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## **A Comparison of Residential Rental Indices**

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**Abstract:**

*This paper compares several different methods of measuring changes in residential rental levels for North Shore City in New Zealand. The data set comprised 35,431 tenancies over the period 1992-1998. Of these, 9,256 were single tenancies and 26,175 repeated tenancies.*

*The indices compared were median, hedonic, repeat rent, weighted repeat rent and hybrid. The median index simply chained median rents over time. The hedonic index used standard multiple regression methodology. The repeat rent index used just the repeated transactions. The weighted repeat rent index again just used repeated tenancies and down-weighted the index for length of time between tenancies. The hybrid index combined aspects of the hedonic method with the repeat rent method.*

*Technically the hybrid method appeared to be the most appropriate, but the trade off was this method was more costly in terms of operator time and data requirements. The repeat rent method is relatively simple and has low administrative costs. The median method is very easy to set up but suffers from both seasonal and constant quality difficulties. The hedonic method is also costly in terms of time and data requirements. On balance the hybrid method was preferred.*

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## **Introduction**

The accurate measurement of changes in residential rental levels is important for two main reasons. Firstly, both tenants and landlords frequently use existing contract rental figures as a benchmark in rent fixing procedures. They then update this amount by a percentage to reflex current market conditions. Secondly, changes in rental levels are an important component of the consumer price index. If these changes are not being measured accurately then the Reserve Bank of New Zealand may use incorrect interest rate settings. This paper uses residential rental data from North Shore City in New Zealand to compare four main types of indices; median, hedonic, repeat and hybrid.

At the time of the 1996 census North Shore City had a population of 171,494. The city is situated to the north of the Auckland harbour and is one of four cities comprising the Auckland region. Population growth averages 2-3% per year and approximately 20% of dwellings are private sector rentals. The rate of population growth is amongst the highest in the country. During the period 1993-1997 growth in private sector residential tenancies averaged 5% per year.

## **Data**

Two sets of data were collected for this study. The primary data set contained information on the geographical location of the rentals, the dwelling type, the number of bedrooms, the rent paid, and the tenancy commencement date. The sample was taken from the entire urban area of North Shore City and only included those private sector residential tenancies registered in the Ministry of Housing (Tenancy Bond Centre) during the period of 1992 to 1998. This sample is thought to be a good representation of the private tenancy population since landlords must lodge bond money with the Tenancy Bond Centre if a bond was collected. For reasons of privacy the data set did not contain individual street addresses but properties could be located to within a census mesh block.

Over 39,000 rental observations were recorded in the data set. From these, 35,431 effective tenancies were identified (including 9,256 single tenancies and 26,175 repeat

tenancies). Observations that appeared to have data entry errors, or that may have biased the indices were excluded from the analysis, those included:

- Properties identified neither as flats nor as houses.
- Properties with area geography identity codes not found for North Shore City on the map of Northern Auckland Urban Zone 1991.
- Properties with no bedroom or more than four bedrooms.
- Rental observations before 1992 when there were only 15 tenancies recorded.
- Properties with tenancies 10 times or more during the 7 years sample period.
- Rents out of the ranges of \$70 to \$350 for one-bedroom properties, \$100 to \$500 for two-bedroom properties, \$130 to \$700 for three-bedroom properties and \$160 to \$1,000 for four-bedroom properties. Although the dollar cut off amounts used here were somewhat arbitrary they were based on the authors' experience of what was considered reasonable.
- Repeat rents with no time interval between tenancies.
- Repeat rents with rent change out of the range of “-20% to +50%” between tenancies.

A summary of the rental data is contained in Table 1. The data set is dominated by three-bedroom houses and repeat tenancies are much more common than single tenancies. A single tenancy is a property that was only rented once during the 7 year period studied. A repeat tenancy is a property renting between 2 and 9 times over the study period.

**Table 1: Summary of Effective Rents**

Observation Type	Single Tenancies		Repeat Tenancies		All Tenancies Pooled	
	Rental Mean \$ (Sta. Deviation)	Observations	Rental Mean \$ (Sta. Deviation)	Observations	Rental Mean \$ (Sta. Deviation)	Observations
By no. of bedrooms:						
One-bedroom	163.26 (40.95)	770	168.45 (45.58)	2535	167.24 (44.59)	3305
Two-bedroom	224.60 (53.74)	2885	217.57 (47.43)	9429	219.22 (49.07)	12314
Three-bedroom	286.00 (70.30)	4560	279.45 (60.07)	12091	281.24 (63.10)	16651
Four-bedroom	355.06 (105.14)	1041	343.83 (90.67)	2120	347.53 (95.81)	3161
By dwelling type:						
Flats	217.35 (68.68)	3243	210.02 (56.83)	11156	211.67 (59.78)	14399
Houses	289.80 (82.00)	6013	282.53 (70.04)	15019	284.61 (73.73)	21032
By wards:						
East Coast Bays	272.90 (84.60)	1495	261.80 (70.74)	4242	264.69 (74.75)	5737
Glenfield	255.68 (65.62)	2186	244.82 (57.46)	6021	247.71 (59.93)	8207
Takapuna	276.10 (99.09)	2324	257.06 (80.55)	7503	261.57 (85.68)	9827
Onewa	250.46 (70.25)	2167	241.19 (68.97)	5690	243.74 (69.44)	7857
Devonport	273.17 (105.60)	1084	257.66 (95.66)	2719	262.08 (98.83)	3803
Summary	264.41 (64.94)	9256	251.62 (74.01)	26175	254.97 (77.22)	35431

The secondary data set contains information on demographic changes and household incomes taken from the 5 yearly Census conducted by Statistics New Zealand (1991), (1996). Data on average house prices within the wards of North Shore City was obtained from Quotable Value New Zealand.

## Index Methods

### (a) Median

The traditional way of measuring changes in residential rental levels is to compare median rents over time by constructing a median chain index. This is done by selecting a specified time period as the base and setting the median rent in this period equal to a number (often 1 or 100 or 1,000). The median rent in the second and subsequent time periods is then calculated as a percentage change on the base period and the index is adjusted accordingly.

Data on median rents is available from the Ministry of Housing (Tenancy Bond Centre). The main disadvantage of using median rents is the constant quality change problem.

That is, the type of property being transacted in one period may not be a representative sample of the total population of rental properties. This problem can arise from seasonal effects, such as tertiary students renting lower quality accommodation at the start of the academic year. Problems can also arise if properties being added to the rental housing stock are better quality than the average of properties within the existing rental pool. Similarly, upgrading the existing rental housing rather than simply maintaining it can lead to non-constant quality bias. Because the population of North Shore City was expanding at 2-3% per year and there was a substantial amount of new housing being built each year from 1992-1998 then it is very likely that the constant quality problem is a real issue in this study.

**(b) Hedonic**

The hedonic method involves the use of multiple regression analysis (MRA). MRA has been widely used as a tool for the mass appraisal of residential properties since the 1970's. To construct a MRA equation the analyst collects information on transaction prices, transaction dates and quality attributes of properties in the data set.

Case, Pollakowski and Wachter (1991) used the hedonic method to develop a price index in four American counties. Mark and Goldberg (1984) discussed alternative MRA approaches for the development of property price indices and more recently Malpezzi, Chun and Green (1998) developed a house price index using log-linear form.

When using MRA methodology for the construction of a rental index, the analyst typically takes the amount of rent as the dependent variable and regresses this against a set of independent variables that describe the quality attributes of properties. By using time dummy variables, the drift of price movement over time from the constant term can be measured.

The accuracy of a hedonic index is dependent on how well the equation is specified. In practice it is hard to specify a complete and appropriate set of property attributes because data on some attributes may be unavailable. For example, in this study the street number

of the rental properties was not available so the rental data set could not be matched with the Quotable Value New Zealand database on individual property attributes. As public servants became more experienced in operating privacy legislation it is likely database matching will be permitted provided only aggregated results are published.

**(c) Repeat**

Pioneering use of the repeat sales methodology was reported by Wyngarden (1927) and Wenzlick (1952). These early workers lacked the computation power of modern computers and relied on chain indices. Later Griliches (1961) applied hedonic methods to repeat sales for automobiles. The modern idea of a repeat sales index for property was developed by Bailey, Muth and Nourse (1963) and later refined and modified by Case and Shiller (1987), (1989) and (1990). This method also utilises MRA methodology but avoids the difficulty of setting up the appropriate model and selecting the complete set of independent variables by basing the price index on repeat sales. The repeat method assumes that the price index of the underlying properties in a geographical area can be represented by the price index found on the typical sub-group of properties, which transact twice or more during the same period. If the characteristics and quality of the sub-group properties remain unchanged, the price change between previous and current transactions is due to the time period that intervened.

The Bailey, Muth and Nourse (BMN) index is constructed by regressing the log price change between previous and current sales (dependent variable) on a set of time dummy variables (the only independent variables) for each property, using ordinary least squares regression.

The Case and Shiller refinement to repeat sales methodology challenged the assumption that the difference between the individual property log price and the citywide log price index is non-correlated through time. They showed the variance is likely to increase with the time interval between sales and so is the regression residual. The reasons for this are firstly, the influence of depreciation over longer intervals, and secondly, the benchmark of the previous rent setting is less useful when the time interval lengthens.

Accordingly, the Case Shiller method down-weights sales observations corresponding to larger time intervals between sales. This is done by a three step weighted regression where the first step follows the BMN method. The second step uses the residuals from step 1 as the dependent variable and regresses this on the holding time period. The third step repeats step 1 after the log price changes have been divided by the square root of the filtered value from step 2. In this paper the Case Shiller method is referred to as the weighted repeat sales (WRS) method.

In this paper both the BMN and WRS methods are tested on repeat rental data instead of repeat sales data. A common criticism of the repeat methods when applied to sales data is that a lot of data is wasted because houses only transact every 7-10 years and most of the sales in any given period are not repeat transactions. However, this criticism is not nearly as valid when applied to the rental market because the average length of a residential tenancy is less than two years. In 1996 there was a population of 12,367 private sector rental dwellings in North Shore City. During 1996, 6,685 new rental tenancies were recorded for the city.

### **Hybrid**

The hybrid property sales index method was developed by Case and Quigley (1991), further refined by Clapp et al (1991), Quigley (1995) and Eichholtz (1997). This approach combines elements of both the hedonic and repeat methods. The hybrid method normally uses all transaction data in the construction of the index and is less likely to be biased by the “starter home churn” problem. This means that first home sales, which tend to transact more than the market as a whole, are over represented in some repeat sales indices. Sometimes these first homes are sold by the developer on a low deposit with a compensating higher price. When these homes sell under normal financing arrangements in the second hand market the prices are reduced accordingly. This effect can put a downward bias on the index.

The hybrid model makes use of repeat transaction data to catch the time interactive effects on property price changes, while the hedonic part of the model deals with the quality change problem and makes use of all transaction observations. For example, the Eichholtz study of buildings in Amsterdam used dummy variables to account for changes in building use over time as it switched from residential to commercial or vice versa.

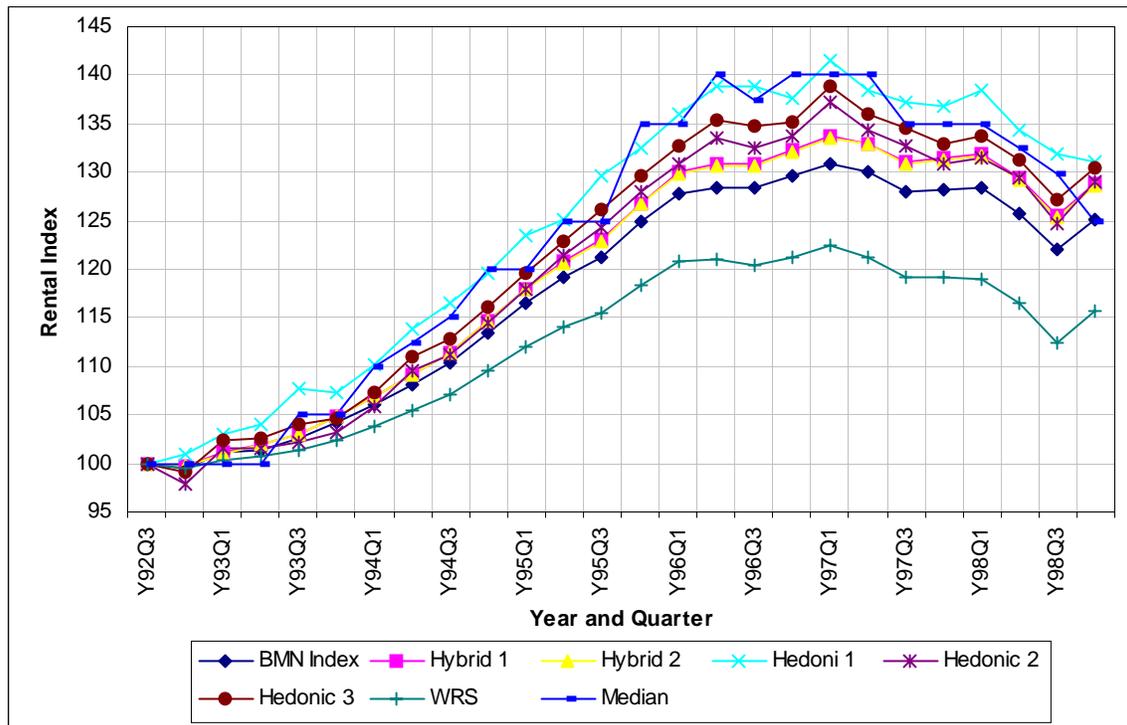
The hybrid index method suffers from similar difficulties to the hedonic and repeat methods. The analyst still has to choose the appropriate functional form for the equation and needs to obtain a complete set of property attributes. Including all the transacting data may be more representative than just including repeat transactions but there is still the question of how well the transacting data represents the total population.

However, the above constraints are more valid for the house sales market than the rental market since the turnover rate in the rental market is so much higher. Rental properties that had more than 10 tenancies over the 7 year period studied were excluded from this study on the grounds that they may have certain undesirable characteristics not reflected in the market in general.

### **Results and Analysis**

This section of the paper discusses eight rental indices the authors have developed for North Shore City. These indices are shown in Figure 1 below. There is one median index, three hedonic indices, two repeat sales indices and two hybrid indices. The first repeat index is based on the BMN model and the second utilises the WRS model.

Figure 1: Index Comparison



The first hedonic model uses single tenancy transactions; the second, repeat tenancies and the third, all tenancies. Both hybrid models use just repeat tenancies. Hybrid model 1 has a very similar functional form to the BMN repeat index but includes a new independent variable to measure changes in rents due to the time interval between tenancies. This is done by taking the log of the time interval between tenancies.

Hybrid model 2 includes additional independent variables as follows:

- Log of the number of bedrooms
- Dummy variables for location by wards
- Dummy variables for dwelling type (house or flat)
- Log of yearly median household income growth by wards
- Log of yearly population growth by wards
- Log of average house prices by suburb

The results of the regressions are presented in Table 2.

**Table 2: Regression Results Comparison**

Types of Model	R-square	Standard Error of R-square	95% Confidence Range of R-square	F-statistic (significance)
Hedonic Model 1 (single tenancies, n=9,256)	0.624	0.1875	(0.257, 0.992)	466 (0.000)
Hedonic Model 2 (repeat tenancies, n=26,175)	0.636	0.1728	(0.297, 0.975)	1388 (0.000)
Hedonic Model 3 (all data, n=35,431)	0.633	0.1772	(0.286, 0.980)	1848 (0.000)
BMN Model (repeat tenancies, n=26,175)	0.460	0.0708	(0.321, 0.600)	497 (0.000)
Hybrid Model 1 (repeat tenancies, n=26,175)	0.460	0.0708	(0.321, 0.600)	478 (0.000)
Hybrid Model 2 (repeat tenancies, n=26,175)	0.465	0.0705	(0.327, 0.603)	387 (0.000)
WRS Model (repeat tenancies, n=26,175)	0.373	0.0709	(0.234, 0.512)	361 (0.000)

It is interesting to note that hedonic model 1 appears to closely track the median index and is subject to relatively large fluctuations. This is probably because hedonic model 1 only uses single tenancies and these suffer more from constant quality upward drag and seasonal fluctuations than the other hedonic models. All the hedonic models appear to explain around 63% of the variation in rents with the most powerful explanatory variable being the number of bedrooms.

In this study (1992-1998) properties showing repeated renting are much more likely to be representative of the rental population than single tenancies. This is because if a residential rental lasts for more than five years it may well be at less than market rents because landlords are reluctant to increase the rent for sitting tenants. Also single tenancy properties are more likely to be only temporarily in the rental market since the owners often rent for a period while waiting to sell the dwellings as owner-occupied housing. The uncertainty surrounding such tenancies may lead to landlords discounting the weekly rent in order to attract tenants.

Figure 1 also shows that both the repeat rent methods are at the bottom end of the graph, particularly the WRS method. The down-weighting factor applied by Case and Shiller to paired transactions corresponding to longer time intervals between house sales may not be appropriate in the faster churning rental market context. The BMN index is closer to

the hedonic and hybrid methods but may be still under estimating actual movements in the rental market.

The two hybrid indices produce very similar results. This shows the explanatory power of the additional variables included in hybrid model 2 are negligible. However, log of the time interval between tenancies is a significant variable with a correlation of 29.9% to the dependent variable. The table of correlation coefficients is produced in Table 3. The explanation for the names of the abbreviated variables is as follows:

LN <i>Pit</i>	Log of rental price, the dependent variable
R <i>itt'</i>	Change in the log rent between tenancies
LN_INTER	Log of time interval between tenancies
LN_POP	Log of annual population growth (1991-1996)
LN_INC	Log of median household income growth (1986-1996) by individual wards
LN_SALES	Log of average house price (1998) in individual suburbs
LN_ROOMS	Log of number of bedrooms

Clearly, the number of bedrooms is a very important variable when explaining differences in rental levels between properties. However, this variable drops out when using the repeat methods.

**Table 3: Correlation Coefficients**

		LN Pit	R itt'	LN_INTER	LN_POP	LN_INC	LN_SALES	LN_ROOMS
LN Pit	Pearson Correlation	1.000	.151**	.086**	-.004	-.011*	.114**	.656**
	Sig. (2-tailed)	.	.000	.000	.441	.046	.000	.000
	N	35431	17509	16616	35431	35431	35381	35431
R itt'	Pearson Correlation	.151**	1.000	.299**	-.017*	-.008	.002	-.026**
	Sig. (2-tailed)	.000	.	.000	.026	.298	.784	.001
	N	17509	17509	16612	17509	17509	17489	17509
LN_INTER	Pearson Correlation	.086**	.299**	1.000	-.017*	-.020**	-.013	.039**
	Sig. (2-tailed)	.000	.000	.	.029	.009	.085	.000
	N	16616	16612	16616	16616	16616	16596	16616
LN_POP	Pearson Correlation	-.004	-.017*	-.017*	1.000	.651**	-.297**	.128**
	Sig. (2-tailed)	.441	.026	.029	.	.000	.000	.000
	N	35431	17509	16616	35431	35431	35381	35431
LN_INC	Pearson Correlation	-.011*	-.008	-.020**	.651**	1.000	-.245**	.063**
	Sig. (2-tailed)	.046	.298	.009	.000	.	.000	.000
	N	35431	17509	16616	35431	35431	35381	35431
LN_SALES	Pearson Correlation	.114*	.002	-.013	-.297**	-.245**	1.000	-.157**
	Sig. (2-tailed)	.000	.784	.085	.000	.000	.	.000
	N	35381	17489	16596	35381	35381	35381	35381
LN_ROOMS	Pearson Correlation	.656**	-.026**	.039**	.128**	.063**	-.157**	1.000
	Sig. (2-tailed)	.000	.001	.000	.000	.000	.000	.
	N	35431	17509	16616	35431	35431	35381	35431

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

### Summary and Conclusions

The issue of which index is best is not clear-cut because the answer depends on who is using the index, what they are using the index for and the costs and benefits of each option. Furthermore, there is no way of determining what the actual movement in rentals is since no precise benchmark exists. The median index is inexpensive to compile and easily updated but is likely to over-estimate actual changes because it may violate the constant quality requirement. In a city such as North Shore where there has been significant growth in the rental housing stock, the median method almost certainly does violate constant quality.

In theory, the hedonic methods outlined should work well but there are considerable practical difficulties in being able to capture all the important independent variables. The

data does exist in various databases but matching these databases involves matching individual property records and this may violate privacy legislation in New Zealand.

The two repeat methods discussed in this paper were developed in relation to house price indices. As houses change hands relatively infrequently neither of these models is calibrated to work in the much faster churning residential rental market. The advantage of the repeat methods is their relatively low data requirement thereby reducing the cost of assembling such indices. This disadvantage of repeat sales not being representative of the whole housing market is again largely overcome in a rental market where the average length of tenancy is less than two years. In the absence of a property rental database recording upgrades to rental properties, the model assumes repairs and maintenance to property equals depreciation. This may not be a valid assumption.

The hybrid methods discussed in this paper combine elements of the repeat and hedonic methods. Hybrid model 1 achieves the same result as the hybrid model 2 which is more complicated and has more extensive data requirements. Hybrid model 1 follows the same methodology as the BMN repeat method but has an additional variable to account for the time interval between tenancies.

In conclusion the authors recommend hybrid model 1 as the best model to use based on accuracy and available and easily obtained data.

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