however, it was recognized that prices could be satisfactorily explained by a smaller number of characteristics with as few as a dozen variables proving to be statistically significant.

A major difficulty with CAMV models is lack of data. That is, information for the required number of characteristics is often not recorded, which restricts applications of such models to more general valuation use. With low cost electronic storage and retrieval systems the data paucity has been overcome to some extent. However, the cost of physical collection continues to limit the information stored in many databases.

Regression Based Methodologies Used for Index Construction

The most commonly used regression-based methods for constructing an index of property prices are the hedonic model, referred to immediately above, and the repeat sales and hybrid models. While each has its supporters and detractors, all have been used to formulate price indices that are more credible than indices obtained from simple descriptive measures, such as the median or arithmetic mean. The practical limitations of these methods rests almost entirely on the availability of data as well as the effort expended in collecting the data. The problem of data availability is particularly acute in respect of the hybrid method. These three methods will now be outlined.

Repeat Sales Method

The repeat sales (RS) method is based upon the sale of the same property more than once. Quality is assumed constant over the time periods of the initial and subsequent sales. The RS method, pioneered by Bailey, Muth and Nourse (1963) and adopted by others, has the advantage that constant quality can be controlled.[1] The RS method is a variant of the *explicit time-variable* (ETV) approach, represented by the following equation.

$$\text{ETV} \qquad \ln(P_{it}) - \ln(P_{i\tau}) = \left(\sum_{j=1}^{k} \beta_j \ln(X_{jit}) + \sum_{t=1}^{T} c_t D_{it} \right) - \left(\sum_{j=1}^{k} \beta_j \ln(X_{ij\tau}) + \sum_{\tau=1}^{T} c_\tau D_{i\tau} \right) + \varepsilon_{it\tau}$$

where

P_{it} and $P_{i\tau}$ are the prices of repeat sales with initial sale at time τ and the second sale at time t;

X_τ and X_t denote the structural and locational attributes at each respective sale;

c_τ and c_t are the coefficients of the respective time dummies;

$D_{i\tau}$ represent the dummy variables used to capture time.

If housing quality is constant between transactions then,

$$\sum_{j=1}^{k} \beta_j \ln(X_{jit}) = \sum_{j=1}^{k} \beta_j \ln(X_{ji\tau})$$

and the equation reduces to,

$$\ln(P_{it}) - \ln(P_{i\tau}) = \sum_{t=1}^{T} c_t D_{it} - \sum_{\tau=1}^{T} c_\tau D_{i\tau} + \varepsilon_{it\tau}$$

The dependent variable is the log of the price ratio developed for a property that has been sold twice. The estimating equation becomes,

$$\ln\left(\frac{P_{it}}{P_{i\tau}} \right) = \sum_{t=1}^{T} c_t D_{it} + \varepsilon_{it\tau}$$

[1] Constant quality is assumed since the same group of properties is used over time to calculate the index. The quality of these properties should not appreciate or depreciate over the relevant time period for the assumption to hold.

where

$P_{it}/P_{i\tau}$ is the price relative for property i;

D_{it} is a dummy variable which equals -1 at the time of the initial sale and +1 at the time of the second sale, and 0 otherwise; c_t is the logarithm of the cumulative price index in period t.

The logarithm of the initial value of the index is normalized by setting initial sales in D_1 equal to zero, and the T subsequent coefficients are estimated by OLS regression.

The constant quality approach, which is the main advantage of this method, requires only two sale prices and dates of sale to construct the index. The RS method requires data only for those properties that are sold at least twice during the period of interest and for which no attributes changed between transactions.

Criticisms of the RS method point to issues such as ignoring depreciation, improvements in quality during the period between sales are not taken into account, frequently sold properties may not be representative of the larger population, changes in attribute prices over time[2], and a large number of sales is required to obtain an adequate sample of repeat sales. Also, the time period between an initial and subsequent sale is not constant for all properties in the sample. Hence the time of sale for a particular property, relative to some other property in the sample, may have occurred at a different point in the cycle. Price differences would therefore be influenced by cyclical factors that are not included in the model. The method thus gives rise to the problem of omitted variables, such as holding period between transactions.

The RS method may also give rise to sample selection bias through the *starter home hypothesis*[3] in so far as those properties that transact more than once, with no change in property attributes other than age between transactions, will differ

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[2] House styles change over time which may cause the value of certain property attributes to change over time. For example, the contribution of a bathroom to property value may be different in the present to, say, its contribution five years ago.

[3] House that sell more frequently may be *starter homes* bought by individuals with a shorter expected duration of stay.

systematically from the attributes of those properties where change has occurred. If the transactions used to calculate the index are based on a non-representative sample, then the RS method is inappropriate. Additionally, by restricting the data set to repeat sales with no change in property attributes, the RS method necessarily excludes most potential observations required to calculate an index reflecting the movement in prices.

Price change will, in general, be greater when the holding period is longer. Since the RS method does not explicitly include a variable to account for the impact of holding period, this effect is relegated to the error component of the model which gives rise to heteroscedasticity. A correction procedure for the holding period induced heteroscedasticity known as weighted repeat sales (WRS) was used by Case and Schiller (1989) who had available a large RS data set. This procedure did not address the major criticisms of the RS method.

Hedonic Method

Hedonic analysis does not restrict the number of characteristics used to explain variation in price. All sales transactions are used to calculate the index. This overcomes the sample selection bias inherent in the repeat sales method.

The hedonic method has been criticised because it fails to take advantage of the controls inherent in repeat transactions. For some properties, certain attributes will not have changed between the first and subsequent transactions. Price differences will be attributed to changes in the intervening time period and changes in other characteristics of the property. In addition, the choice of functional form and the set of explanatory variables used for estimation of the model's parameters, are also potential sources of bias in the hedonic model.

Fleming and Nellis, 1985, (FN) employed a hedonic regression model in the development of an index of the purchase prices of new and old houses in the UK. During the sample period the housing market in the UK came to dominate personal wealth, due in part to the rapid inflation of house prices during the 1970s.

The data used for the FN study consisted of a large database (over 150,000 transactions), provided by a mortgage corporation (Halifax Building Society) from the beginning of 1983. The building society's transactions represent a good cross-section of all properties transacted in the UK market.

In this heterogeneous market, price is determined by the equilibrium forces matching purchasers' wants with the properties offered for sale. FN assume that property price is a function of the following hedonic characteristics:

Price = f{Location, Type of property, Age, Tenure, No. of rooms, No. of bathrooms, Heating, Garage, Garden, Land, Road charge liability (amount)}

Indices were constructed using two approaches; a base weighted method and a time-dummy method. Both of these standardised methods (base-weighted and time-dummy) provide consistent results, and they are virtually indistinguishable from one another. However, they diverge significantly from the non-standardised simple averages method. This was magnified when the series was projected into the future.

Hybrid Model

A hybrid model was proposed by Case and Quigley (1991)[4] to overcome the bias and inefficiency of the hedonic and repeat sales methods. This model pools the data and the repeat-sale and hedonic equations are jointly estimated using generalized least squares. The model assumes that repeat-sales and single sales are drawn from the same population. The model, however, does require a relatively large data set. The choice of methodology is limited by the availability of data.

Case, et al. 1991, examined alternative methodologies for developing house price indices using data obtained from Fairfax County, Virginia. This study examined bias and efficiency issues using hedonic and repeat sales methodologies. Sources of bias in the use of hedonic indices include incorrect functional form and an incorrect set of explanatory variables.

[4] This model is described in Case, Pollakowski and Wachter, 1991, pp. 291-292.

Case, et al.[5] make the observation that there is an established view among economists that housing markets are geographically localized and the construction of indices are typically for a local geographic area. In addition, the type of housing is important: single-family detached, single-family attached and multi-family dwellings constitute individual housing markets. Indices are therefore constructed for a particular component of the housing stock and as such are only valid for this component. The mean rate of price appreciation and the variance of individual prices about this mean for a particular component of the housing stock, are not uniform across different segments of the housing market.

In most cases the hedonic models performed better than the corresponding hybrid models with lower standard errors, higher explanatory power and narrower confidence intervals. The hedonic model estimated on unchanged repeat transactions and changed repeat transactions show smaller standard errors and narrower confidence intervals than other models. The restrictive repeat sales (attributes unchanged over time) model performed best but these transactions are misleading since, by their nature, these transactions will have the smallest error variances.

The worst performing model was the naive repeat-sales model (changing attributes over time was not controlled), indicating the importance of identifying those repeat transactions of properties whose characteristics, in addition to age, change between transactions.

> "To obtain unbiased estimates of housing price indices it is essential that the regression relationship be specified correctly with respect to both functional form and regressors." (Case et al. page 305)

The median is generally unsuited for index construction in localised markets due to the heterogeneity of dwellings and movement of the underlying distribution of prices at various stages in the economic cycle. The heterogeneity problem is addressed by the repeat sales (RS) method provided that sufficient transactions for

[5] Case, Pollakowski and Watchter, 1991, pp. 287-289.

properties of constant quality across time are available and these transactions are reflective of the housing stock of interest. Even under these restrictive conditions, the RS method is unsatisfactory since depreciation is not taken into account.

The hedonic regression model takes account of quality changes and the impact of the various attributes influencing price. It produces robust parameter estimates that can be statistically and theoretically validated. While this method does not depend on repeat sales, it does require a considerable amount of information on the attributes of each property. The adequacy of currently available data on which to base the index is therefore of great importance. This will become a key issue later when the available property attributes[6] are used to produce estimates of the coefficients and satisfactorily explain variation in price.

While the hedonic regression model produces robust parameter estimates, the functional form of the model must be correctly specified. In addition, transformation of variables should reflect the underlying relationship between the dependent and explanatory variables and problems of multicollinearity, heteroscedasticity and autocorrelation must be identified and appropriately dealt with in order to statistically validate the parameters.

Australian Studies

Rossini, Koomans & Kershaw, (1995) carried out a study based on transaction prices collected in the South Australian town of Port Pirie during the period January 1986 to December 1992. The population of Port Pirie at this time was approximately 15,000 and falling. A large silver-lead-zinc smelter is located in the town. The analysis was conducted using quarterly data, with typically 50 to 70 sales in each quarterly period. The dwellings in this town or regional sub-market, were relatively homogenous reducing the impact of housing quality. A hedonic model, with a semi-log functional form, was employed to obtain the price index.

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[6] The availability of sufficiently suitable attributes is dependent on the information collected and stored in the database, which for this study is provided by the Real Estate Institute of Victoria.

Two models were estimated with the log of price as the dependent variable. The first model contained only time dummies[7] on the right-hand side while the second model included additional explanatory variables to account for differences in housing types. The results for the former model suggested an average price increase of 11.2% per annum while the latter model indicated increases of 6.98% per annum. Repeat sales were insufficient to carry out the analysis on a quarterly basis. Even when annual data were used the repeat sales results were unreliable, indicating annual growth rates of between 0 and 10 per cent.

The authors formed the view that the use of descriptive measures, such as the median or simple average, as a technique for measuring price changes is unreliable. Geographic location, housing type and quality changes need to be taken into account. The relative homogeneity of dwellings in Port Pirie is likely to have had a strong influence on the results obtained for the repeat sales and hedonic models. Both methods should produce indices that are very similar since changes in the quality of the housing stock is effectively controlled and other hedonic characteristics would be similar for all properties.

Costello (1997) used four methods to form an index of property prices for a local housing market in Scarborough, Western Australia for the period 1988 – 1996. Residential *strata title* property was chosen for index construction by Costello due to the high quality of the data for this type of property. The most significant influence on selling price in most studies has been the building area. This information is readily available from title documents for strata title properties. Additions to building area are included on the strata title document, making it easier to screen sales for the repeat sales analysis. Other significant variables are building age, room details, date of sale and building style.

OLS procedures were employed to analyse the data. High levels of multicollinearity led to the restriction of the number of explanatory variables to area and age of building. The estimated equation exhibited heteroscedasticity, with the variable 'area' identified as the source of this problem. To correct for the

[7] The use of time dummies only as explanatory variables is equivalent to the arithmetic mean.

problem a weighted least squares procedure was employed. The estimates of price change thus obtained were slightly lower than those obtained using OLS. Autocorrelation was not evident in the residuals based on the Durbin-Watson test.

Costello concluded that the median is generally unsuited for index construction in localised markets due to the heterogeneity of dwellings and movement of the underlying distribution of prices at various stages in the economic cycle. The heterogeneity problem is addressed by the repeat sales (RS) method provided that sufficient transactions for properties of constant quality across time are available and these transactions are reflective of the housing stock of interest. Even under these restrictive conditions, the RS method is unsatisfactory since depreciation is not taken into account.

The hedonic regression model takes account of quality changes and the impact of the various attributes influencing price. It produces robust parameter estimates that can be statistically and theoretically validated. While this method does not depend on repeat sales, it does require a considerable amount of information on the attributes of each property. The adequacy of currently available data on which to base the index is therefore of great importance. This will become a key issue in the next section when the available property attributes are used to produce estimates of the coefficients and satisfactorily explain variation in price.

While the hedonic regression model produces robust parameter estimates, the functional form of the model must be correctly specified. In addition, transformation of variables should reflect the underlying relationship between the dependent and explanatory variables and problems of multicollinearity, heteroscedasticity and autocorrelation must be identified and appropriately dealt with in order to statistically validate the parameters.

Section III Data and Estimation

The data used in this study was provided by the Real Estate Institute of Victoria (REIV). The REIV claim record approximately fifty per cent of all sales in the state. A major deficiency of the data base arises from incomplete records. Most regression-based studies used to predict property price rely on variables (descriptors) such as *BUILDING AREA*, *LOT SIZE*, type and number of ROOMS, *AGE* and type of *CONSTRUCTION*, and possibly others depending on the study and availability of data. The REIV data base relies on members, or agents, to voluntarily provide information on properties that they have recently sold. The type and quality of information provided is tempered by the ease with which the member can supply it and the member's future reliance on the REIV database.

Despite this apparent shortcoming, with careful filtering and an adequate sample of properties upon which to base the index, the REIV data base may be relied upon to produce an index that is superior to the more commonly used median measure.

Data for ten Melbourne suburbs for the years 1995 to 1999 were provided by the REIV. The data are filtered to ensure that the data meet certain criteria. Some sales were omitted due to incomplete information on some descriptors. Sale prices that were unusually large or small were removed as they could not be verified and, if correct, were likely to be inconsistent with the sample under consideration.

The ten suburbs chosen for this study vary in age, proximity to the city centre and population size, refer Table 1. The older suburbs are located closer to the city centre and typically have a significant proportion of solid brick and weatherboard houses. In the newer suburbs, such as Melton and Mill Park, house construction is predominantly brick veneer.

Local building codes have contributed to shaping the type and quality of housing in a particular suburb over time. For this reason, house prices tend to cluster about some given value which is specific to that suburb. For a professional valuer, the average price of a dwelling in Toorak would fall within a very different range to a dwelling in, say, Clifton Hill or North Melbourne. Local characteristics influence value in such a way that when these characteristics are grouped together as a bundle (which is represented by a dwelling), in the sense described by Rosen (1974), the bundle embodies the implicit prices of the *local* characteristics. Price comparisons should therefore be confined to comparable properties in the same geographic area.

Table 1: Population Size and Distance to CBD
Source: Domain.com (http://www.domain.com.au/) and Melway Street Directory

Suburb	Post code	Population	Approx. Distance from CBD
Box Hill	3128	14,397	15 km
Carlton	3053	8,521	5 km
Clifton Hill	3068	15,525	5 km
Ivanhoe	3079	14,377	10 km
North Melbourne	3051	8,795	5 km
South Yarra	3141	17,225	5 km
Toorak	3142	12,348	5 km
Ringwood	3131	28,299	25 km
Melton	3337	23,062	35 km
Mill Park	3082	23,234	18 km

It is expected that weatherboard houses are a less expensive type of construction, compared with solid brick or brick veneer, they should command a lower price. While this expectation may be true in general, property sale prices in the suburb of Box Hill over the period in question are at odds with this norm. This is principally explained by the aggregation of dwelling type (*HOUSE*, *UNIT* or *FLAT*) and construction type (*BR*, *BV* and *WB*). Units and flats are either solid brick (*BR*) or brick veneer (*BV*) construction and it is apparent from the data for this suburb that the mean prices for units and flats are less than for houses.

Specification of Regression Equation and Testable Hypotheses

Based on the work by Rosen (1974), variation in property price may be explained by a vector of attributes, or hedonic characteristics. For this study, this takes the following general form:

Price = f(LOT SIZE, ROOMS, HOUSE, UNIT, FLAT, SOLID BRICK, BRICK VENEER, WEATHERBOARD, TIME dummies)

The list of descriptors is restricted to those available in the REIV's database. Alternative functional forms were examined to produce an estimated hedonic model that is both theoretically and statistically satisfactory. Individual equations were estimated for each suburb enabling a number of hypotheses to be tested.

Specific hypotheses related to the signs of the coefficients and the relevance of key variables.

For example, the null hypothesis for the coefficient of the variable *ROOMS*, states that this coefficient is not positive or zero. The alternative hypothesis states that this coefficient is positive. Rejection of the null hypothesis is desired. The hypotheses relating to the signs of the coefficients are presented from this perspective, that is, rejection of the null hypothesis in each case is desired.

The coefficients of the variables *HOUSE* and *UNIT*, are expected to be positive, relative to that of *FLAT*.[8] The magnitude of the *HOUSE* coefficient should be greater than that of the coefficient for *UNIT*. With the exception of the Box Hill data, the coefficients for the variables *SOLID BRICK* and *BRICK VENEER* are expected to be positive when the variable *WEATHERBOARD* is captured by the constant term in the regression. For reasons discussed earlier, due to the mix of properties in the suburb of Box Hill, the variables *SOLID BRICK* and *BRICK VENEER* are expected to have negative coefficients.

The coefficients for the time dummies reflect price movements over time, and as such, neither the signs nor magnitudes of their coefficients can be predetermined. A number of tests were constructed during the estimation process and the results are presented below.

Regression Results for Box Hill Data

Several linear equations, represented in Table 2 by ***PRICE*,** and log-linear equations, represented by **Ln(*PRICE*)**, were estimated for Box Hill. The results confirm that the variable *LOT SIZE* is not significant, based on a standard t-test.[9] The variable *ROOMS* is highly significant, based on its t-statistic, in all equations

[8] The dummy variable representing *FLAT* is removed from the estimating equation and its impact is captured by the constant term. This will cause the coefficient of the variable *HOUSE* to be positive if house prices are greater than flat prices on average. A similar argument holds for *UNIT*.

[9] Using a 5% level of significance, the t-statistics should be at least 1.96. Equations 6 and 8, presented in Table 2, contain t-stats greater than 1.96, however, the R^2 and F-statistic for these models are inferior to most other models included in the table.

where it was included. When *ROOMS* was excluded from the equation, the variable *LOT SIZE* was just significant. However, the explanatory power of the equation dropped significantly. As discussed previously, the inclusion of *LOT SIZE* reduces the sample from 1,192 to 452 and changes the distribution of the sample among construction type. The loss of information, due to the huge reduction in sample size, reduces the explanatory power of any model that includes *LOT SIZE*. This is evident from the adjusted R^2 and F statistics in Table 2. Due to the mixture of property types (*HOUSE*, *UNIT* and *FLAT*) in Box Hill, each of which represent a significant proportion of sales transactions, including the variable *LOT SIZE* in the equation restricts the available sample to houses only. Hence this variable, because of its huge impact on sample size, cannot be relied upon to consistently explain variation in price and should not be included in the model.

Table 2: Estimated Regression Equations for Box Hill Data

	Const.	Lot Size	Rooms	House	Unit	BR	BV	YR_96	YR_97	YR_98	YR_99	Adj-Rsq	F-stat
Price	-14078.29		22984.32	45077.67	22276.4	-7811.25	-3290.81	1058.22	19226.39	40047.86	61764	0.615	212.10
t-Stat	*-2.17*		*23.24*	*9.93*	*5.76*	*-2.11*	*-1.01*	*0.28*	*5.41*	*11.10*	*17.92*		*n = 1192*
Price	-14078.29		22984.32	45077.67	22276.4	-7811.25	-3290.81	1058.22	19226.39	40047.86	61764	0.615	212.10
t-Stat (White)	*-2.04*		*20.12*	*9.66*	*6.77*	*-1.78*	*-0.90*	*0.35*	*6.06*	*11.26*	*17.41*		*n = 1192*
Ln(Price)	10.8121		0.1340	0.3580	0.21321	-0.0698	-0.0249	0.0140	0.1314	0.2567	0.3853	0.663	212.10
t-Stat (White)	*289.92*		*22.54*	*12.55*	*9.39*	*-2.95*	*-1.30*	*0.70*	*6.46*	*12.21*	*18.96*		*n = 1192*
Price	25887.95	15.82	20121.80			5569.45	-2515.04	9273.07	33675.05	64816.23	92776.79	0.452	47.53
t-Stat	*2.08*	*1.51*	*11.14*			*0.80*	*-0.53*	*1.42*	*5.24*	*9.34*	*13.60*		*n = 452*
Price	25887.95	15.82	20121.80			5569.45	-2515.04	9273.07	33675.05	64816.23	92776.79	0.452	47.53
t-Stat (White)	*2.00*	*1.21*	*11.33*			*0.69*	*-0.54*	*1.94*	*5.85*	*9.51*	*12.92*		*n = 452*
Price	134588.8	31.34452				14921.5	118.5868	16146.12	36734.41	61642.91	93149.32	0.30	28.66
t-Stat (White)	*14.79903*	*2.168319*				*1.611507*	*0.022487*	*2.884273*	*5.836741*	*8.271632*	*11.50804*		*n = 452*
Ln(Price)	11.276	0.000102	0.098451			0.012847	-0.010605	0.06787	0.194507	0.351066	0.468744	0.22	47.49
t-Stat (White)	*179.4786*	*1.702976*	*12.17145*			*0.319391*	*-0.474129*	*2.346886*	*5.864686*	*10.12964*	*13.72155*		*n = 452*
Ln(Price)	11.80784	0.000178				0.058604	0.002281	0.101498	0.209476	0.335539	0.470567	0.31	29.31
t-Stat (White)	*256.555*	*2.687045*				*1.296742*	*0.088785*	*2.984725*	*5.740698*	*8.822328*	*12.2207*		*n = 452*

Property type (*HOUSE*, *UNIT* and *FLAT*), construction type (*BR*, *BV* and *WB*) and years (1995, …, 1999) are included as binary (dummy) variables. To estimate the regression equation one variable from each of these three groups was excluded. The coefficients may be interpreted with reference to these excluded variables. For example, the coefficients for *HOUSE* and *UNIT* are both positive relative to the excluded variable *FLAT*. From the first equation given in Table 2, the average price of a house is greater than that of a flat by $45,077 and a unit is greater by the amount $22,276.

It is also observed from Table 2 that the coefficients for construction types *SOLID BRICK* and *BRICK VENEER* are negative relative to *WEATHERBOARD*. This is consistent with the results previously obtained from the descriptive statistics for Box Hill. The t-ratio for *BRICK VENEER* indicates that this descriptor is not significant in explaining price variation. The contribution of the binary variable *BRICK VENEER* is not significantly different from the variable *WEATHERBOARD*, the construction type variable incorporated in the regression constant. Retaining the variable in the model will be useful for index calculation for this construction type. On the basis of this result, the indices for *WEATHERBOARD* and *BRICK VENEER* properties should be very similar.

The benchmark year is 1995, all other years may be compared with this year. For each of the years 1996 to 1999 it is observed that the coefficients are increasing over time, indicating that property prices are increasing year-on-year. All years, with the exception of 1996, possess highly significant coefficients, that is, they are significantly different from the benchmark year of 1995.

For all models the variable *ROOMS* is highly significant, with a t-ratio in excess of 20 and for those equations with *LOT SIZE* included, its t-ratio is 11 or higher. The variable *ROOMS* embodies information about building size, which is one of the most significant property characteristics accounting for price variation in a specific local area where *LOT SIZE* tends to be similar for most properties. Empirically, the choice between the linear relationship and the log-linear model slightly favours the log-linear model. Theoretically, a non-linear relationship between price and the various descriptors is expected.

In addition to OLS[10] tests of significance, Table 2 contains the White Heteroscedasticity-Consistent Standard Errors & Covariance, denoted by *t-Stat (White)*. Some minor changes in the t-ratios are evident when compared with the standard OLS values. However rejection of the null hypothesis, that a coefficient is not significant in explaining price, is unchanged using either test statistic.

[10] Estimates obtained using the ordinary least squares algorithm.

Some heteroscedasticity is likely to be present due to the cross-sectional nature of the data, hence the *White* algorithm is necessary to estimate standard errors which are used to correctly calculate the t-statistics.

As mentioned previously, the data are pooled time-series and cross-sectional, as they include observations on a range of different properties across a period of five years. The time-series nature of the data would suggest potential autocorrelation. The Durbin-Watson statistic of 1.62 indicates that the hypothesis of autocorrelation cannot be supported.[11] The consistency of the results for all models and the low correlation between the explanatory variables indicate that there is no evidence of multicollinearity. The hypothesis of no multicollinearity is also supported by the joint consistency of the significance of the t-ratios and R^2 for all models. In addition, as the sample size gets larger and closer to the population, the degree of multicollinearity is lessened as it is a feature of the sample and not of the population.[12]

Model Variations

Models that are used to explain price variation are typically of a general form, such as that presented in Table 2, and a 'best' model is sometimes obtained by considering variations of this form. The relationship between price and the explanatory variables (property descriptors) was considered to be non-linear, this is theoretically plausible and, as indicated immediately above, can also be empirically supported. What has not been considered in the models provided in Table 2 is the functional form of the explanatory variables themselves. The explanatory variables, in so far as this is feasible, may themselves be non-linear and/or interact with each other.

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[11] The Durbin-Watson (DW) statistic is the standard test for first order autocorrelation. Tabulated values for the DW statistic may be found in most econometric text books, for example Gujarati (2003). A specific test for $n \geq 200$ and $k = 10$ at 0.01 level of significance gives; $d_l = 1.571$ and $d_u = 1.779$. The value of 1.62 is therefore in the inconclusive range.

[12] A number of the more common tests employed in detecting the presence of multicollinearity are provided in Gujarati (2003). These include the pair-wise correlation matrix, high R^2 and low t-ratios. The correlation matrix, not provided here, does not display evidence of multicollinearity.

All explanatory variables with the exception of *ROOMS* and *LOT SIZE* are binary and must therefore enter the estimating equation in this form. The variable *ROOMS* may be transformed in some non-linear way or it may interact with some of the other (binary) variables in the model in such a manner as to influence variations in the dependent variable.

The variable *ROOMS* was examined for various transformations (squared, square-root, log) but none achieved the significance of the original variable. The square-root and log transformations, when included with the original variable, were significant but did not contribute additional information to the model.

The most acceptable model to describe property prices in the suburb of Box Hill, given the available sample data, is the log-linear model. This is the third model given in Table 4.2 above. This model can be theoretically and empirically supported, the signs of the coefficients are as expected and the model explains approximately 66 percent of the variation in sale price.

Estimation of Regression Equations for Other Suburbs

The general regression equation specified earlier in this Chapter is employed to estimate the coefficients of the models for all remaining suburbs. The age of a suburb will often determine the mix of dwelling type (*HOUSE*, *FLAT* or *UNIT*) and the type of construction (*SOLID BRICK*, *BRICK VENEER* or *WEATHERBOARD*). The estimated equations for each suburb are provided in Table 3 below. The log of the price as the dependent variable provided the best explanation of the variation in property price. The independent variables, for the most part, were not transformed. The variable *ROOMS* was a key variable for all suburbs. With the exception of the suburbs Carlton and Toorak, the variable *ROOMS* was not transformed – for these two suburbs only, the log of ROOMS (*LN_RMS*) proved to be the most significant.

Alternative functional forms and transformations were examined to model the data for each suburb. Those models considered to be best, on the basis of standard theoretical criteria (correct signs and magnitude) as well as statistical criteria (significance of coefficients using t-test, joint F-test, and proportion of variance explained as measured by the adjusted R^2), are presented in Table 3. New (independent) variables were formed by combining existing variables. Only occasionally were these constructed variables significant. The *White Heteroskedasticity-Consistent Standard Errors* were used to obtain the reported t-ratios for all models. No evidence of multicollinearity was present in any of the models estimated.

Table 3: Estimated Regression Equations for Selected Melbourne Suburbs

Variable	Const	ROOMS	YR_96	YR_97	YR_98	YR_99	BR	BV	HOUSE	UNIT	Adj R-sq	F-stat	DW
North Melb	10.84	0.15	0.01	0.16	0.36	0.42	0.13	0.31	0.33	0.12	0.50	96.98	1.18
t-Statistic	*175.50*	*19.05*	*0.28*	*4.48*	*10.02*	*13.55*	*2.83*	*4.74*	*11.49*	*3.36*		n = 853	
South Yarra	10.81	0.25	0.06	0.22	0.29	0.43	0.05	0.12	0.39	0.09	0.67	607.22	1.65
t-Statistic	*294.58*	*48.75*	*2.25*	*9.28*	*12.85*	*18.21*	*1.96*	*2.58*	*17.80*	*5.11*		*n = 2655*	
Ivanhoe	10.81	0.19	0.06	0.18	0.29	0.45	0.08		0.21		0.65	229.54	1.46
t-Statistic	*223.53*	*22.05*	*1.54*	*5.17*	*8.21*	*12.57*	*3.57*		*7.06*			*n = 853*	
Mill Park	11.04	0.11	0.07	0.09	0.17	0.34					0.52	131.64	1.67
t-Statistic	*285.28*	*17.52*	*3.82*	*5.29*	*8.66*	*10.97*						*n = 609*	

Melton	Const	ROOMS	YR_96	YR_97	YR_98	YR_99	BV	R_BV	Adj R-sq	F-stat	DW
Coefficient	9.69	0.31	-0.04	-0.09	0.18	0.36	0.95	-0.18	0.39	43.01	1.68
t-Statistic	*27.99*	*5.07*	*-1.31*	*-2.19*	*4.20*	*9.04*	*2.70*	*-2.86*		*n = 457*	

Ringwood	Const	ROOMS	YR_96	YR_97	YR_98	YR_99	BR	BV	HOUSE	R_BR	Adj R-sq	F-stat	DW
Coefficient	10.92	0.09	-0.03	0.04	0.16	0.26	-0.36	0.12	0.16	0.10	0.51	103.11	1.73
t-Statistic	*281.01*	*12.69*	*-1.09*	*1.82*	*7.49*	*12.18*	*-3.44*	*6.77*	*9.17*	*5.53*		*n = 896*	

	Const	LN_RMS	YR_96	YR_97	YR_98	YR_99	BR	BV	HOUSE	UNIT	Adj R-sq	F-stat	DW
Toorak	9.89	1.40	0.07	0.25	0.23	0.34	0.17	0.24	0.37	0.11	0.70	526.15	1.71
t-Statistic	*147.24*	*48.25*	*2.33*	*8.07*	*7.39*	*10.90*	*3.38*	*3.47*	*12.92*	*4.05*		*n = 2020*	
Carlton	10.79	0.66	0.02	0.13	0.26	0.36	0.12	0.28	0.29	0.17	0.52	87.26	1.60
t-Statistic	*141.90*	*17.96*	*0.61*	*3.58*	*7.18*	*9.94*	*2.66*	*4.39*	*8.32*	*4.63*		*n = 709*	

Clifton Hill	C	ROOMS	YR_96	YR_97	YR_98	YR_99	HOUSE	UNIT	BV_U	Adj R-sq	F-stat	DW
Coefficient	10.91	0.13	0.06	0.25	0.39	0.52	0.52	0.25	0.29	0.64	143.67	1.54
t-Statistic	*222.88*	*17.03*	*2.17*	*8.94*	*14.52*	*18.48*	*12.33*	*4.50*	*2.54*		*n = 644*	

Constructing a Property Price Index

The choice of property-type index that may be constructed using a hedonic regression model is based on constant quality. It is possible to isolate a particulate type of property, such as a five-room solid brick house. The quantity and quality of data available from sales transactions will affect the reliability of the index, however, as discussed in the suburb-models immediately above, there are theoretical and statistical criteria that may be used to validate a particular model. To provide an indication, property prices over the sample period for a five-room dwelling (the average number of rooms per dwelling in the sample) in the suburb of Box Hill, are presented in Table 4. An index for several different property types has been constructed with 1995 as the base year.

Table 4: Property Prices in Box Hill – Hedonic versus Mean and Median

	1995	1996	1997	1998	1999
5-Room Solid Brick House	$129,378	$131,202	$147,549	$167,235	$190,194
5-Room Brick veneer House	$135,323	$137,232	$154,329	$174,921	$198,935
5-Room Solid Brick Unit	$111,934	$113,513	$127,655	$144,687	$164,550
5-Room Brick veneer Unit	$117,078	$118,729	$133,522	$151,336	$172,113
5-Room Weatherboard House	$138,735	$140,692	$158,220	$179,330	$203,949
Index based on Hedonic regression	100.00	101.41	114.05	129.26	147.01
Mean	$131,324	$141,194	$154,224	$170,314	$186,028
Index based on Mean	100.00	107.52	117.44	129.69	141.66
Median	$125,000	$137,500	$150,000	$162,500	$169,750
Index based on Median	100.00	110.00	120.00	130.00	135.80

The hedonic index indicates that a typical property in the suburb of Box Hill has increased by approximately 47 percent during the five-year period 1995 to 1999. This increase is slightly greater than that indicated by the mean measure and about 11 percent higher than is indicated by the median. The results in Table 4 also support the relative prices of construction type solid brick, brick veneer and weatherboard. The mix of properties in the Box Hill sample provides the unusual result that the average weatherboard dwelling price is greater than that for solid brick or brick veneer.

The indices for all other suburbs, with the exception of Melton[13], are provided in Table 5. In each case for the hedonic index, a five-room dwelling is assumed. The dwelling type and construction is as indicated, which in many cases depends on the sample data. In the case of Mill Park, for example, the sample consists almost entirely of brick veneer houses.

[13] The model estimated from the sample data for Melton explained only 39 percent of the variation in price and some the estimated coefficients did not have the expected signs.

Significant differences exist between the indexes based on the hedonic regression and those based on the mean and the median. These differences are not consistent. For example, the hedonic measure is closer to the median-based measure for North Melbourne, whereas it is closer to the mean-based measure for Ivanhoe. The median-based measure for Ivanhoe indicates that, during the sample period, prices have increased by some 78 percent, whereas the hedonic-based measure suggests the increase should be approximately 57 percent – this provides a very different signal to a property investor.

Table 5: Property Price Indices for Selected Melbourne Suburbs

			1995	1996	1997	1998	1999
Nth Melb	5-R-Br-H	Hedonic	100.00	100.88	116.96	142.75	152.36
		Mean	100.00	98.97	113.72	126.39	141.99
		Median	100.00	95.39	111.84	115.95	153.29
Ivanhoe	5-R-Br-H	Hedonic	100.00	105.79	120.13	133.56	156.76
		Mean	100.00	102.57	120.02	144.69	153.68
		Median	100.00	108.33	130.56	158.47	177.78
Mill Park	5-R-Bv-H	Hedonic	100.00	107.47	108.97	118.14	141.13
		Mean	100.00	105.33	109.23	118.01	148.46
		Median	100.00	105.31	111.25	118.90	142.25
Ringwood	5-R-Br-H	Hedonic	100.00	97.37	104.06	117.90	130.30
		Mean	100.00	97.47	108.41	117.75	132.07
		Median	100.00	94.32	104.50	117.27	127.73
Sth Yarra	5-R-Br-H	Hedonic	100.00	106.12	124.84	133.17	153.14
		Mean	100.00	103.43	123.39	118.82	145.10
		Median	100.00	98.98	126.90	114.21	140.36
Toorak	5-R-Br-H	Hedonic	100.00	107.47	128.24	125.47	140.59
		Mean	100.00	114.97	123.04	133.63	145.95
		Median	100.00	118.04	118.43	133.33	151.37
Carlton	5-R-Br-H	Hedonic	100.00	102.23	113.96	129.30	143.71
		Mean	100.00	99.54	102.12	116.55	123.85
		Median	100.00	103.41	108.86	118.26	130.79
Clifton Hill	5-R-Br-H	Hedonic	100.00	106.45	129.02	147.64	167.56
		Mean	100.00	100.07	121.49	137.94	150.54
		Median	100.00	104.94	122.09	145.35	154.22
Carlton	5-R-Br-H	Hedonic	$210,305	$214,997	$239,655	$271,931	$302,229
		Mean	$209,989	$209,032	$214,444	$244,741	$260,082
		Median	$183,500	$189,750	$199,750	$217,000	$240,000

Hedonic: 5-R-Br-H ~ 5 room, solid brick, house and 5-R-Bv-H ~ 5 room, brick veneer house.
The estimated dollar prices for the suburb of Carlton are provided to give an indication of how prices obtained using the model compare with the actual prices for this suburb.

Both the mean and median-based methods for Carlton are very close, and they differ significantly from the hedonic-based measure. The hedonic index, which is based on solid brick (accounting for 94 percent of all transactions) houses (more than 60 percent of properties in the sample), is likely to be the most consistent indicator of price change.

Section IV Conclusion

Housing wealth in Australia represents some 60 percent of private sector wealth. For many Australians approaching retirement, their home-equity represents a key component of retirement income. For home-owners, the wealth stored in their home may be established by reference to an index of property price changes in their local area. The accuracy of the reference benchmark price index will have implications for the wealth perception of home owners. The decision to sell and relocate to a more desirable retirement location may be influenced by the perception of value communicated by a property price index. If publicly reported property price indices are used as an index of value by lenders, and hence are used to calculate the owner's equity, it is important that these indices reflect the correct movement in prices over time.

The median is the most commonly used measure reported by the various media and despite its major shortcomings is unlikely to be supplanted in the future. Among its shortcomings is an inability to account for quality changes across periods. There are no diagnostic tests available to validate the median measure. Alternative measures require an understanding of more advanced index construction methods and improvements in data collection and verification. Within the residential property industry in Victoria, there seems to be little incentive to increase the quantity and quality of data collection. While the various statutory and professional bodies responsible for collecting and distributing information on property price movements achieve a high level of data integrity within their respective terms of reference, they are constrained by the resources at their disposal.

A number of alternative approaches for the construction of property price indices were examined. Most of these require a larger data set of sales transactions, with several property characteristics recorded for each transaction. The types of properties typically found in a specific location, in particular the mix of properties, will have implications for the appropriate sample of sales transactions required to formulate a reliable index. Newer suburbs tend to be less heterogeneous than older suburbs with respect to housing style, size and type of construction. Such heterogeneity, where it exists, typically requires a larger sample to more accurately reflect the mix of properties in a given geographic location.

Property price change in a given location, relative to a benchmark property for that location, is primarily explained by the type, quality and number of attributes possessed by a particular property. The implicit prices of these attributes, which are reflected in the overall price of a dwelling, may be estimated by a hedonic regression model. For all suburban locations examined, with the exception of Melton, the hedonic model provided robust estimates of the attribute coefficients.

Key property attributes that may be used to explain price changes play a significant role in estimating price. For each of the suburbs analysed, the number of rooms (*ROOMS*) emerged as the dominant explanatory variable in the respective models. This variable is a reliable proxy for *building area* and to a lesser extent for *LOT SIZE*. All of the suburb-models, with the exception of one, explained at least 50 percent of the variation in price. Some, such as Toorak and South Yarra – for which the number of sales transactions were comparatively large, explained approximately 70 percent of the variance.

An important feature of the regression-based method of explaining price variation is the ability to conduct a series of hypothesis tests on the model and the model's coefficients. These tests provide an objective means of validating the estimated equation and, when validated, a higher level of confidence may be assumed in its application. In addition, tests for omitted variables may be employed to add support to an estimated regression model.

The use of dummy variables has been employed to capture a number of the attributes, such as housing type, construction type and time. This technique assumes that the coefficients of these binary variables are constant across each of these categories. For example, the rate of change in the variable *BR* (solid brick construction) for a house is the same as it is for a flat or a unit. This is an assumption imposed on the model and improves the tractability of parameter estimation when sample size is ‘small’. Given the availability of a large data set, it would be possible to test the validity of this assumption. With sufficient data for each housing style and type of property, differences in the coefficients may be determined. While this assumption may be cause for concern it is likely that the effect of location is dominant and provided the index is constructed for a local region the coefficients for these variables will exhibit stability. Further analysis, assuming a sufficiently large data set is available, would confirm the appropriateness of this assumption.

Another undesirable side effect of the assumption of constant coefficients across all property types in a given location is that while it is possible to estimate a unique price for any given type of property, there is only one index for all properties. This is best illustrated by reference to Table 4 for the Box Hill data. It may be easily verified that for the 5 property types in this suburb, each has increased by 47.01 percent during the five year period. When the sales transactions for all property types are included in the estimating equation, a single index will result. This index will reflect, as it should, the weight of transactions for a particular type of property. While to some extent this is a limiting feature of this specification of the regression-based dummy variable approach, in the absence of a sufficiently large sample it becomes necessary in order to reflect the underlying movement in the prices of those properties that are being transacted.

Property price indices based on the hedonic regression model take account of all available information without being unduly influenced by extreme values. Indices that are based on this model will prove to be more accurate and more consistent over time than simple descriptive methods such as the median or mean.

Concluding Remarks

The study highlights the importance of having available an extensive data base. Property price indices that are based on simple descriptive measures provide, at best, a rough estimation of price changes. Hedonic-based methods can improve the accuracy of index construction. With improved data collection procedures, and the inclusion of additional information for each transaction, such indices may be used to monitor price changes in different categories of property.

Since property represents a large component of private personal wealth for a majority of Australians, it is incumbent on the industry, both real estate and financial, to improve the accuracy of publicly reported information on price movements. This will enable all participants in the market to make better informed decisions when a residential property transaction is being considered.

The principal contribution emanating from this research is to call attention to the shortcomings of using the median as a measure of property price change and to demonstrate the use of hedonic regression analysis as a superior method of residential property price index construction.

Bibliography

Andrews, D., 2001, “City Sizes, House Prices and Wealth,” Reserve Bank of Australia, ***Bulletin***, December.

Aoki, K., Proudman, J. and Vlieghe, G., 2001, “Why House Prices Matter,” ***Bank of England Quarterly Bulletin:***, Winter.

Badcock, B. and Beer, A., 2000, ***Home Truths, Property Ownership and Housing Wealth in Australia***, Melbourne University Press.

Bailey, M.J., Muth, R.F., and Nourse, H.O., 1963, A Regression Method For Real Estate Price Index Construction,” ***American Statistical Association Journal***, Vol 58, pp.933-942.

Bond, M.T., Seiler, V.L. and Seiler, M.J., 2002, “Residential Real Estate Prices,” ***Journal of Real Estate Research***, Vol 23, Nos 1/2

Case, B., Pollakowski, H.O. and Wachter, S., 1991, “On Choosing Among House Price Index Methodologies”, ***AREUA Journal***, Vol. 19, No.3.

Case, B., and Quigley, J.M., 1991, “The Dynamics of Real Estate Prices,” ***Review of Economics and Statistics***, Vol. 22, No.1.

Case, K.E., Quigley, J.M., and Shiller, R.J., 2001, “Comparing Wealth Effects: The Stock Market versus the Housing Market,” ***NBER Working Paper 8606***, National Bureau of Economic Research, November.

Costello, G.J., 1997, “Transaction Based Index Methods for Housing Market Analysis,” ***Australian Land Economics Review***, Volume 3, No.2.

Dunham, J., ***A Guide to Property Values, Data and Analysis from the Records of the Valuer General – Victoria***, Department of Natural Resources and Environment, 2000 Edition.

Ellis, L. and Andrews, D., 2001, “City Sizes, Housing Costs, And Wealth,” ***Research Discussion Paper 2001-08***, October 2001, Economic Research Department, Reserve Bank of Australia.

Epple, D., 1987, “Hedonic Prices and Implicit Markets: Estimating Demand and Supply Functions for Differentiated Products, ***Journal of Political Economy***, Vol 95, pp.59-80.

Fleming, M.C. and Nellis, J.G., 1985, "The Application of hedonic indexing Methods: A study of house prices in the United Kingdom", ***Statistical Journal***, Volume 3, September.

Gatzlaff, D.H., and Ling, D.C., 1994, "Measuring Changes in Local House Prices: An Empirical Investigation of Alternative Methodologies," ***Journal of Urban Economics***, Vol 35, pp.221-244.

Girouard, N. and Blöndal, S., 2001, "House Prices and Economic Activity," ***Economics Department Working Papers No. 279***, Organisation for Economic Co-operation and Development, January.

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

Gujarati, D.N., 2003, ***Basic Econometrics***, Fourth Edition, McGraw-Hill, New York.

Paris, C., 1993, ***Housing Australia***, MacMillan Education Australia Pty Ltd., 107 Moray Street, South Melbourne.

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

Rosen, S., 1974, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition" ***The Journal of Political Economy***, Volume 82, Issue 1 (Jan.-Feb., 1974), 34-55.

Rossini, P.A., Koomans, R.R., & Kershaw, P.J., 1995, "Constant Quality House Prices in an Australian Context, A Case Study of Port Pirie, South Australia," unpublished paper presented at ***Pacific Rim Real Estate Society Conference***, RMIT University, 23-24 January, 1995.

Stevens, G.R., 1997, "Some Observations on Low Inflation and Household Finances," Reserve Bank of Australia ***Bulletin***, October, pp 38-47.

Streeting, M., 1990, "A Survey of the Hedonic Price Technique," Resource Assessment Commission, ***RAC Research Paper No.1***, September.