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Peter Bacon & Associates
ECONOMIC CONSULTANTS

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Methodological Issues in the Design of a Residential Letting Price Index for Dublin

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Executive Summary

1. Four general methodological approaches to constructing a house price index can be identified in the literature and these have been used to varying degrees in different areas. There is no definitive conclusion as to which index is best and the answer will depend to an extent on the nature of the data that are available. The four approaches use mean prices, the median price, repeat contracts and an hedonic methodology. This report contains estimates of the trend in rental values in Dublin produced using modified versions of all four approaches applied to a database containing rental values for 368 apartments in Dublin City centre and 320 apartments in surrounding areas for the 4 years 2000 to 2003.

2. Using the mean and median prices to estimate price changes gives the following results. A modified mean was used which excluded the 5 highest values in each year so as to reduce the impact of outliers on the results.

Table A: Indices Estimated using Mean and Median Values

	Mean Values		Median Values	
	City	Suburbs	City	Suburbs
2000	100	100	100	100
2001	112.27	115.25	107.09	108.55
2002	117.76	114.97	118.11	111.61
2003	123.39	109.40	118.11	108.01

These methodologies may be useful in some cases but the potential for them to provide biased and erratic results with the current dataset means that they cannot be accepted to be sufficiently reliable metrics on which to base the index.

3. The remaining two approaches are considerably more complex in terms of index construction. They aim to control for the fact that property is not a homogenous good and has qualities that will affect its value. A modified dataset was used in the case of the repeat contracts approach to exclude properties where it was known that alterations in the underlying quality had occurred. The index values produced by these methodologies were calculated and the results are shown in Table B.

Table B: Results of Alternative Methodologies

	Repeat Contracts (limited)		Mix Adjusted	
	City	Suburbs	City	Suburbs
2000	100	100	100	100
2001	110.8	111.2	113.0	111.2
2002	114.6	114.1	118.5	118.4
2003	114.9	112.9	123.8	117.7

4. The annual percentage rise that results from the calculations by each method are shown in Table C. While similar trends for city and suburban properties are indicated by each of these methodologies, there are considerable differences between the values produced by the two approaches with the repeat contracts

approach showing lower rates of price increase in almost all cases. The market has eased considerably in 2003 in all areas even though monetary values in the city may not yet have fallen.

Table C: Estimated Annual Percentage Rental Value Increases

		Mean Values	Median Value	Repeats (limited data)	Mix Adjusted	CSO estimate
2001	City	12.3	7.1	10.8	13.0	16.55
	Suburbs	15.3	8.6	11.2	11.2	
2002	City	4.9	10.3	3.4	4.8	2.16
	Suburbs	-0.2	2.8	2.6	6.4	
2003	City	4.8	0.0	0.3	4.5	-3.02
	Suburbs	-4.8	-3.2	-1.0	-0.5	

5. Segmenting the market according to the quality of the apartments appears to be a relevant exercise. The estimates produced are shown in Table D and are generally consistent with the trends identified apart from the very strong performance of the high end of the city apartment market in 2003.

Table D: Annual % Rental Changes for Market Segments

	City Index		**Suburban Index**	
	High	Low	High	Low
2001	12.31	14.31	19.97	14.3
2002	3.08	5.07	-0.35	6.62
2003	9.04	3.27	-3.66	-0.89

One explanation for these results may be that as the growth in rents in the city area for quality apartments eased, city apartments were seen as preferable substitutes for locations further from the city.

6. It is not possible at this stage to say that any one of these methodologies is inherently superior to the others. Certainly, it would be inadvisable to rely solely on the mean or the median even though they do not produce results greatly out of line with the others. The mix adjusted model is employed in Ireland to estimate house price indices but requires a lot of information on each property. On the other hand, the repeat contracts approach is generally used where the dataset has a high number of matches as is the case here. Since the methodology should be the most appropriate for the dataset that is available, the modified version of the repeat contracts approach would appear to have certain advantages. This methodology is not as demanding in terms of the data that are required as the hedonic approach and the variables in the dataset can be used to improve the accuracy of the estimates.

1. Review of Relevant Methodologies

1.1 Overview

There are obvious similarities between the requirements of a price index for property rental values and a house price index. The main issue that must be handled in the construction of both is that there is no homogenous good that can be described as a house. Four general methodological approaches to constructing a house price index can be identified in the literature and these have been used to varying degrees in different areas. There is no definitive conclusion as to which index is best and the answer will depend to an extent on the nature of the data that are available. This report outlines each of the approaches, including some modifications where appropriate, and calculates price indices for the dataset of rental properties. The dataset contains rental values for 368 apartments in Dublin City centre and 320 apartments in surrounding areas for the 4 years 2000 to 2003

The two simplest approaches are to base the index on the mean or the median rental values of each property. While these are somewhat simplistic, the literature contains a number of instances where these easily applied and understood approaches provide good indications of changes in prices and they are still widely used. These are dealt with below and their short-comings are noted.

Two alternative approaches are dealt with in following sections and, while quite different in terms of their methodologies, they share a common belief that due to the nature of property it is important to focus on the qualities of the properties and to adjust the values as these qualities change from one period to the next. This is done in the repeat contracts methodology by comparing the rental values obtained for the same property in different periods and then calculating the change in price in annual terms. The final hedonic or mix adjusted approach most closely resembles the methodology that is employed in commonly cited house price indices in Ireland, but this should not be taken to mean that it is therefore inherently superior given the dataset that is available here. The basis of this approach is to identify a typical house in a base year by assessing the occurrence of certain characteristics in all the properties for which observations in that year exist. Then, by comparing the frequency of occurrence of qualities in the base year with subsequent years, any changes in prices can be concluded to result from price changes rather than changes in the underlying properties or the mix of properties for which data are available.

In addition to showing trends over time the estimates are produced separately for the city and suburbs and indicate some differences in trends in these two areas. There is no guarantee that all or any of these approaches will provide similar estimates and comparisons are drawn between the estimates that are produced. These are also compared with the rental price index that is compiled by the CSO and used in calculating the general consumer price index in Ireland. Where differences in the values estimated are observed possible explanations are provided. In addition, the relative strengths and weaknesses of each approach are identified. Although the number of observations in the dataset varies from year to year, the consultants are

satisfied that it is sufficient to provide estimates within acceptable levels of statistical error.

1.2 Mean (Average) Prices

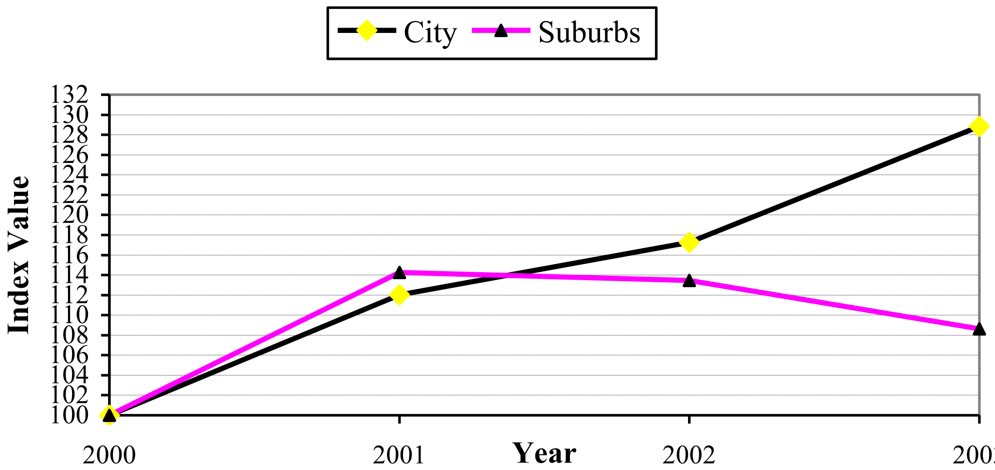
The first methodology is to find the average value of all trades undertaken in each particular period and calculate the change from one period to another. This approach is used by the Department of the Environment, Heritage and Local Government (DoEHLG) in compiling their index of house prices[1]. The results obtained by applying this approach to the dataset are shown in Table 1.1[2].

Table 1.1: Mean Rental Values Index

	Mean Value (€/month)		Percentage Increase		Index	
	City	Suburb	City	Suburb	City	Suburb
2000	928.79	1,193.09			100	100
2001	1,040.36	1,363.17	12.0	14.3	112.01	114.26
2002	1,089.21	1,354.81	4.7	-0.7	117.27	113.47
2003	1,197.61	1,296.91	9.9	-4.3	128.84	108.62

This indicates that although average values in the suburbs are higher than in the city area, the rate of growth has been much lower in recent years and has been negative in 2003[3]. In contrast, the results indicate that market conditions in the city area have remained very strong in 2003. These trends are shown in Figure 1.1.

Figure 1.1: Mean Values Residential Letting Price Index



This is the simplest approach but contains the underlying assumptions that the

[1] The DoEHLG has been working on changing from this model but this work will not be completed until 2004 at the earliest.

[2] When interpreting these and other results in this report it is important to remember that the estimates provided relate to contracts undertaken in the period. Thus, an average increase of 4.7% as indicated for the city in 2002 does not mean that the average rents received rose by 4.7%. Instead, the average rent for properties for which a new contract was formed was 4.7% higher in 2002 than in 2001. In contrast to house prices where a price can be assigned to a property even when it is not sold on the basis of observed increases, the same cannot be done for rental values that clearly remain unchanged for the period of the contract.

[3] The higher rental values in the suburbs are explained by larger apartments in these areas.

properties rented in any particular time period are typical of all properties and of those rented in other periods. The problem is that while the properties traded in one period might be typical of all properties existing at that time – this is not certain but can be assumed, excluding outliers, on the basis of sampling theory – the characteristics of the total stock of houses do change over time. This is the biggest problem to be overcome in construction an index of property values. A further problem is that, like any other average, this average is affected by outliers, in particular, very high value properties. In this case, city data had a small number of very high value entries in 2003 while the suburban data indicate some very high individual values in 2000 and 2002. As a result, the average returns may not relate to what is happening to a typical property.

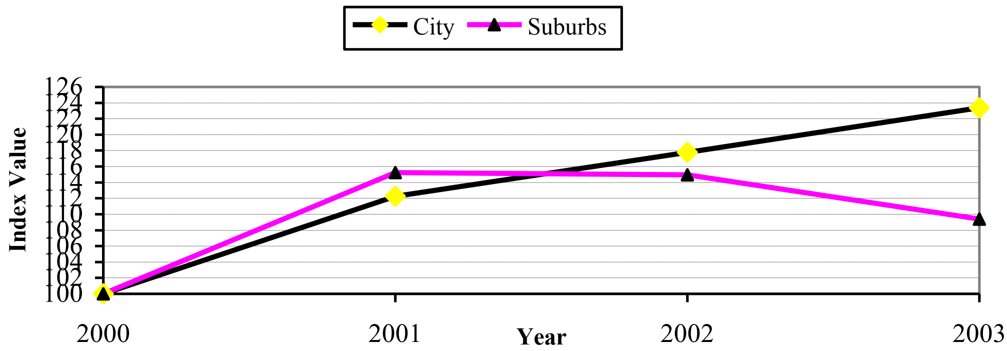
Excluding outliers can help improve the accuracy of the estimates produced by this methodology and the literature suggests that, in periods of stable price trends – for example when prices are rising consistently – the results here can be quite good. The calculation was redone but the top 5 most expensive properties were excluded in each year. The results of this modified mean methodology are shown in Table 1.2 and Figure 1.2[4].

Table 1.2: Modified Mean Rental Values Index

	Mean Value (€/month)		Percentage Increase		Index	
	City	Suburb	City	Suburb	City	Suburb
2000	909.92	1,121.87			100	100
2001	1,021.53	1,292.97	12.3	15.3	112.27	115.25
2002	1,071.50	1,289.76	4.9	-0.2	117.76	114.97
2003	1,122.71	1,227.35	4.8	-4.8	123.39	109.40

The effect of this adjustment is to generally smooth the trends somewhat but not to alter them radically. The clear picture is that city rents continue to rise, albeit more slowly than in earlier years, but that market conditions are much softer in the suburbs where rents have fallen in 2003[5].

Figure 1.2: Modified Mean Values Residential Letting Price Index



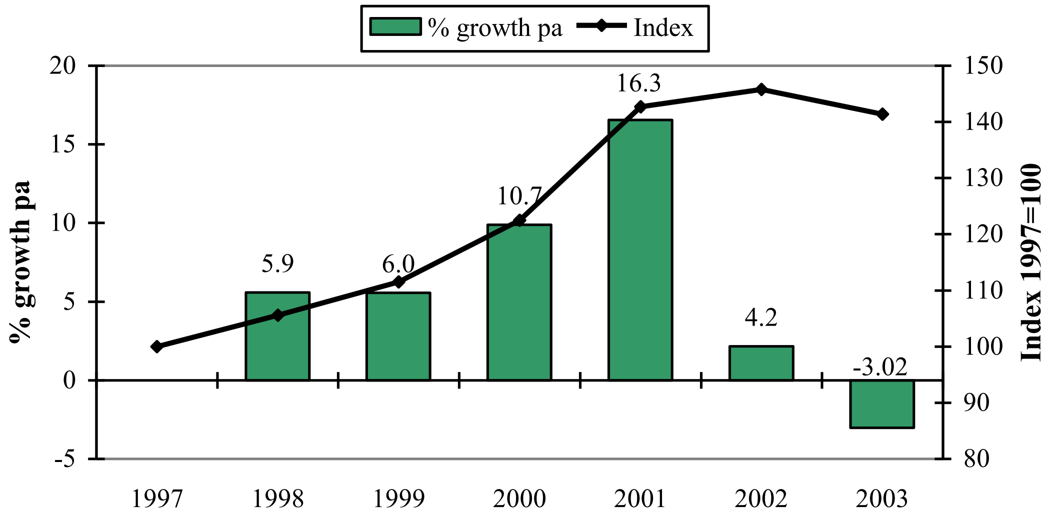
[4] In interpreting this graph, it is important to remember that the vertical scale is an index. This means that what may appear visually as a straight line, for example the city index for 2001 to 2003, should not be interpreted as suggesting a constant rate of growth. If an index is rising linearly it means that the rate of increase is slowing.

[5] Of course, this conclusion is stated only as the result produced by this methodology and not as an overall judgement on the market.

While adjustments such as this are obviously somewhat arbitrary in nature it is considered that this modification is more likely to produce an estimate that is more typical of the property market in any given year. As a result, these estimates are used to represent the values produced by the mean value approach. In general, the literature suggests that this approach tends to overestimate property price changes in both directions and the results are less reliable in periods of volatility when, arguably, accurate measures are most required[6]. As will be seen below, the estimates produced in this report generally support this finding.

The CSO also produces an estimate of rental values based on mean values. Data on rents are collected every February, May, August and November. Local authority rent data are also collected every March, June, September and December for inclusion in the CPI calculations but are excluded here. Estate agents and management companies throughout the country supply private rent data but it is not possible to net out the Dublin data separately[7]. The trends in rental values in recent years are shown in Figure 1.3[8].

Figure 1.3: CSO Data on Rents



In line with the estimates for the suburban area, this suggests a much weaker market in 2003. However, as this includes apartments spread across the whole country it may not be sufficiently precise top indicate trends in Dublin city centre.

1.3 The Median Price

Using the median to identify changes in rental values represents a fairly similar approach to the above except that the use of the median means that the impact of outliers is reduced. This removes the need for arbitrary decisions regarding exclusion.

[6] Conniffe, D. and D. Duffy (1999) 'Irish House Price Indices: Methodological Issues'. *The Economic and Social Review*, Vol. 30 (4), pp. 403-423

[7] Annual growth rates in this figure are to mid-July year-on-year

[8] The limited data repeat contracts approach is used in this comparison. The modified mean values are used throughout this section.

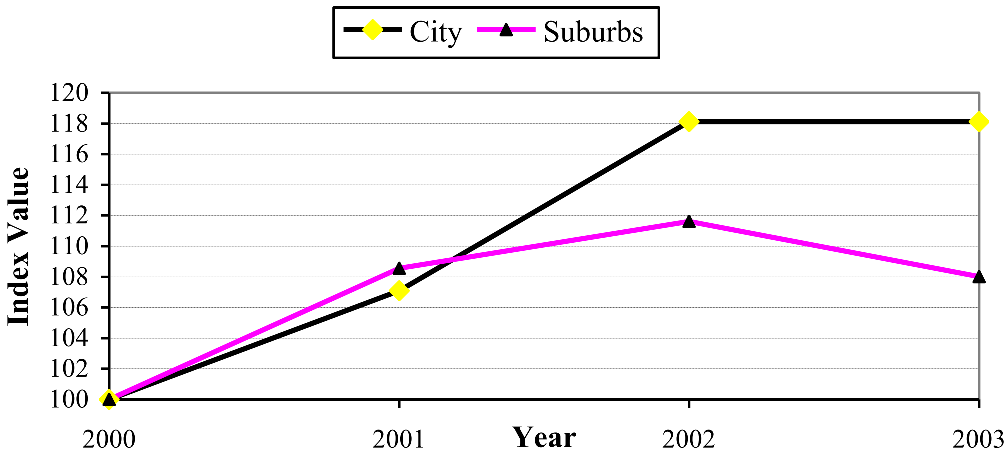
The literature suggests that the results produced by the median tend to be closer to the outcome of other models than in the case of the mean and that trends are smoothed[9]. However, while this problem – related to the assumption that the properties for which data are available in any period are typical of the range of properties – is reduced, the estimates remain susceptible to error as the characteristics of the housing stock change over time. Thus, the use of the median does not address the second problem identified with the mean.

The estimates obtained by using the median are shown in Table 1.3 and are illustrated in Figure 1.4.

Table 1.3: Median Rental Values Index

	Mean Value (€/month)		Percentage Increase		Index	
	City	Suburb	City	Suburb	City	Suburb
2000	889	1,111			100	100
2001	952	1,206	7.1	8.6	107.09	108.55
2002	1,050	1,240	10.3	2.8	118.11	111.61
2003	1,050	1,200	0.0	-3.2	118.11	108.01

Figure 1.4: Median Residential Letting Price Index



These estimates show a somewhat different picture than emerged using the mean suggesting lower increases in most of the earlier years and a flat market in the city with falls in suburban areas in 2003. However, use of the median with this dataset gives rise to a further problem. Although rental data are potentially continuous, this is not likely to be the case when using a dataset with a limited number of properties. The result is that the estimates produced can be erratic. This arises because even a small change in the property identified as the median in any year may have a large impact on the annual change in value. For example, for the city apartments, the median value is €1,050 in 2002 showing a rise in rental costs of 10.3% in 2002 and 0% in 2003. However, if the apartment with the next highest value was taken as the median then the value in 2002 is €1,079 per month. This would give a rise of 13.3%

[9] Conniffe and Duffy *op. cit*. found that the median produced intermediate measures of price growth rates when compared to other methodologies and was closest to the results produced by the Hedonic approach described below. They describe as 'unusual' a finding by one group of researchers that the results produced by the median were inferior to the mean.

in 2002 and a fall of 2.7% in 2003. As a result of this problem, the consultants conclude that the median, while a potentially useful indicator of change when used with large datasets would be inappropriate to use in this case.

1.4 Examining Repeat Contracts

The repeat contracts approach is an intuitively simple approach to handling the problem that the underlying qualities of properties may change over time. The methodology matches the rents for the same property in different years and puts any change down to price inflation. Properties that undergo major refurbishment would have to be excluded while matches could conceivably be made between closely similar properties for which observations exist in different years. This approach is popular in the US for compiling house price indices where large integrated databases exist, but is not used extensively in Ireland or the UK because of the dispersion of data on sequential trades among commercial organisations and the lack of a Zip postal system. With regards to the existing database, these problems do not arise and therefore this approach is worthy of consideration.

Three potential problems arise. The first is that the valid data in any year are restricted to a sub-set of all the properties for which data on new contracts are available. Furthermore, for the current dataset, the number of possible matches is likely to be much higher in 2002 than in 2001 – since it can be matched with both 2000 and 2001 – and lower in 2003 since the year is only half over. The importance of this problem would be greatly reduced as data accumulate over subsequent years.

The second potential problem is that the quality of individual properties may change over time. Thus, price changes would be due to these alterations rather than monetary factors, but this would not be picked up in the analysis. It is possible to provide some check for this possibility by limiting the assessment to some time period only. This is done and estimates are produced. However, it is not thought that this should be a major problem in the existing dataset. Changes in the condition of individual properties can be identified through changes in the grades assigned and the data also allow for occasional changes in practice regarding the separate renting of parking spaces in some periods. If either happens, the property is effectively not the same item in the two observations. The methodology is further refined in the estimation by excluding matches where this occurs.

The third potential problem is that this approach continues to assume that the properties for which observations are available in any given year are typical of all properties. Clearly where national data are available as in the US this is not an issue. However, there is no guarantee that this is the case with this dataset and it is not possible to control for this sampling error in this methodology. This means that the estimates produced should be interpreted as indicating the general change in rental values only if it is assumed that the sample contained in the dataset is an unbiased sample of all apartments in Dublin.

The methodology for this approach is set out in Section 2 and estimates are produced for the city and for the suburban properties. Estimates are also produced for the modified versions of this approach.

1.5 The Hedonic Mix Adjusted Approach

Residential property is not an homogenous good but a good that is made up of a number of different characteristics the quality of each of which can determine the value that will be placed on the property. Location is an obvious characteristic affecting price along with size, condition, proximity to facilities, type of property and others. The defining characteristic of the hedonic approach is that it overtly recognises that there is no typical apartment but that all properties can be categorised according to predetermined characteristics. An 'average' house is defined for a base year according to the occurrence of a pre-specified set of characteristics or qualities. Each characteristic is given a weighting according to its occurrence and is then 'priced' for this year according to the proportion of the total rental value that is assigned to the presence of this characteristic. Occurrence of each characteristic in the base year is compared with its occurrence in subsequent years. Their frequency of occurrence in this latter year is used to derive a predicted value for properties in that year that can be compared with the actual outcome. Thus, by controlling for the relative importance of each characteristic in each year in terms of all observations, it can then be concluded that any difference between the predicted rental value and the actual value implies price inflation or deflation for similar products.

In some respects this methodology is akin to the approach that underlies the CPI which is based on a 'basket' of goods that are weighted at regular intervals according to the *Household Budget Survey*. In this case the basket is replaced by the property. The extra complication is that, unlike the situation with the CPI where the contents of the basket and the price of each is known, the contents of the basket i.e. the characteristics that determine rents, are not well known and are not priced individually. This means that the relative importance or contribution of each factor in determining the value of the property must be identified through regression.

The literature, reviewed below, contains many attempts to define the set of characteristics that is most relevant but it is probably true to say that the set will vary from place to place. For example, within the context of the existing dataset it is likely that a good view over the coast might be a key variable in determining value in the suburbs, while security or ambient noise might be important issues in the city. Being able to identify which characteristics are relevant is the first requirement and regression analysis is used for this purpose. However, acceptable results will only be achieved if appropriate numerical values can be placed on variables and this poses obvious problems, for example, in relating one view to another. In addition, the data are seldom as rich as might be hoped. However, the grading system that is used in the dataset provides a proxy for a number of what are actually qualitative factors and greatly simplifies the use of this approach.

This approach has been developed in the UK and the methodology underlies the permanent-tsb/ESRI House Price Index. One advantage, given the fairly short time period for which data are available, is that this methodology requires only a base year and one other year. Naturally, a greater number of years can reduce any sampling errors that may appear and may also help in identifying if there are missing variables. The main drawback is that this is a complex methodology that requires more, and richer, data than the other approaches. However, the available dataset is an adequate basis on which to proceed. In utilising these data a key assumption is that the grades that are applied to properties in the dataset are appropriate. If not, the regression will identify this problem and it is likely that the available variables will have insufficient explanatory power to enable reliable estimates to be derived.

The Hedonic approach is also used below on a derived dataset to examine if rental value trends have differed between different segments of the market. This is done by segmenting the properties according to their values, having first controlled for apartment size, into low and high end market segments. The results show this to be an important procedure.

2. The Repeat Contracts Approach

2.1 Methodology

As well as recognising that problems with estimating indices may arise due to the potential for volatility to be introduced in poorly integrated markets, the repeat contracts approach also recognises the heterogeneity of housing as a transacted good. As a result, the technique has been used to control for differences in the quality of the houses comprising the sample used for statistical estimation. For this reason the repeat contract index has been described as a "constant quality" price index. The methodology was first proposed for developing real estate price indices 35 years ago has been used quite widely in compiling indices particularly in the US[10]. Its relative rarity in Ireland and the UK stems from the fact that there are many mortgage suppliers each with their own databases. Few houses appear more than once in any particular dataset and where they do it is likely that there may be some underlying factor that causes this. As a result, they would not be typical of all properties. However, this is not a problem in this case given the existence of this single dataset.

The methodology has been further refined by a number of researchers who made important advancements in the technique in recent times. This work includes direct methodological studies to ensure that distortions are not introduced by the methodology and studies that compare the results with other approaches for common datasets[11]. The methodology has been further refined by research such as that by Case and Shiller[12] who use the methodology to examine whether the fact that property transactions mostly involve trades between private individuals undertaking transactions involving the whole assets – rather than public auctions of optimal proportions – has implications for property ownership as part of a balanced portfolio and Goetzmann[13] who examined the relative returns from property within a portfolio. The literature contains a number of examples of the methodology being applied to

[10] Bailey, M., R. Muth and H. Nourse (1963) 'A Regression Method for Real Estate Price Index Construction'. *Journal of the American Statistical Association*, Vol. 58, pp. 933-942

11 See, Gatzlaff, D. and D. Haurin (1997) 'Sample Selection Bias and Repeat Index Estimates'. Journal *of Real Estate Finance and Economics,* Vol. 14, pp. 33-50. Also, Clapp, J. and C. Giacotto (1992) 'Estimating Price Induces for Residential Property: A Comparison of Repeat Sales and Assessed Value Methods'. *Journal of the American Statistical Association*, Vol. 87, pp. 300-306, and Gatzlaff, D. and Geltner, D. (1998) 'A Transaction-based Index of Commercial Property and its Comparison to the NCREIF Index. *Real Estate Finance*, Vol. 15(1) pp 7-22. For a general overview see Case, B., H. Pollakowski and S. Wachter (1991) 'On Choosing Among House Price Index Methodologies'. *AREUEA Journal*, Vol. 19(3) pp 286-307.

[12] Case, K. and R. Shiller (1989) 'The Efficiency of the Market for Single-Family Homes' *American Economic Review*, Vol. 79, pp. 125-137.

[13] Goetzmann, W. (1990) 'The Performance of Real Estate as an Asset Class'. *Journal of Applied Corporate Finance,* Vol. 3, pp. 65-76

datasets[14] and it underlies the official index produced by the Office of Federal Housing Enterprise Oversight[15].

The great benefit of the repeat contracts approach is that it limits the extent to which changes in the composition of the sample used for estimation can influence the estimated index. By utilising information on the values of the same physical units at two points in time the approach controls for differences in housing attributes across properties in the sample without estimating their marginal contribution to total value. This makes it considerably simpler and less demanding in terms of data than the mix adjusted approach discussed below. Multivariate regression is employed to account for the fact that all properties do not transact in every period.

Two potential problems arise in using this approach. First, while the information that is required on individual properties to utilise this methodology is limited, the number of observations from any year that can be used is only a subset of the total available due to the need to find matches. Thus, there is considerable 'wasted' data. One way to increase the number would be to match what are considered to be similar properties at different times rather than looking for the identical property to reappear in the data. While this would increase the number of available observations in any year, there are problems since it inevitably introduces the need for judgements in relation to the properties. Since apartments with similar addresses might have rather different qualities that can affect prices, it was decided that the potential for errors to be introduced exceeded the likely gains from doing this given the data variables that are available. As a result, only repeat observations of the exact property were included.

Second, it is not certain that actual properties will not have changed over time. Researchers are aware of this problem and have used modified versions of the methodology to attempt to control for the influence of such changes. These have generally involved weighting for instances of repeats where there is a long period of time between observations. This issue is examined below. However, the dataset also makes it possible to control for this problem where it is clear that there have been alterations to the property irrespective of the time between repeat observations. The estimates are recalculated to examine if this is a relevant issue with this methodology.

The methodology requires that at least one contract value must be observable for each period for which the index value is to be estimated and that the total number of repeat contract observations must be at least equal to the number of periods. These are not particularly onerous requirements and pose no constraint with the current dataset. The procedure involved in this approach can be described by using a simple numerical example that gives periodic index changes[16]. Assume a dataset of four properties with four years of observation. The data are shown in Table 2.1 and are

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[14] For examples, see Gatzlaff, D. (1997) 'House Price Appreciation' in *The State of Florida's Housing*. Real Estate Research Centre, University of Florida and Abraham, J. and W. Schauman (1991) 'New Evidence on Home Prices from Freddie Mac Repeat Sales'. *AREUEA Journal* Vol. 19(3) pp. 333-352

[15] Calhoun, C. (1996) *OFHEO House Price Indexes: HPI Technical Description*, OFHEO: Washington, D.C. provides a review of the precise methodology employed in compiling the official indices.

[16] The example is loosely based on Gatzlaff, D. and Geltner, D. (1998) 'A Transaction-based Index of Commercial Property and its Comparison to the NCREIF Index. *Real Estate Finance*, Vol. 15(1) pp 7-22

constructed such that the rise in value in 2000-01 was 5%, in 2001-02 it was 3% and in 2002-03 it was 7% (after rounding to whole €). In practice, of course, these values will not be known in advance since they are the results that are to be produced by the procedure. Blank cells indicate that the rent was not subject to any review in that period i.e. there is no repeat observation.

Table 2.1: Assumed Values for Illustration (€ per month)

	2000	2001	2002	2003
Property A	1,000			1,157
Property B	2,299	2,414		
Property C	696		752	
Property D		1,738	1,791	

Assume the rates of growth are not known. Let r_t represent the percentage rate of growth of rental values in year t. Equations to describe the rents in these properties could be written as follows:

Property A: $1,000*(1+r_{01})*(1+r_{02})*(1+r_{03}) = 1,157$
Property B: $2,299*(1+r_{01}) = 2,414$
Property C: $696*(1+r_{01})*(1+r_{02} = 752$
Property D: $1,738*(1+r_{02}) = 1,791$

The system is multiplicative since the increase involves compounding when more than 2 observations are observed for any property. To make it additive, express the values as natural logs after dividing both sides by the first observed rental value for each property. This gives the following system of equations.

Property A: $LN(1,157/1,000) = LN\,(1+r_{01}) + LN(1+r_{02}) + LN(1+r_{03})$
Property B: $LN(2,414/2,299) = LN\,(1+r_{01})$
Property C: $LN(752/696) = LN\,(1+r_{01}) + LN(1+r_{02})$
Property D: $LN(1,791/1,738) = LN(1+r_{02})$

The right-hand-side (rhs) of this series of equations can be rewritten as the product of these variables and a dummy variable that takes on a value of 1 in a year for which an observation is present and zero when no observation is made. The equations are now:

Property A: $LN(1,157/1,000) = LN\,(1+r_{01})*1 + LN(1+r_{02})*1 + LN(1+r_{03})*1$
Property B: $LN(2,414/2,299) = LN\,(1+r_{01})*1 + LN(1+r_{02})*0 + LN(1+r_{03})*0$
Property C: $LN(752/696) = LN\,(1+r_{01})*1 + LN(1+r_{02})*1 + LN(1+r_{03})*0$
Property D: $LN(1,791/1,738) = LN\,(1+r_{01})*0 + LN(1+r_{02})*1 + LN(1+r_{03})*0$

It is clear that this has not changed the value of any equation but this standardisation now makes it possible to use linear regression to estimate the variables $r_{01,}$ r_{02} and r_{03}. Labelling these variables as β, the regression equation can be expressed as:

$$Y = D\beta + \varepsilon$$

where Y is a column vector of the log rental value relative observations, β is a column vector of year by year percentage growth (the answers required), D is a dummy variable matrix whose rows correspond to the observations and columns correspond

to the time periods, and ε is a column vector of the regression error terms. These errors arise from 'noise' in the system i.e. any difference between what the regression predicts will be the cumulative growth and the actual growth observed (or assumed as in the case of this example). Obviously, in this example, the errors will sum to zero since the values were constructed using precisely the same growth rate for each property. In reality, there will be some variation. However, this variation is likely to be limited since, as with the existing actual dataset, the number of observations greatly exceeds the number of time periods for which growth rates were to be estimated. This greatly increases the degrees of freedom present and the regression will be better able to filter out this noise.

The set of linear equations to be estimated in this example will be limited to the four equations above. For the dataset as a whole, the only differences will be that there will be a number of equations equal to the number of properties and that the Y values i.e. the dependent variables on the left hand side (lhs) will depend on the actual observed values contained in the dataset. This is why the number of observations must at least equal the number of time periods i.e. to ensure that there are as many equations as there are unknowns.

In this example, the regression results are:

estimated $\beta_{01} = 0.0488$ $LN(1.05)$
estimated $\beta_{02} = 0.0295$ $LN(1.03)$
estimated $\beta_{03} = 0.0677$ $LN(1.07)$

Clearly, this has returned the precise rates if growth used in constructing the data as there is no noise i.e. errors are zero. In practice, to minimise the impact of noise, it may be necessary to use a weighted least squares methodology to do the regression.

2.2 Estimated Values for the Index

Separate indices have been compiled for city area and the suburban area. Initially, equal weightings were applied to all the information available in compiling the index. This is revised below. Adopting a value of 100 for values in the year 2000, the resulting indices are shown in Table 2.2 along with the implied annual percentage increases.

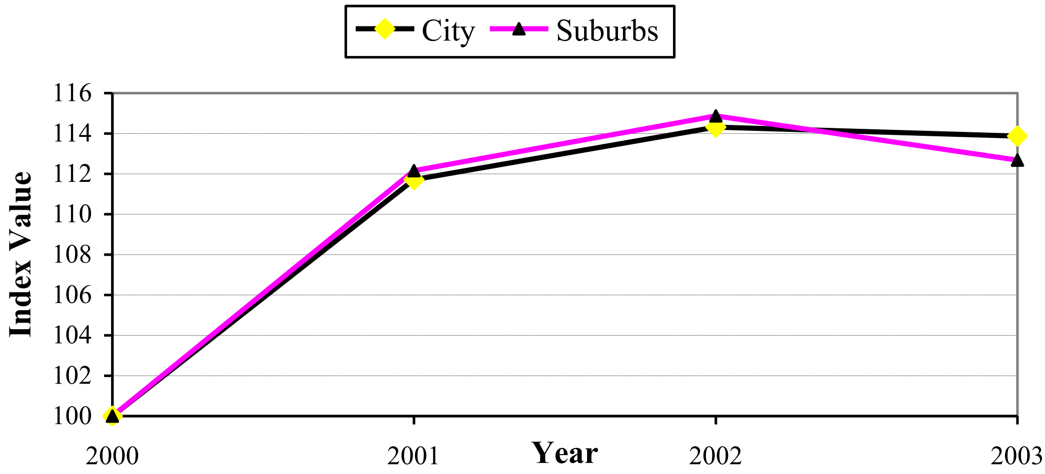
Table 2.2: Repeat Contracts Residential Letting Indices

	City Property		Suburban Property	
	Index	Annual %	Index	Annual %
2000	100		100	
2001	111.72	11.7	112.16	12.2
2002	114.31	2.3	114.87	2.4
2003	113.88	-0.4	112.68	-1.9

The technical results of the methodology are contained in Appendix A1. The R-squared value resulting from the regression used to obtain the city index was 0.623

and was 0.642 for the suburban index[17]. These values indicate acceptable levels of explanatory power in the regressions. Figure 2.1 shows the index values plotted against the given year for the city and suburban regions respectively. This shows that rental prices have risen at similar rates in the two areas but that the rate of increase has levelled off and may have fallen back slightly in 2003, particularly in the suburban areas.

Figure 2.1: Repeat Contract Residential Letting Price Index



It has been suggested in the literature that a hybrid of the repeat contract and mix adjusted models is possible and has suggested improved results in some instances. In this case, the basic methodology of comparing values for the same property at different points in time is retained. The innovation to allow for the possibility of changes in the underlying quality of the properties is the recognition that the longer is the period of time between successive observations the greater are the chances that the quality of the underlying property will have changed. To accommodate this, researchers have attempted to assign appropriate weights to observations on the basis of the length of time between observations. Thus, observations from successive years will be given a greater weighting in the calculation relative to observations that are a number of years apart. Alternatively, observations that occur further apart than a predetermined number of years can be excluded. In order to evaluate if the weighting of any particular price comparisons would have an effect on the trend observed above, the repeat contracts index was re-evaluated with all the 3 year comparisons taken out. The index obtained is shown in Table 2.3 and Figure 2.2.

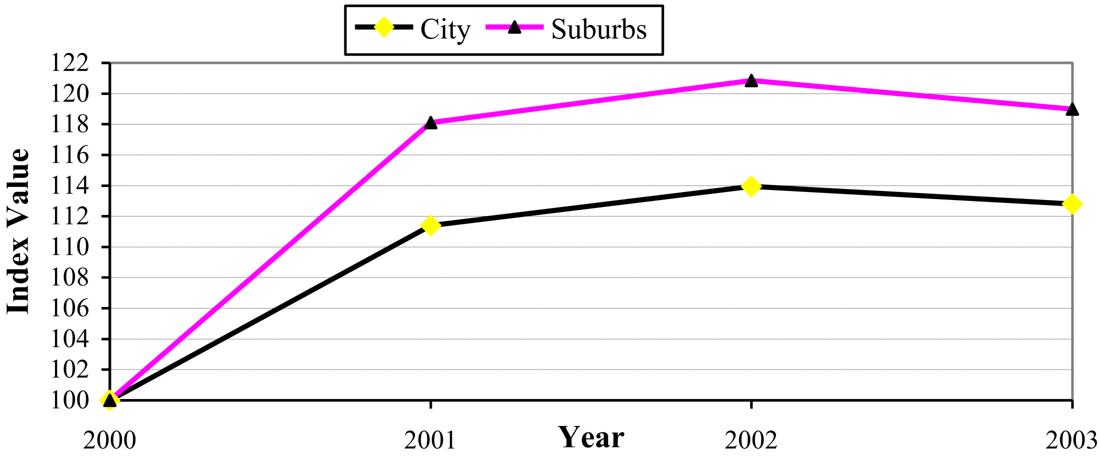
Table 2.3: Constrained Repeat Contracts Index

	City Property	Suburban Property
2000	100	100
2001	111.39	118.10
2002	113.94	120.84
2003	112.80	118.99

[17] For regression through the origin i.e. the no-intercept model as used here, R-square measures the proportion of variability about the origin in the dependent variable that is explained by the regression. This statistic cannot be compared to R-square measures for models which include an intercept as is used in the mix adjusted methodology below.

In this case, the R-squared values from the regressions used were 0.60 for the city data and was 0.673 for the suburban data. Again these are acceptable values.

Figure 2.2: Constrained Repeat Contracts Index



It initially appears that this revision has had a meaningful impact on the results obtained. However, closer examination shows that the city values are almost identical in the two versions of the model and are well within what might be considered to be reasonable error intervals for the results. The new results for the suburban properties are compared with the unconstrained model from above and the results found using the mix adjusted model in the next section in Table 2.4.

Table 2.4: Effect of Constraining the Suburban Repeat Contracts Index

	Repeat Contracts		Mix Adjusted
	All Years	Constrained	
2000	100	100	100
2001	112.16	118.10	111.24
2002	114.87	120.84	118.38
2003	112.68	118.99	117.74

This shows that the constrained model index in years 2002 and 2003 is now much closer to the mix adjusted results. However, before it can be accepted that this indicates more reliable values it should be recalled that the number of data observations that can now be used in compiling the repeat contracts estimates is reduced. While the results for the suburban properties are indeed altered, the change in the index relies on a very large, non-credible rise in 2000-2001 when the number of valid observations that can be included in the constrained model is lowest. In fact, the annual percentage rise in 2002 and 2003 remains close what was found originally using all the data. Furthermore, as will be seen in the next section, the R-square values of the regressions for the suburban properties in deriving the mix adjusted values turn out to be rather low.

Since the city index is largely unchanged and these doubts are introduced in respect of the suburban index, it is concluded that weighting against long time interval price comparisons will have little effect on the final results and that there is no improvement in accuracy through constraining the model in this manner. This is not altogether unexpected for two reasons. First, the number of years for which results are available is low so the quality of the properties will not have changed greatly.

However, the low number of years is not a great problem since the fact that repeat contracts in respect of rental properties are more likely to appear fairly close together, unlike in the case of traded properties where transaction costs are much higher and properties are traded much less regularly. Thus, the rate of occurrence of repeats is fairly high. Second, in contrast to house prices where application of this revision has showed some impact, tenants are much less likely to alter the property than would be the case with owner-occupiers who would be the main buyers and sellers of residential property. Thus, the property is more likely to remain unchanged over any period in respect of the properties in this data set.

However, it is clear from the dataset that some changes so occur. The dataset has an advantage over those on which the literature is based in that the occurrence of these changes is easy to identify. Two variables indicate potentially important variables that could distort the results. The first relates to parking. In a number of cases parking is included in the rent in one period but excluded in another. This is particularly the case in the city area where parking spaces have a distinct value and can be treated exclusively. The second is the grade that is assigned to each property. This is a particularly valuable variable as indicated in the next section and identifies where, in the judgement of property experts, the underlying quality of the property has changed. Clearly this will change the rental value in a stable market and it can be argued that the two observations do not relate to the letting of identical properties although it is the same property.

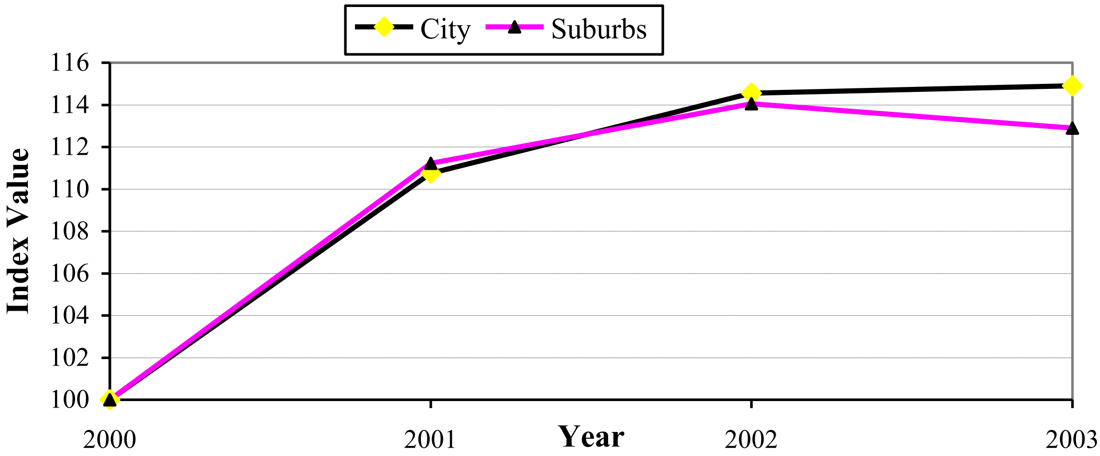
The repeat contracts methodology was redone on a dataset from which properties that changed grade or for which the situation in relation to parking had changed were removed. (This will be referred to as the limited data approach). Taking out all the comparisons in which there was a change in grade or change in the parking status has resulted in smaller datasets. The original city dataset had 571 comparisons (observations) while the modified dataset with no grade change or parking status change had 365 observations. This represents a 36.08% reduction in the number of observations used in the new regression for the city index. The original suburb dataset had 256 observations while the modified dataset with no grade change or parking status change had 211 observations. This represents a 17.57% reduction in the number of observations used in our new regression for the suburban index. The much lower number of deletions is because there are much fewer instances of parking being treated exclusively in the suburbs. The revised estimated indices are shown in Table 2.5 and illustrated in Figure 2.3 .

Table 2.5: Limited Data Repeat Contracts Index

	City Property	Suburban Property
2000	100	100
2001	110.75	111.22
2002	114.56	114.06
2003	114.91	112.90

In this case, the R-squared values from the regressions used were 0.694 for the city data and was 0.70 for the suburban data. Again these are acceptable values.

Figure 2.3: Limited Data Repeat Contracts Index



The effect of modifying the methodology in this manner is shown in Table 2.5 by comparing the percentage annual growth rates of the basic approach which includes all data with this approach which deletes certain data that are determined to relate to observations that should not be included. The net effect is to smooth the trends somewhat – the rate of increase is not quite as high in 2001 while the slowdown is not quite as pronounced either. Notably, this suggests that values have not actually fallen in the city in 2003 but may have stabilised.

Table 2.5: Repeat Contracts Approach with All Data and Limited Data (% pa)

	All Data		Limited Data	
	City	Suburbs	City	Suburbs
2001	11.7	12.2	10.75	11.22
2002	2.3	2.4	3.44	2.55
2003	-0.4	-1.9	0.31	-1.02

Overall, the change in the estimates produced as a result of this modification is not numerically large, but in the opinion of the consultants this is a meaningful and useful modification. It can now be concluded with greater certainty that the changes identified relate to monetary factors i.e. inflation, and not to changes in the underlying properties.

2.3 Assessment

Measuring price movements in property markets is particularly difficult, because the assets are highly heterogeneous and not necessarily frequently traded. A repeat contract index can be described as a "constant quality" index. The use of repeat contracts on the same physical property units helps to control for differences in the quality of the houses/apartments comprising the sample used for statistical estimation. The methodology has an advantage over the hedonic or mix adjusted indices described in the next section when lack of information in relation to important property characteristics occurs. Hedonic indices require consistent, detailed information of property characteristics whereas the repeat contract approach only

requires the periodic contract prices. However, this requirement has constrained their use in Ireland due to the lack of a comprehensive database of repeat contracts but is clearly not a problem in this instance. One potential problem is that the repeat contract index methodology is inherently wasteful of data, as only properties that have appeared at least twice in a given portfolio are eligible for inclusion the sample of repeat contracts. However, this is not a great problem here since repeat contracts for rental properties appear fairly close together, unlike in the case of traded properties where properties are traded much less regularly. The rate of occurrence of repeats is therefore sufficiently high. Furthermore, this issue would become less important over time.

The results obtained indicate that rental values in both the city and suburban areas have risen at similar rates, that the increase has slowed considerably in the past two years and that values are beginning to fall in the suburban area.

It has been suggested in the literature that the use of the repeat contracts methodology requires one to consider the implications of the elapsed time between observed contracts the assumption being that the sampling variability of observed changes in contract values will increase with the length of time between contracts changes as factors other than market appreciation are increasingly likely to influence the values of individual housing/apartment units. This was examined but was not found to have an impact on the results that could be interpreted in a reliable manner. However, this issue was re-examined by excluding observations where it was judged from the data that changes had occurred to properties. That the dataset allowed this to be done is an important factor to be considered in the decision regarding which is the best approach. This has the effect of smoothing the trends somewhat and concluded that values in the city area have not fallen in 2003. Although the changes in the estimates as a result of this modification were not large, it is clear that this increases the confidence that changes in prices are not due to changes in the underlying properties but are monetary. As a result, this modified approach is recommended and these revised estimates are used in drawing conclusions below.

3. The Mix Adjusted 'Hedonic' Index

3.1 Methodology

The Hedonic approach originated in the development of value indices for manufactured products that combined measures of quantity and quality. The basic technique is, for each time period, to regress price (or log price) on the set of variables measuring quality and take their regression coefficients as the implicit prices of the quality components. The index series is then produced by taking some standard set of frequencies of characteristics, usually those of the base year, and applying the successive sets of prices. This methodology underlies the main house price indices developed in recent years in Ireland and the UK to a large extent due to the influence of the index produced by the Halifax Building Society in the UK. The IP-ESRI index is a direct application of this as described in Baker and Duffy (1998)[18].

The Hedonic approach measures price in terms of the value of the set of attributes/characteristics that a property possesses. In order to remove that part of price variation due to changes in the mix of house characteristics over time, and so to measure the variation caused by inflationary factors, it is necessary to disaggregate prices into their constituents statistically. This is accomplished using multivariate regression analysis. On this basis it is possible, given data on the prices and the attributes of the houses/apartments rented in different time periods, to estimate the change in average price from one time period to another on a standardised basis.

The technical details of the construction of the Halifax House Price Index are described in Fleming and Nellis (1997)[19] and earlier papers by the same authors. Information on the characteristics of all properties is clearly very important in the construction of the Hedonic index and the Halifax database contained information on a number of house characteristics such as purchase price, location(region), type of property, age, tenure, number of rooms, number of separate toilets, number of garages etc.

In relation to the present study, a set of rental prices P_i (i=1,2,....n) may be observed in any time period (t) in which each apartment (i) is let. Apartments can be priced differently due to differences in qualitative characteristics (such as parking – yes/no), and to differences in quantitative characteristics (such as the number of bedrooms or the grading). Thus, for each house i, we can write P_i as some function of these various characteristics, X_j, together with a group of unmeasured factors (assumed to be randomly distributed) which are specific to each house but for which data are not available. This is the random error term, e_i. In general terms the relationship may be expressed as:

$$P_i = b_0 + b_1X_{1i} + b_2X_{2i} + \ldots\ldots\ldots\ldots\ldots b_jX_{ji} + e_i$$

[18] Baker, T. & D. Duffy (1998) *Irish Permanent House Price Index: Methodology Explained*.
[19] Fleming, M. and J. Nellis (1997) *The Halifax House Price Index: Technical Details*.

where b_1, b_2,…b_j are the regression coefficients corresponding to the qualitative and quantitative variables (X_j).

The Hedonic approach is used to derive the IP-ESRI house price index in Ireland. This index is calculated monthly and is based on the permanent-tsb database of properties traded in each month. The evidence indicates that this is a reasonably unbiased sample of all houses traded in Ireland. The variables included are size (square footage), the dwelling type, location, and type of heating fuel. Location has been a particularly difficult variable to measure appropriately because of the influence of what are described as micro-locational variables on which no information is available. Basically, these relate to the effect that small variations in physical location can have on prices. To try to accommodate the locational issue as far as possible the index divides the country into price bands and separate areas within Dublin. However, some of the division is somewhat arbitrary and further research has not indicated consistent correlations between the divisions and prices. This is an indication of the greatest drawback of this approach – that it requires precise and complex data that are not always available.

Some of the problems associated with the national price indices do not arise with the current database. It is less complex and divides the population into two areas – city and suburbs – and contains information on apartments only. The characteristics described include rental value, the number of bedrooms, whether there is a parking space and a grading level indicating the quality of the accommodation. Given the nature of the data employed in this study, qualitative characteristics can only be represented by 'dummy variables' which take the value of one or zero depending upon the presence or absence of a particular attribute. These are the variables on which the regressions are based, along with a constant term (an intercept) with rental value being the dependent variable. Therefore the explanatory variables are:

Variable 1: The number of bedrooms (A quantitative variable)
Variable 2: Parking Status (A qualitative variable; represented by a dummy variable, i.e. 1 or 0)
Variable 3: The apartment grading (A quantitative variable)

The technique of ordinary least squares or two stage least squares allows us to estimate the coefficients b_j pertaining to each of the explanatory variables X_j for any set of apartments. These coefficients indicate the relative importance of the variables in explaining the variation of house prices in any one time period t. The regressions then produce the regression coefficients corresponding to the three variables denoted as V1, V2 and V3 respectively in the technical appendix[20]. Having obtained estimates of the coefficients, b_j, it will be appreciated that the average price for any set or sub-set of apartments in any period depends on the number of observations on each characteristic in that period. Therefore, standardisation to allow for the varying mix of characteristics between one period and another may be accomplished by applying a standard 'representative' set of weights corresponding to the numbers of each characteristic observed in a chosen period. It is common to adopt as a standard, the

[20] It will be noted from the technical appendix that in a number of cases V3 is a constant and is deleted from the analysis. V3 relates to the availability of parking space, and for virtually all, and sometimes all, cases in the suburbs this is included with the apartment. When this happens it is not a relevant explanatory variable and is excluded.

set of characteristics that pertained in the base period and this is the practice adopted here. Thus, the index numbers calculated represent the movement of average prices for apartments possessing the same characteristics as for those rented in the base period. The index numbers themselves are computed by comparing the weighted prices in each period with the weighted average price in the base period.

The next step is to apply the methodology to derive index numbers. The methodology is applied here to produce base-weighted standardised price index numbers, whereby a weighted average of the estimated regression coefficients is calculated. The steps involved may be summarised as follows:

- Calculate the weights, Q_j (base period/year), the proportions of the qualitative variables and the means of the quantitative variables present in the base period.
- With price recorded in natural log form, use the technique of ordinary least squares or two stage least squares to estimate the regression coefficients b_j for the j explanatory variables, in both the base period (i.e. b_j (base period)) and for every subsequent time period t (b_{jt});
- Calculate the base-weighted index for the current period (I_t) as follows:

$$I_t = (\text{antilog} \sum b_{jt}Q_{j(\text{base period})})/(\text{antilog} \sum b_{j\ (\text{base period})}Q_{j(\text{base period})})\ *100$$

Summation is carried out over all variables included in each regression.

3.2 Estimated Index Values

The hedonic index values are calculated using actual rental prices but adjusted to allow for changing characteristics of apartments that comprise the sample in each year. Differences from the previous methodology would be expected if the qualities of the typical apartment changed over time, for example, if the overall quality was improving with time. This would not be adequately reflected in the repeat contracts approach in the short term. Separate indices have been compiled for city area and the suburban area. The calculated indices and the implied annual percentage price changes are shown in Table 3.1.

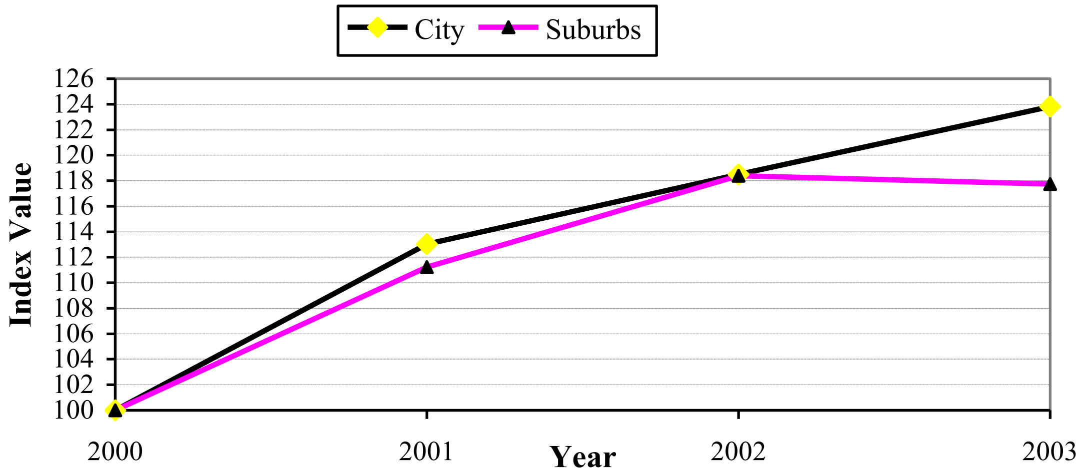
Table 3.1: Mix Adjusted (Hedonic) Rental Price Indices

	City Index		**Suburban Index**	
	Index	Annual %	Index	Annual %
2000	100		100	
2001	113.03	13.0	111.24	11.2
2002	118.51	4.8	118.38	6.4
2003	123.82	4.5	117.74	-0.5

Figure 3.1 shows these index estimates for each year for the city and suburbs respectively. The trends are somewhat similar to what was found by using the previous methodology. Furthermore, the price increases for the two areas are once again similar up to 2003, with the city performing more strongly in 2003. However, there are two important differences between the results produced by the two models. First, the rate of growth appears higher in almost all cases using this methodology.

Second, this methodology gives the result that prices in the city in 2003 are continuing to rise whereas the previous result was a virtually static outcome with respect to 2002.

Figure 3.1: Mix Adjusted Residential Letting Price Index



Two issues are important in terms of understanding the differences between the two models and must be considered in any assessment of the relative accuracy of the two sets of results. The first is that while the R squared values for all the regressions performed on the city prices and characteristics turned out to lie between the range of 0.701 and 0.814, the R squared values for regressions performed on suburban data lie in a wider and lower range of 0.566 and 0.715. Indeed, the r-square values for the city regressions found here are particularly high. Further details are contained in Appendix A2. This suggests that the explanatory power of the suburban regressions is lower meaning that some relevant variables are not present. This is a common problem with this methodology and is given considerable attention in the literature[21]. Such omitted variables could include measures of the quality of the view (particularly for properties along the coast), proximity to transport, the history of local prices and proximity to social and leisure facilities. Notice that none of these would be particularly important in the city in distinguishing between properties, particularly with respect to new properties. However, while this is relevant, closer examination shows that the lowest R-square is found in 2000 and when this is excluded the other years lie in a more acceptable range of 0.659 to 0.715. This suggests that market volatility as would be induced during a period of rapidly rising prices with excess demand may be relevant in this year thereby suppressing the explanatory power of the measured variables. However, it is not clear why this only affects the suburban results.

This issue of market volatility is related to the second possible explanation for the divergence observed. The regressions were performed on annual data. Thus, prices set early in the year have as much explanatory power as prices set late in the year. This is not an issue in house price indices that are compiled using this methodology since these generally utilise monthly data. Over a month the trend will not change greatly so that there is no need to distinguish the date of the trade. Furthermore, this means that the linearity assumptions that underlie the OLS methodology are valid.

[21] See, for example, the discussion in Baker, T. & D. Duffy (1998) *Irish Permanent House Price Index: Methodology Explained.*

However, trends can change over the course of the year and errors can creep into the regressions. Perhaps more importantly in terms of the results that are produced, the utilisation of data across the whole year without any weighting would mean that there would be a time lag in identifying changes in the trend. For example, if over a two year period prices were rising rapidly early in the period but then started to slow in the first year and fell towards the later part of the period, this methodology would underestimate the extent of the change that had occurred in both periods. Conversely, an upturn would also not be reflected fully until well underway. The effect would be an overestimate in a period when rent increases are slow, or are falling, and an underestimate in an upturn.

3.3 Market Segment Indices

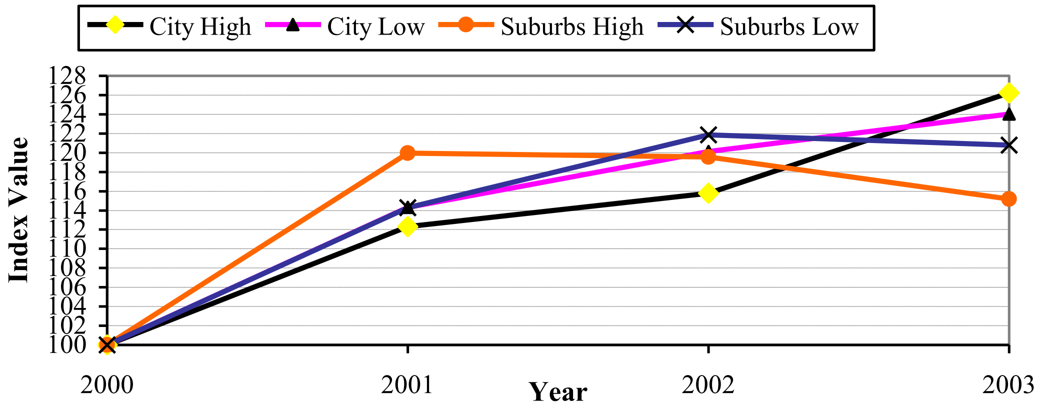
These regressions were necessarily undertaken using a limited number of variables and although reasonable R-square value were obtained there are inevitably missing explanatory variables. In an effort to try to reduce the potential effect of these variables, it was decided to construct separate indices for apartments at the high and low ends of the market by splitting the datasets into high value and low value rentals according to the underlying quality of the property in question. It is necessary in doing this to look at the three explanatory variables. The grading and the parking status are straightforward and can essentially be considered as indicators of the quality of an apartment. A high grading and available parking will probably correspond to a high value apartment. However the number of bedrooms is not a quality indicator but is the single most important determinant of overall value. For example, an apartment with three bedrooms might cost more than one with two bedrooms but it cannot be concluded that the larger apartment is a high value property in terms of the market at which it is aimed. This means that it is necessary to segment that dataset so that the comparison in a high-value or low-value assessment is between apartments with the same number of bedrooms.

The approach taken is to group all the apartments in each area according to their number of bedrooms. This resulted in three groups in each area, apartments with one bedroom, apartments with two bedrooms and apartments with three bedrooms. An average price was calculated for each category. Any apartment that was equal to or above the average price for its respective category was considered a high-value rental and any apartment that was below the average price was considered a low-value rental. This process was applied in each year to both the city and suburban areas. The high-value rentals for each of the three categories were then grouped together. This was similarly done for the low value rentals giving four datasets: high and low market in the city and the same for the suburbs. This meant that the number of bedrooms was excluded from the market segmentation and could therefore be used as a variable in regressions to be performed. The resulting indices for each category are shown in Table 3.2 and illustrated in Figure 3.2 The R-square values of the underlying regressions were all in the range .769 to .872 for the high value market segment but lower values were obtained for the low value segment in the suburbs in 2000 and 2001. The cause of this has not been determined it is probably the result of volatility in the market. Details are contained in Appendix A3.

Table 3.2: Hedonic Rental Price Indices for High and Low Market Segments

	City Index		Suburban Index	
	High	Low	High	Low
2000	100	100	100	100
2001	112.31	114.31	119.97	114.30
2002	115.77	120.11	119.55	121.87
2003	126.24	124.04	115.18	120.79

Figure 3.2: Mix Adjusted Residential Letting Price Index



It is immediately clear that there is considerable variation between market segments. The high end of the city apartment market appears to have continued to perform strongly in 2003 while other markets have weakened. The extent to which performance has differed in different market segments is indicated by Table 2.3 which shows annual percentage growth rates in each market.

Table 3.3: Annual % Rental Changes for Market Segments, Hedonic Approach

	City Index		Suburban Index	
	High	Low	High	Low
2001	12.31	14.31	19.97	14.30
2002	3.08	5.07	-0.35	6.62
2003	9.04	3.27	-3.66	-0.89

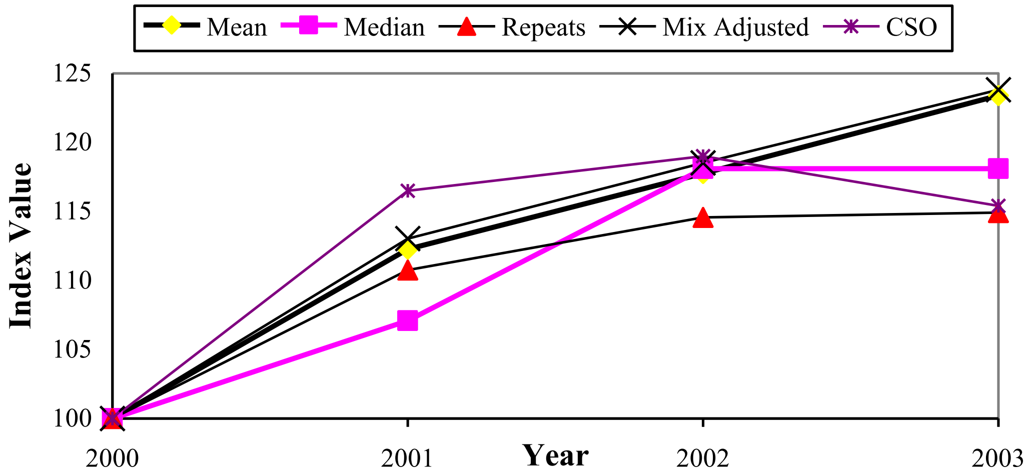
These estimates are consistent with the trends identified by the other approaches that show markets to have weakened in 2003, particularly in the suburbs. However, this analysis indicates that this trend is a lot less obvious in the city, particularly at the higher end of the market. While it cannot be conclusively stated that rents have been rising at over 9% in this market in 2003, this market segment would appear to be performing more strongly than others. On the other hand, high value apartments in the suburbs have shown the greatest weaknesses in terms of rental values. One explanation may be that as the growth in rents in the city area for quality apartments eased in 2002, clients who were otherwise looking at the suburbs were attracted back to the city. This is consistent with the observation of considerable weakness in the suburbs. This implies that this segmentation along quality lines is a relevant variable to consider in identifying price trends. The corollary is that high specification apartments in the city and in the suburbs are substitutes for each other, and that location is the key determinant of rent within each market segment.

4. Findings and Conclusions

A number of methodologies have been employed in this report to estimate rental price indices for the data covering the years 2000-03. The results produced by each methodology are compared in Figure 4.1 for the city data and Figure 4.2 for the suburban properties and with those produced by the CSO in compiling the consumer price index.

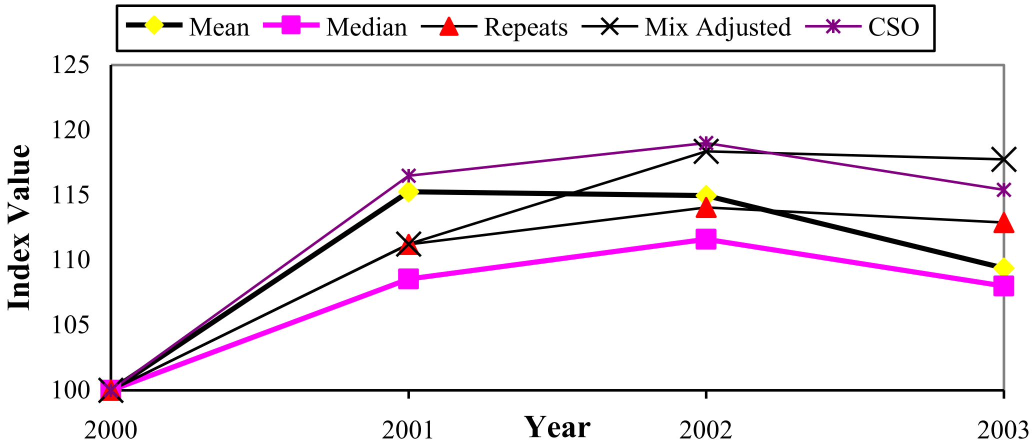
Figure 4.1 shows that all methods indicated rising values up to 2002. The results diverge in 2003 with the mean and mix adjusted methodologies indicating continuing growth. One possible interpretation of this is that, given the tendency of the mean to be influenced by extremes is that the higher end of the market in the city might be performing stronger than the general run. Furthermore, the potential for the mix adjusted approach to lag developments may explain its relatively high result. The lowest growth estimate overall is delivered by the repeat contracts approach but with 2003 not yet complete it must be remembered that the number of observations for 2003 for which matches can be found is limited. The sharpest slowdown is indicated by the CSO methodology

Figure 4.1: Comparison of Estimated Indices (City)



The picture is a lot clearer with respect to the suburbs as shown in Figure 4.2 with all the methodologies showing declines in 2003. Once again the mix adjusted approach suggests a stronger performance than the others with a decline of only 0.5% on the year. The greatest decline is recorded by the mean based estimates reflecting the tendency of the mean to exaggerate both upturns and downturns.

Figure 4.2: Comparison of Estimated Indices (Suburbs)



It is clear from these figures and from the data in Table 4.1 that price growth has moderated in recent years. This weakening is most pronounced outside the city area with growth, albeit weaker than previously, continuing in the city in 2003. However, while visual representations of indices are useful for comparisons, they may provide a distorted idea of trends is some instances. To ensure clarity, Table 4.1 summarises the percentage growth estimates produced by each methodology for each year, while Figures 4.3 and 4.4 show these visually.

Table 4.1: Estimated Annual Percentage Rental Value Increases

		Mean Values	Median Value	Repeats (limited data)	Mix Adjusted	CSO
2001	City	12.3	7.1	10.8	13.0	16.55
	Suburbs	15.3	8.6	11.2	11.2	
2002	City	4.9	10.3	3.4	4.8	2.16
	Suburbs	-0.2	2.8	2.6	6.4	
2003	City	4.8	0.0	0.3	4.5	-3.02
	Suburbs	-4.8	-3.2	-1.0	-0.5	

Figure 4.3: Comparison of Estimated % p.a. Increases (City)

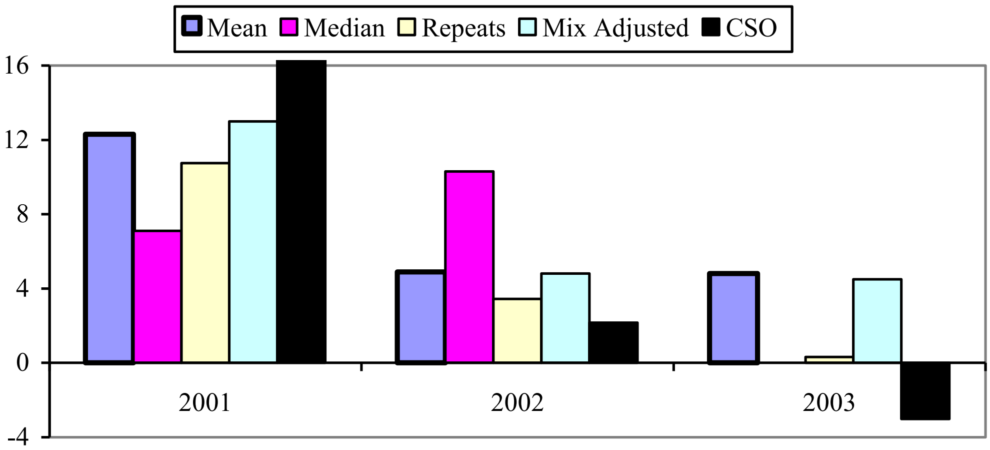
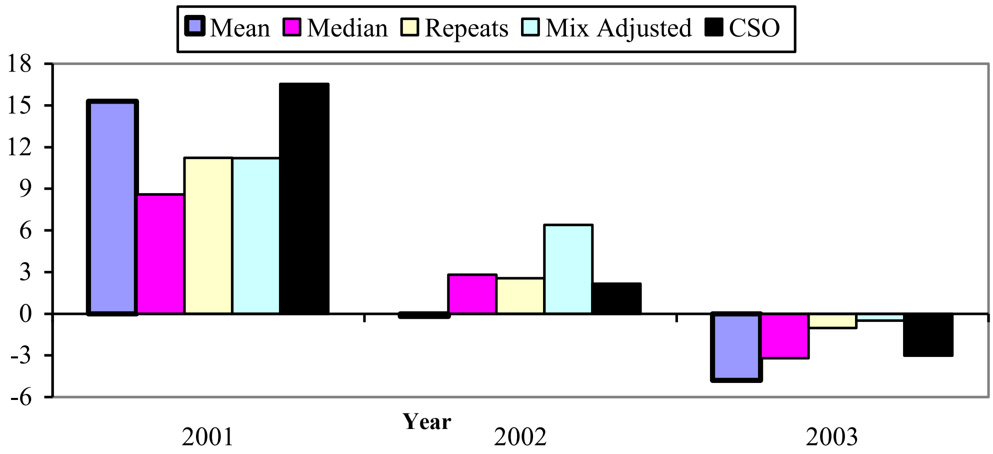


Figure 4.4: Comparison of Estimated % Increases p.a. (Suburbs)



Clearly the rental market has weakened overall, but there is divergence in the estimates produced for 2003. This is in keeping with the literature which suggests that divergence between the results of the various methodologies tends to increase when trends change. In stable markets they are more likely to agree. The evidence suggests that values in the city have been more resilient than in the suburbs.

This divergence is particularly clear when the market is segmented into high and low quality apartments. The high end of the city apartment market appears to have continued to perform strongly in 2003 while other markets have weakened. The extent to which performance has differed in different market segments is indicated by Table 4.2 which shows annual percentage growth rates in each market.

Table 4.2: Annual % Rental Changes for Market Segments, Hedonic Approach

	City Index		**Suburban Index**	
	High	Low	High	Low
2001	12.31	14.31	19.97	14.30
2002	3.08	5.07	-0.35	6.62
2003	9.04	3.27	-3.66	-0.89

These estimates are consistent with the trends identified by the other approaches that show markets have weakened in the suburbs. One explanation may be that as the growth in rents in the city area for quality apartments eased in 2002, clients who were otherwise looking at the suburbs were attracted back to the city. This implies that apartments in the city and in the suburbs are substitutes for each other.

It is not possible to say that any one of these methodologies is definitely superior to the others and the literature does not lead to a particular conclusion on this matter. Certainly, it would be inadvisable to rely solely on the mean or the median even though they do not produce results greatly out of line with the others. The mix adjusted model is widely employed in Ireland but requires a lot of information on each property. On the other hand, the repeat contracts approach is generally used where the dataset has a high number of matches as is the case here. In reaching a conclusion it is important to remember that the methodology that is used should be the

one that is most appropriate for the dataset that is available. In this respect, the modified version of the repeat contracts approach would appear to have certain advantages. This methodology is not as demanding as the hedonic approach in terms of the data that are required and the variables in the dataset can be used to improve the accuracy of the estimates.

5. Technical Appendix

A1: Regression Results for the Repeat Contracts Index

A1.1. City Model 1: All information included

Multiple R	.789
R Square	.623
Adjusted R Square	.621
Standard Error	.074

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	5.138	1.713
Residuals	567	3.116	0.005

F = 311.65750 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
X	.1109	.005	.698	23.426	.000
Y	.0259	.005	.167	5.132	.000
Z	-.005	.006	-.019	-.661	.509

A1.2. Suburbs Model 1: All information included

Multiple R	.801
R Square	.642
Adjusted R Square	.638
Standard Error	.070

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.247	.749
Residuals	253	1.253	.005

F = 151.193 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.115	.007	.720	16.782	.000
V3	.027	.007	.177	3.861	.000
V4	-.022	.009	-.104	-2.541	.012

A1.3. City Model 2: No 3-year comparisons included

Multiple R	.774
R Square	.600
Adjusted R Square	.597
Standard Error	.072

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	3.979	1.326
Residuals	513	2.655	.005

F = 256.300 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
X	.108	.005	.692	22.420	.000
Y	.025	.005	.169	5.219	.000
Z	-.011	.007	-.048	-1.610	.108

A1.4. Suburbs Model 2: No 3-year comparisons included

Multiple R	.820
R Square	.673
Adjusted R Square	.669
Standard Error	.065

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.027	.676
Residuals	234	.987	.004

F = 160.231 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.1163	.007	.731	17.750	.000
V3	.027	.006	.180	4.232	.000
V4	-.019	.009	-.082	-2.097	.037

A1.5. Suburbs Model 3: Data Deleted

Multiple R	.833
R Square	.694
Adjusted R Square	.692
Standard Error	.067

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	3.672	1.224
Residuals	360	1.618	.005

F = 272.341 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.108	.005	.700	21.318	.000
V3	.038	.006	.232	6.751	.000
V4	.004	.008	.014	.449	.654

A1.6. Suburbs Model 3: Data Deleted

Multiple R	.837
R Square	.700
Adjusted R Square	.696
Standard Error	.062

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	1.897	.632
Residuals	207	.813	.004

F = 160.953 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.117	.007	.750	17.910	.000
V3	.028	.007	.185	4.215	.000
V4	-.012	.009	-.053	-1.324	.187

A2: Regression Results for the Mix Adjusted Index (all properties)

A2.1 City Properties 2000

Multiple R	.837
R Square	.701
Adjusted R Square	.697
Standard Error	.116

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	7.378	2.459
Residuals	234	3.154	.0135

F = 182.491 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.294	.0157	.717	18.770	.000
V3	.030	.016	.070	1.832	.068
V4	.305	.033	.334	9.312	.000
(Constant)	5.452	.100	54.342	.0000	

A2.2 City Properties 2001

Multiple R	.853
R Square	.728
Adjusted R Square	.724
Standard Error	.105

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	5.841	1.947
Residuals	197	2.186	.011

F = 175.457 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.303	.016	.760	19.168	.000
V3	.013	.016	.031	.792	.429
V4	.248	.026	.356	9.567	.000
(Constant)	5.742	.082		70.423	.000

A2.3 City Properties 2002

Multiple R	.854
R Square	.730
Adjusted R Square	.725
Standard Error	.098

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	4.397	1.466
Residuals	168	1.626	.010

F = 151.462 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.2716	.016	.729	16.671	.000
V3	.0266	.017	.071	1.568	.119
V4	.094	.013	.307	7.299	.000
(Constant)	6.296	.042		149.464	.000

A2.4 City Properties 2003

Multiple R	.902
R Square	.814
Adjusted R Square	.809
Standard Error	.133

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	8.462	2.821
Residuals	109	1.936	.0178

F = 158.81034 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.316	.0259	.588	12.227	.000
V3	.032	.0268	.053	1.193	.235
V4	.1597	.0159	.458	10.068	.000
(Constant)	6.074	.0482		126.056	.000

A2.5 Suburban Properties 2000

The instrumental variable V3 is a constant and is deleted from the analysis.

Multiple R	.753
R Square	.566
Adjusted R Square	.561
Standard Error	.196

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	7.476	3.738
Residuals	149	5.722	.038

F = 97.338 Significant F =.000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.1308	.0204	.369	6.421	.000
V4	.321	.034	.541	9.409	.000
(Constant)	5.712	.103		55.643	.000

A2.6 Suburban Properties 2001

Multiple R	.812
R Square	.659
Adjusted R Square	.651
Standard Error	.183

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	8.363	2.788
Residuals	129	4.324	.034

F = 83.170 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.137	.019	.370	7.076	.000
V3	.279	.190	.078	1.467	.145
V4	.343	.028	.673	12.456	.000
(Constant)	5.456	.228		23.922	.000

A2.7 Suburban Properties 2002

The instrumental variable V3 is a constant and is deleted from the analysis.

Multiple R	.845
R Square	.715
Adjusted R Square	.711
Standard Error	.158

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	8.574	4.287
Residuals	137	3.420	.0250

F = 171.712 Significant F = .000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.1780	.0166	.494	10.696	.000
V4	.276	.0208	.613	13.264	.000
(Constant)	5.909	.0707		83.549	.000

A2.8 Suburban Properties 2003

The instrumental variable V3 is a constant and is deleted from the analysis.

Multiple R	.834
R Square	.695
Adjusted R Square	.687
Standard Error	.147

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	3.855	1.928
Residuals	78	1.690	.021

F = 88.98778 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.195	.021	.584	9.244	.000
V4	.197	.024	.516	8.167	.000
(Constant)	6.113	.083		73.775	.000

A3: Regression Results for the Mix Adjusted Index (segmented)

A3.1 City Properties 2000 (High end)

Multiple R	.908
R Square	.824
Adjusted R Square	.818
Standard Error	.091

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	3.705	1.235
Residuals	95	.792	.008

F = 148.176 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.329	019	.781	16.895	.000
V3	.023	.020	.053	1.157	.250
V4	.237	.030	.350	8.032	.000
(Constant)	5.707	.093		61.470	.000

A3.2 City Properties 2001 (High end)

Multiple R	.934
R Square	.873
Adjusted R Square	.868
Standard Error	.071

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.843	.948
Residuals	82	.414	.005

F = 187.604 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.352	.016	.885	21.996	.000
V3	.001	.016	.004	.086	.932
V4	.203	.022	.373	9.289	.000
(Constant)	5.898	075		78.853	.000

A3.3 City Properties 2002 (High end)

Multiple R	.906
R Square	.820
Adjusted R Square	.813
Standard Error	.082

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.213	.738
Residuals	73	.485	.007

F = 111.047 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.334	.020	.871	17.085	.000
V3	-.027	.019	-.071	-1.375	.173
V4	.086	.015	.285	5.670	.000
(Constant)	6.336	.054		117.656	.000

A3.4 City Properties 2003 (High end)

Multiple R	.916
R Square	.839
Adjusted R Square	.827
Standard Error	.148

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	4.636	1.545
Residuals	41	.892	.022

F = 71.023 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.453	.046	.751	9.803	.000
V3	.006	.048	.008	.122	.903
V4	.120	.033	.271	3.698	.001
(Constant)	6.093	.108		56.316	.000

A3.5 City Properties 2000 (Low end)

Multiple R	.910
R Square	.827
Adjusted R Square	.823
Standard Error	.075

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	3.614	1.205
Residuals	134	.754	.006

F = 214.004 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.310	.013	.896	23.391	.000
V3	.011	.014	.029	.756	.451
V4	.045	.054	.030	.834	.406
(Constant)	6.149	.160		38.417	.000

A3.6 City Properties 2001 (Low end)

Multiple R	.890
R Square	.792
Adjusted R Square	.786
Standard Error	.073

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.212	.737
Residuals	110	.582	.005

F = 139.398 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.273	.016	.855	17.466	.000
V3	.012	.016	.038	.776	.440
V4	.070	.038	.082	1.853	.067
(Constant)	6.252	.111		56.411	.000

A3.7 City Properties 2002 (Low end)

Multiple R	.950
R Square	.9902
Adjusted R Square	.898
Standard Error	.053

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.336	.777
Residuals	91	.255	.003

F = 277.777 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.277	.013	.837	20.765	.000
V3	.033	.014	.098	2.388	.019
V4	.040	.011	.133	3.729	.000
(Constant)	6.379	.031		203.488	.000

A3.8 City Properties 2003 (Low end)

Multiple R	.955
R Square	.912
Adjusted R Square	.908
Standard Error	.063

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	2.558	.853
Residuals	63	.247	.004

F = 217.172 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.300	.017	.811	17.324	.000
V3	.019	.017	.046	1.124	.266
V4	.065	.014	.210	4.788	.000
(Constant)	6.314	.032		198.244	.000

A3.9 Suburban Properties 2000 (High end)

Multiple R	.877
R Square	.769
Adjusted R Square	.762
Standard Error	.148

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	4.686	2.343
Residuals	64	1.406	.022

F = 106.646 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.254	.025	.693	10.056	.000
V4	.167	.038	.298	4.320	.000
(Constant)	6.060	.114		53.177	.000

A3.10 Suburban Properties 2001 (High end)

Multiple R	..893
R Square	.798
Adjusted R Square	.785
Standard Error	.145

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	3.887	1.296
Residuals	47	.983	.021

F = 61.935 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.265	.027	.681	9.942	.000
V3	.153	.152	.069	1.010	.318
V4	.185	.031	.428	6.046	.000
(Constant)	5.993	.206		29.122	.000

A3.11 Suburban Properties 2002 (High end)

Multiple R	..889
R Square	.790
Adjusted R Square	.782
Standard Error	.154

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	3	4.307	2.154
Residuals	48	1.143	.024

F = 90.454 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.264	.030	.629	8.756	.000
V4	.211	.035	.429	5.976	.000
(Constant)	6.055	.119		50.989	.000

A3.12 Suburban Properties 2003 (High end)

Multiple R	.930
R Square	.865
Adjusted R Square	.856
Standard Error	.103

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	1.906	.953
Residuals	28	.296	.011

F = 90.018 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.283	.026	.805	10.940	.000
V4	.123	.034	.268	3.639	.001
(Constant)	6.272	.120		52.109	.000

A3.13 Suburban Properties 2000 (Low end)

Multiple R	.625
R Square	.391
Adjusted R Square	.376
Standard Error	.158

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	1.279	.640
Residuals	80	1.991	.025

F = 25.705 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.102	.022	.423	4.641	.000
V4	.203	.052	.354	3.890	.000
(Constant)	6.044	150		40.282	.000

A3.14 Suburban Properties 2001 (Low end)

Multiple R	.588
R Square	.345
Adjusted R Square	.329
Standard Error	.139

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.793	.397
Residuals	78	1.503	.019

F = 20.576 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.115	.01	.551	5.978	.000
V4	-.137	.081	-.157	-1.703	.093
(Constant)	7.160	.252		28.406	.000

A3.15 Suburban Properties 2002 (Low end)

Multiple R	.811
R Square	.659
Adjusted R Square	.651
Standard Error	.111

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	2.017	1.009
Residuals	84	1.043	.012

F = 81.262 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.172	.016	.691	10.770	.000
V4	.142	.026	.354	5.516	.000
(Constant)	6.256	.079		79.412	.000

A3.16 Suburban Properties 2003 (Low end)

Multiple R	.735
R Square	.540
Adjusted R Square	.521
Standard Error	.127

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.874	.437
Residuals	46	.743	.016

F = 27.053 Significant F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
V2	.168	.024	.717	7.084	.000
V4	.036	.042	.087	.860	.394
(Constant)	6.571	.119		55.410	.000