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FURTHER EVIDENCE OF SEASONAL INFLUENCES IN AUSTRALIAN HOUSING MARKETS - A CASE STUDY OF PERTH

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Abstract: *This paper examines the impact of seasonal influences on housing market activity in Perth Western Australia. Empirical tests are used to examine the influence of a quarterly season on the demand for housing and the observed real house price changes during that season. The empirical tests use a large set of housing transactions for the period 1988 - 1995. Data is examined for the aggregate Perth housing market and 13 distinct spatial regions. Variations in the volume of transactions are examined by constructing ratios from four period moving averages. Variations in real house price changes are examined through construction of constant quality (hedonic) house price indexes for the aggregate market and all spatial regions. The explanatory power of the statistical tests is improved by "stacking" the regional data to provide more observations for use with standard parametric tests for seasonality. The results of these tests confirm some significant seasonal influences. The volume of transactions and hence demand is greatest during the first quarter of a year and lowest during the last quarter. The observed real house price changes are highest in the first quarter of a year and lowest during the third quarter. The paper concludes with some commentary on the likely causes of these seasonal influences and some suggestions for future research.*

1 Introduction

Understanding the influence of seasonal influences in housing markets is important for several reasons. First seasonal influences are important in determining the demand and supply characteristics of housing markets. Second, seasonal influences might influence price changes that are observed in housing markets. The question of variations in demand and supply is important in understanding the influence of housing transactions within the general macro-economy. An understanding of the influence of seasonal factors on price changes for housing in specific regions is important for time-series analysis of specific house price series.

There are several important issues related to tests of seasonality in Australian housing markets. The major Australian housing markets are the capital cities, large urban conurbations with many specific housing sub-markets. Within Australian housing markets detailed transaction data is only available for limited periods.[1] This creates difficulties in using some of the standard parametric statistical tests for seasonality in housing markets due to small time-series and the resultant lack of a suitable number of observations for specific seasonal periods[2]. Further it is possible that the influence

[1] In Western Australia detailed transaction data is only available in a digital format from the third quarter of 1988.

[2] For example in this study the sample period is from 1988-1995. In testing seasonal characteristics of sales volumes the number of observations available for statistical tests is limited by the moving average procedure. From the total of 26 quarterly periods there are 7 observations on the first and second quarter and only 6 observations available for the third and fourth quarter. This limits the degrees of freedom available in applying standard *t* test or ANOVA procedures.

of aggregation within capital city housing markets hides many of the important seasonal influences that might apply to specific housing market segments. It is also possible that there are distinct differences in the seasonal volumes of the supply of new and existing housing.

If housing markets are influenced by seasonal variations in demand and supply then there are important considerations in the collection and interpretation of transaction data. First the demand side of the market can be observed from the record of transactions available from title authority records. The volume of housing transactions for a given period represents the demand for housing in a particular region.

Accurate details concerning the supply of housing in a particular period are not so easy to obtain or interpret. The various real estate agencies throughout Australia maintain records for homes listed through their membership. These records generally deal with the time at which the property was listed for sale so if a property does not sell for several months then it might still be part of the existing supply. Another issue concerns the fact that not all properties listed for sale are listed through member agents of the institutes. In summary these problems make it difficult to accurately reconcile the true supply of housing for sale in particular market segments for particular periods.

This paper makes two specific contributions to the literature dealing with seasonal influences in Australian housing markets. First, a method for analysis of demand within a housing market for seasonal influences and second a methodology to establish whether seasonal influences impact upon the observed price changes between seasons. Section 2 reviews the literature relating to seasonal studies of housing markets both in Australia and overseas. Section 3 of the paper comprises the empirical study. This includes an overview of some important characteristics of time-series data including an overview of the influence of trend and cyclical components. Towards this end a specific dataset is used in the empirical study. This includes a ‘short’ time series from 1988-95 with a very evident trend and cyclical component. This specific data period is used to demonstrate how these techniques might be used with selected short time series. The seasonal characteristics of variations in demand are examined using a moving average procedure. The effect of seasonal factors on price changes is tested with the use of a disaggregated dataset where individual regional indexes are ‘stacked” so as to increase the number of observations available for statistical testing. The paper concludes with some commentary on the likely causes of these seasonal influences and some suggestions for future research.

2 Related literature

The study of seasonal influences in housing markets has been of interest in a number of U.S. studies for many years. Rosen (1973) recognised that a number of factors such as household moving patterns, marriages and family formation rates contribute to housing seasonality. He concludes that seasonality of demand is the dominant factor. Harris (1989) reports empirical evidence of strong second and third quarter seasonality in a housing price model estimated for the period 1970-85, with prices at their lowest level during the fourth quarter. Reichert (1990) developed a reduced form price model to explain regional differences in new and existing housing prices. It is reported that the number of existing homes placed on the market during any given quarter varies significantly although these influences were not so pronounced in the supply of new housing.

Seasonality has also been an important consideration in the large number of studies examining the informational efficiency of housing markets. In general the methodology used in these studies has been to estimate indices for specific housing markets and to examine the serial correlation properties of the time series. In using these techniques seasonal influences in indices must be considered. In some US studies (Case & Shiller (1989), Clapp Dolde & Tirtiroglu (1995) Dolde & Tirtiroglu (1997)), seasonal influences have been considered as an influence on quarterly real house price changes. These studies have not addressed the issue of varying volumes in the demand for housing between seasons but acknowledge some seasonal influence in price changes between quarterly seasons by using annual index differences in serial correlation tests. It is important to note that in these studies the evidence of seasonality of price changes is not statistically significant. Case & Shiller (1989) report evidence of price changes being highest in the second quarter and lowest in the third quarter of a year. They argue that much of this may be due to seasonality in the composition of types of homes sold over the year. In general, Case & Shiller's (1989) results for tests of seasonality are not statistically significant possibly due to the fact that the time series used limits the degrees of freedom available for use in standard parametric tests, an issue specifically addressed in this study. The other important reason for using annual differences in these studies concerns index accuracy (discussed in the next section).

Kuo (1996) extends on the Case & Shiller study by using the same data series to examine a Bayesian method to estimate the serial correlation and the seasonality of the price behaviour of the residential housing market. The empirical results suggest that seasonality is not a statistically significant influence on returns although the returns to seasonal dummy variables are strongest for the second quarter of a year closely followed by the first quarter.

Alexander & Barrow (1994) examine the seasonality of regional house prices in the UK. They report evidence of seasonal influences on the causal flows of housing transactions between regions in the UK. It is found that causal flows tend to be northwards and that there is also some relationship with the migration patterns particularly in the south of England.

There has been a distinct lack of empirical research concerning the seasonal influences operating within Australian housing markets. Whereas anecdotal evidence has suggested that important seasonal factors are apparent there has not been suitable data available to test these assertions empirically. Rossini (2000) conducted the only empirical study in recent years. This study examined seasonal effects in the housing markets of Adelaide, South Australia. The results suggest that there are significant seasonal effects on the volume of transactions with the summer and autumn quarters showing some statistically significant seasonal effects. There is little evidence of any statistically seasonal effect on price changes. Rossini suggests that if there is any seasonality in price changes then it is too small to quantify at the sub-market level, however there is some evidence that property prices may be around 1% lower in winter than in other seasons.

3 The empirical study

3.1 Data

This study uses transaction data obtained from the Western Australian Valuer General's Office (VGO). In order that accurate price indexes are constructed for statistical tests the strata-title market segment is used. This is because this market segment contains several very accurately measured property characteristics that enhance index accuracy. The study uses the aggregate Perth housing market and also thirteen specific regional sub-markets within the aggregate Perth market to test for seasonal influences. In order to demonstrate the applicability of the methods with 'short' time-series, data from the period 1988 – 1995 is used.

In the case of establishing seasonal variations in the demand for housing a moving average procedure is used to test the seasonal volumes of transactions for the aggregate data. A detailed overview of the moving average procedure is contained in Table (1). In order to test the seasonal influence on price changes real house price indexes have been estimated for the aggregate market and the thirteen specific regional sub-markets. The index methodology used is discussed in detail in section (3.3).

To increase the explanatory power of these tests, the aggregate data was segmented into thirteen distinct geographic regions for the Perth metropolitan area. The criterion for selection of the regions was determined by direction from the Perth CBD and major transport nodes dividing suburbs. All of the regions contain a number of individual suburbs. No individual suburb was split between different regions. It is important to note that thirteen regions were selected to be of a suitable sample size so as to allow accurate indexes to be estimated according to the explicit time variable (ETV) method (discussed in section (3.4)).

3.2 Important considerations when using time-series data

When analysing time-series data there are several important issues to consider. All time-series data may contain a trend component, a cyclical component and an irregular or random component. All time-series data will comprise at least one of these components but not necessarily all of them. Moreover these components are not necessarily evident when the time-series data is recorded.

In the case of establishing seasonal variations in the demand for housing it is necessary to consider these components of the time-series. The number of transactions recorded represents the total number of housing units demanded for the specific housing market segment during that particular sample period. Table (1) details the volume of transactions for the aggregate sample for the period 1988 – 1995.

A problem arises in that seasonal variations in the volume of transactions for a sample period might be heavily influenced by a trend or cyclical component. The data selected for this sample is for the period 1988 – 1995. This relatively short time-series was characterised by a house price “bubble” in the period 1988 – 89. This was a period corresponding with strong demand, a low supply of homes for sale and a rapid appreciation in house prices. The period of late 1989 through the early 1990s was characterised by a general economic recession and a period of very high interest rates characterised by a decline in real house prices. For these reasons the house price series for the period of 1988 – 95 is characterised by two dominant trend components in the time-series the short upward trend of 1988 – early 1989 and the longer period of a decline in demand for the later period. This is evident in Chart (1) where the house price series for the aggregate sample is shown. The variation in sales volumes for the same period is shown in Chart (2). The trend and cyclical component for sales volumes is apparent although not as pronounced as for the real house price series shown in Chart (1). Note in Chart (2) the different seasonal quarterly periods are distinguished by different shadings.

3.3 Tests for seasonality in transaction volumes

In order to use statistical methods to isolate any trend or cyclical component in the time-series some specific methodology must be used. The method used to transform the data in order to analyse the seasonal variations in volumes is shown in Table (1). The method used is to smooth the trend component from the time-series by taking a four period (annual) moving average through the time-series. This procedure was completed for the aggregate sample and for all region samples. This is a common methodology for de-trending time series data (for a detailed discussion see Flaherty et al: 1999 Chapter 13). The moving average can then be used to compute ratios of the specific quarterly season volume to the relevant four period moving average. This computed ratio is denoted as the variable γ with this variable being used for statistical testing of seasonal volumes in Table (2). Some more detailed notes and examples for calculation of the variable γ are contained within Table (1).

In Table (2) the seasonal variation in the volume of transactions for the aggregate sample and all regions is tested according to the parametric one-sample *t* test procedure. In this test the variable γ is used to test the null hypothesis that the mean γ for a quarterly sample is the same as the mean γ for the full sample (mean γ all periods). Since the sample period available is only from 1988-1995, the number of observations available for statistical tests is limited by the moving average procedure. From the total of 26 observations there are 7 observations on the first and second quarter and only 6 observations available for the third and fourth quarter.

This problem of a limited number of observations can be overcome with a 'stacked' data procedure. In Table (2) the stacked regions test involves stacking the 13 individual regional observations sets so as to increase the explanatory power of statistical tests. The procedure used was to stack the data for all 13 regions. The observations for region 1 are stacked above region 2 through region 13. This creates 338 observations for more robust tests of seasonality. In this way there are 91 observations on the first and second quarter and 78 observations available for the third and fourth quarter.

The results shown in Table (2) confirm some significant seasonal influences on the demand for housing. For the aggregate data (all regions), the volume of transactions is highest in the first quarter of a year and lowest in the last quarter of a year. These results are statistically significant at a level higher than .05. These results are also confirmed when the data is disaggregated into the regional data sets. From the total 13 regions, 6 regions display a statistically significant result confirming the highest volume of transactions occurring in the first quarter of a year. The results for tests on the fourth quarter confirm the lower volume of transactions with statistically significant results for 7 out of the total 13 regions. It is important to note that the seasonal trend is not so evident in all regions. Whereas the general pattern of highest volumes in the first quarter and lowest volumes in the fourth quarter of a year is evident for most regions, four of the regions (regions 4,7,9,11) display no statistically significant seasonal influence for any quarterly period. Region 5 displays the most evident seasonal influences with three statistically significant seasonal quarters and contrary to the general trend, the third quarter of the year has the highest volume of transactions. The stacked region test displays the highest levels of statistical significance due to the greater explanatory power of the tests through the use of more observations.

From these results it does appear that the demand for housing is seasonal, especially in the summer months if quarters 1 and 4 are considered the summer months. These results warrant some discussion in relation to tests of seasonal influences in securities markets where the 'January and July effects' have been observed (Peirson et al (1997)). One of the reasons given for these effects in securities markets is the presence of tax incentive selling during certain months. It is unlikely that this is a plausible explanation in housing markets. The more likely explanation relates to yearly work patterns. More people have holidays and there are extended school breaks during the summer months. It is likely that many housing market participants plan their market activity to coincide with these periods and there are resultant variations in demand and supply for housing services during these periods.

This explanation is consistent with results for studies in countries in the Northern Hemisphere. Harris (1983) reports results of strong seasonal influences in the second and third quarters which corresponds with the northern hemisphere summer being the period between new school years and the extended holiday period. It is interesting that in this Australian study the volume of transactions is lowest in the fourth quarter. This result is also consistent with some U.S. studies but would appear not to relate to any summer / winter effect but is more likely due to the influence of the Christmas period during December. Towards this end it would be useful to examine the volume of transactions on a monthly basis so as to determine if the low volume of transactions is a specific quarterly seasonal influence or predominantly a December monthly influence.

3.4 Tests for seasonality in price changes

An important issue is whether these observed seasonal variations in demand have any statistically significant influence on price changes between quarterly periods. Whereas the methodology for testing variations in demand in the previous section is quite straightforward and the results are quite compelling, the methodology for testing seasonal influences on price changes is more difficult. In this section, the statistical tests for seasonal influences on price changes are completed by using the first difference between quarterly periods. The first differences are derived from real house price indices. The index methodology used is derived from the explicit-time variable (ETV) hedonic procedure as discussed by Costello & Elkins (2000). The hedonic ETV method groups all data for adjacent time periods and includes discrete time periods as independent (dummy) variables. The following is the functional form of equation used for estimation of indices.

$$\ln P_{it} = \sum_{j=1}^{k} \boldsymbol{b}_j \ln X_{jit} + \sum_{t=1}^{T} c_t D_{it} + e_{it}, \tag{1}$$

where P_{it} is the transaction price of property i at time t, i = 1,...,n, and t = 1,...,T; $\boldsymbol{b}_j$, j = 1,...,k , are a vector of coefficients on the structural and housing style attributes, X_{jit}; c_t the time coefficients of D_{it}, quarterly time dummies with values of 1 if the ith house is sold in quarter t and 0 otherwise; and e_{it} is the random error with mean, 0, and variance $\boldsymbol{s}_e^2$. The sequence of coefficients $\hat{c}_1,...\hat{c}_T$ represents the logarithm of the cumulative price index over the time period T. Due to inflation being an important trend and cyclical component in this 1988-95 time series, the sequence of time coefficients was further deflated to represent real log price indexes. The real log price coefficient $\hat{H}_t$ is calculated; $\hat{H}_t = \hat{c}_t - LN(CPI_t)$

Table (3) provides some descriptive statistics for the regional indices. The most important hedonic variables were the building area and age of the building as at the date of the transaction. Table (3) provides an analysis of the means of the selling prices and hedonic variables for the aggregate data (all regions) and for individual regions. It is evident that all regions constitute independent samples with distinctly different mean selling prices and hedonic characteristics.

The means for hedonic variables were subjected to the one-sample t test, testing the null hypothesis that the mean for a particular variable from a region sample is the same as the mean for the aggregate sample (all regions). All regions excepting region 13 have a mean selling price significantly different from the mean for the aggregate sample (at significance level of 5% or higher). All regions except regions 7 and 8 have significantly different mean building areas and all regions have significantly different mean building ages at the date of transaction. It is important to note for the three key hedonic variables for each region; sale, area and age, all the means of at least two of these variables are significantly different than the aggregate data sample for all regions.

Table (3) also provides some statistics for the index level differences and index accuracy. The variable x is the annual (fourth) difference from the relevant real log price index, $x = \hat{H}_t - \hat{H}_{t-4}$. An important fact revealed in Table (3) by this variable is that a number of regions experienced negative average annual rates of real price growth during the sample period 1988-95. In fact this is the case for more than 50% of the regional samples (regions 4, 5, 6, 7, 10, 11, 12).

The mean x result for each region was also subjected to the Wilcoxon signed rank nonparametric test. This procedure tests the hypothesis that an individual region's x variable distribution is the same as the distribution for all regions. Because there is only a small sample size for each region (26 observations) this is more appropriate test than a parametric procedure. The results confirm significantly different distributions for 6 of the total 13 regions.

In summary these procedures confirm that the disaggregation of the sample into specific spatial regions enables the study of specific sub markets. The region samples all appear to be independent of the aggregate data. This is an important consideration because the influence of aggregation might suggest that all sub markets are subject to seasonal influences whereas in reality some specific sub markets may be more or less subject to the influence of seasonal influences than others.

An important issue in house price index construction methods is that of index accuracy. The index accuracy ratios reported in Table (3) are calculated according to the procedure used by Case & Shiller (1989). These index accuracy ratios are calculated from the quarterly index levels, annual (fourth) differences and standard errors derived from the respective regression procedures used to construct the individual indexes. The figures given are ratios of the standard deviation of a variable to the average standard error for that variable. Higher ratios indicate more accurately measured index characteristics. By reference to Case & Shiller's (1989) criteria it is evident that the levels and annual differences of the estimated regional indices are all well measured. The quarterly difference is well measured for most of the regional indices.

In order to test for statistically significant differences in price changes between quarterly periods, the variable z was constructed. The variable z is the first difference from the real log price index: $z = H_t - H_{t-1}$ where; $H_t =$ Hedonic index $\hat{c}_t - LN(CPI_t)$. The results for statistical tests are displayed in Table (4). The one sample t test, tests the null hypothesis that the mean z for a quarterly period sample is the same as the mean for all quarters. The One Way ANOVA tests the null hypothesis that the Mean z is the same for all quarterly period samples.

The results in Table (4) indicate a general trend of first quarter changes (t = 1) being highest and third quarter changes (t = 3) lowest. In the aggregate sample these differences are apparent however the only statistically significant seasonal influence applies to the price change for the third quarter (statistically significant at .10 level). For the regional samples, only one region (region 12) displays a statistically significant higher price change for the first quarterly period. Two regions (regions 2 and 3) display a statistically significant lower price change for the third quarterly period. Results for the one-way analysis of variance (ANOVA) technique are less convincing. The only statistically significant result applies to region 4, which incidentally does not display any significant one-sample t test results.

It is difficult to conclude from these results that there are definite seasonal influences on price changes between quarterly seasonal periods on the basis of the results for the aggregate and regional samples. These results are consistent with those reported by Rossini (2000) where it was reported that there appeared to be a general trend of prices being lower in the winter period although differences were too small to quantify at the sub market level.[3]

It should be noted that this apparent lack of statistical significance might in large part be the result of a limited time series and the resultant low number of observations for specific quarterly periods.[4] The other important consideration is the influence of aggregation that might be diversifying away some seasonal influences that may be more pronounced in particular market segments Because of these problems the 'stacked' index procedure becomes particularly useful in testing the seasonal influence on price changes. It is apparent that the seasonal influence on price changes is only small. In order to establish whether these differences are statistically significant a larger dataset is required.

The explanatory power of these parametric tests is increased with the 'stacking' procedure applied to regional indices. The procedure used was to stack the data for all 13 regional indices where each region has 29 real log quarterly index differences for the sample period, quarter 4, 1988 - quarter 4, 1995. The observations for region 1 are stacked above region 2 through region 13. This creates 377 quarterly index differences for more robust tests of seasonality. The results for these tests are shown in Table (4) and confirm statistical significance for the trend that is indicated in the aggregate data and individual regions. It can be seen that mean real quarterly differences are highest in the first quarter and lowest in the third quarter. These results are statistically significant at levels higher than 1%. In general there is a trend of real house price changes being approximately 2% higher than the annual average in the first quarter and approximately 2% lower than the annual average in the third quarter. The stacked region results also suggest that the second quarter changes are lower at a significance level higher than 10%.

These results also suggest some relationships between the varying levels of demand discussed in section (3.3) and resultant price changes. The increased demand in the first quarter of a year is also accompanied by an increase in prices. Although this

[3] Rossini (2000) examined individual suburbs as sub markets. As a result the sample sizes for sub markets were much smaller than for the regional samples used in this study.

study does not specifically examine supply differentials it might be inferred that the lowest demand associated with the last (fourth) quarter of a year might also be accompanied by a resultant supply lag into the January period of the following fourth quarter. This influence might be especially pertinent if the suggested Christmas effect is correct. This can only be established with a detailed analysis of monthly seasonal trends but it would seem reasonable to infer that some part of the December period would be inactive in terms of new supply of homes for sale.

It is more difficult to reconcile the results for the third quarter of a year. The results for sales volumes in Table (2) do not indicate any statistically significant differences in demand for the third quarter other than for one region (region 5). In addition there does not appear to be a clear trend evident. Some regions appear to have a higher volume of transactions than the annual average and some have a lower volume. The results for price changes in Table (4) suggest quite clearly that price changes in the third quarter of a year are lower than for the annual average. This result does not appear to be directly linked to any significant variation in demand for the third quarter although some inferences can be made from the variations in demand earlier in the year. A plausible explanation is that this result may be linked to supply issues in that the supply of housing available for sale in the winter months is characterised by more homes that have been for sale for longer periods (‘old’ supply). Since demand is clearly higher in the first quarter of a year it is likely that the most attractive homes sell quickly and the least attractive homes are not sold and constitute a larger portion of the supply of homes for sale in the winter quarters of the year. Those sellers wanting to sell are therefore likely to accept lower prices in the winter period because of the lower demand (compared to summer) during this period.

4.0 Conclusions

This paper examines the impact of seasonal influences on housing market activity. Empirical tests are used to examine the influence of a quarterly season on the demand for housing and the observed real house price changes during that season. The empirical tests use a large set of housing transactions for the period 1988 - 1995. Data is examined for the aggregate Perth housing market and 13 distinct spatial regions.

[4] The nonparametric Wilcoxon signed-rank test was also applied to test for seasonality in the aggregate

Variations in the volume of transactions are examined by constructing ratios from four period moving averages. These ratios are used to test for seasonal variations in the demand for housing. The results provide strong evidence that the highest demand for housing occurs during the first quarter of a year and the lowest demand occurs during the last (fourth) quarter of a calendar year. It is unclear whether this low demand in the last quarter is due to a lower volume of transactions for all months during the quarter or is specifically related to the month of December and the influence of the Christmas holiday period. Further analysis of this influence would require testing of monthly seasonal influences. This could be a fruitful area for further research.

Variations in real house price changes are examined through construction of constant quality (hedonic) house price indices for the aggregate market and all spatial regions. Standard parametric tests with the aggregate data and regional samples are limited by a lack of sample size due to the short time series and the fact that observed seasonal differences in price changes are small. The explanatory power of the statistical tests is improved by 'stacking' the regional data to provide more observations for use with standard parametric tests for seasonality. The results of these tests confirm some significant seasonal influences. The observed real house price changes are highest in the first quarter of a year and lowest during the third quarter. In general there is a trend of real house price changes being approximately 2% higher than the annual average in the first quarter and approximately 2% lower than the annual average in the third quarter.

The likely cause of the observed variations in demand relate to yearly work patterns. More people have holidays and there are extended school breaks during the summer months. It is likely that many housing market participants plan their market activity to coincide with these periods and there are resultant variations in demand and supply for housing services during these periods. The increased demand in the first quarter of a year is also accompanied by an increase in prices. The results for price changes suggest quite clearly that price changes in the third quarter of a year are lower than for

and region samples. No statistically seasonal influence was observed and the results are not reported.

the annual average. This result does not appear to be directly linked to any significant variation in demand for the third quarter. A plausible explanation is that that the supply of housing available for sale in the winter months is characterised by more homes that have been for sale for longer periods (‘old’ supply). Those sellers wanting to sell are therefore likely to accept lower prices in the winter period because of the lower demand (compared to summer) during this period.

Regardless of the causes of these observed seasonal effects, these results have important implications for analysis of Australian housing markets. During the past fifteen years there have been numerous international studies examining issues associated with the informational efficiency of housing markets (see Gatzlaff & Tirtiroglu (1995) for an excellent overview). Typically these studies use tests of serial dependence with estimated house price indices to examine serial dependence properties. The results of this study indicate that tests using quarterly index differences are likely to be biased by seasonal influences in price changes. The use of annual index differences has the effect of removing this seasonal trend from the data.

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Table 1: Transaction Volumes for Aggregate Data - Moving Average Transformation Procedure

1	2	3	4	5	6
Period	**Quarter**	**Number of transactions (Y)**	**Four period moving average**	**Centred moving average (CMA)**	**Ratio of quarter to CMA = Y/CMA = g**
88:Q3	3	2,210			
88:Q4	4	2,917	2,355		
89:Q1	1	2,708	2,218	2,287	1.18
89:Q2	2	1,586	1,886	2,052	0.77
89:Q3	3	1,662	1,733	1,809	0.92
89:Q4	4	1,588	1,740	1,736	0.91
90:Q1	1	2,094	1,814	1,777	1.18
90:Q2	2	1,614	1,898	1,856	0.87
90:Q3	3	1,961	1,904	1,901	1.03
90:Q4	4	1,922	2,044	1,974	0.97
91:Q1	1	2,120	2,012	2,028	1.05
91:Q2	2	2,172	1,879	1,945	1.12
91:Q3	3	1,833	1,886	1,883	0.97
91:Q4	4	1,391	1,908	1,897	0.73
92:Q1	1	2,148	2,010	1,959	1.10
92:Q2	2	2,261	2,190	2,100	1.08
92:Q3	3	2,240	2,274	2,232	1.00
92:Q4	4	2,112	2,357	2,315	0.91
93:Q1	1	2,483	2,545	2,451	1.01
93:Q2	2	2,592	2,727	2,636	0.98
93:Q3	3	2,993	3,059	2,893	1.03
93:Q4	4	2,839	3,105	3,082	0.92
94:Q1	1	3,810	3,022	3,063	1.24
94:Q2	2	2,778	2,868	2,945	0.94
94:Q3	3	2,659	2,474	2,671	1.00
94:Q4	4	2,223	2,343	2,408	0.92
95:Q1	1	2,237	2,270	2,306	0.97
95:Q2	2	2,251	2,193	2,231	1.01
95:Q3	3	2,367			
95:Q4	4	1,916			

Notes:

1. Column 1 gives the quarterly sample period; 88:Q3 is the third quarter of 1988.
2. Column 2 gives the quarter number of the sample period, Q1 = 1 Jan - 31 March, Q2 = 1 April - 30 June, Q3 = 1 July - 30 September, Q4 = 1 October - 31 December.
3. Column 3 gives the number of transactions occurring in the sample period.
4. Column 4 calculates the four period moving average (MA). For the first four quarterly periods; ((2,210+2,917+2,708+1,586)/4) = 2,355
5. Column 5 calculates the centred moving average (CMA). For the first period; ((2,355+2,218)/2) = 2,287.
6. Column 6 calculates the ratio of transactions for a quarterly period to the CMA, denoted as the variable γ. For the first period, 2,708 / 2,287 = 1.18. This ratio γ is used in parametric tests to test for statistically significant differences in sales volumes for quarterly periods. The results for these tests are reported in Table 2.
7. It is important to note that the moving average procedure shown here reduces substantially the number of observations available for statistical testing. From the total of 26 observations there are 7 observations on the first and second quarter and only 6 observations available for the third and fourth quarter.

Table 2: Transaction Volumes - Statistical Tests for Seasonal Influences

Region Number	N Transactions	Mean g all periods	Q1 Mean g (t)	Q2 Mean g (t)	Q3 Mean g (t)	Q4 Mean g (t)
All regions	68,799	0.994	1.105 (2.901)†	0.967 (-0.591)	0.993 (-0.048)	0.896 (-2.873)†
1	5,951	0.987	1.083 (1.740)	0.966 (-0.348)	0.978 (-0.152)	0.908 (-2.606)†
2	9,001	0.996	1.137 (2.967)†	0.964 (-0.504)	0.982 (-0.990)	0.882 (-2.713)†
3	10,220	0.999	1.111 (3.768)†	0.991 (-0.250)	0.955 (-1.718)	0.920 (-2.027)
4	5,813	0.989	1.067 (1.747)	1.004 (0.376)	0.957 (-0.938)	0.912 (-2.445)
5	6,253	0.988	1.070 (2.450)†	0.924 (-1.519)	1.097 (3.721)†	0.857 (-3.079)†
6	4,139	1.003	1.171 (3.258)†	0.976 (-0.529)	0.972 (-1.316)	0.868 (-3.322)†
7	2,600	0.990	1.017 (1.068)	0.991 (0.022)	1.048 (1.466)	0.898 (-1.304)
8	4,996	0.990	1.106 (2.761)†	0.961 (-0.530)	1.002 (0.412)	0.877 (-1.905)
9	4,319	0.992	1.090 (2.267)	0.907 (-1.775)	0.980 (-0.251)	0.987 (-0.118)
10	3,606	0.996	1.171 (5.898)†	0.890 (-2.023)	1.043 (1.745)	0.868 (-3.381)†
11	6,604	0.991	1.081 (1.453)	0.990 (-0.012)	0.967 (-1.208)	0.910 (-1.540)
12	2,215	0.985	1.151 (1.746)	0.953 (-0.399)	0.937 (-0.767)	0.877 (-2.745)†
13	3,082	0.995	1.071 (1.492)	1.011 (0.416)	1.033 (0.571)	0.847 (-2.696)†
Stacked Regions	NA	0.993	1.102 (7.992)†	0.964 (-1.966)	0.997 (0.415)	0.893 (-8.027)†

Notes:

1. The variable γ is the ratio of the volume of transactions in a quarterly period to the centred four period moving average. This procedure is explained more fully in Table 1.
2. The sample period is from 1988-1995. The number of observations available for statistical tests is limited by the moving average procedure. From the total of 26 observations there are 7 observations on the first and second quarter and only 6 observations available for the third and fourth quarter.
3. The one-sample t test, tests the null hypothesis that the mean γ for a quarterly sample is the same as the mean γ for the full sample (mean γ all periods).
4. † denotes statistical significance at a level of .05 or higher.
5. The 'stacked regions' tests involve stacking the 13 individual regional observations sets so as to increase the explanatory power of statistical tests. In this way there are 26 x 13 total observations with 7 x 13 observations on the first and second quarter and 6 x 13 observations available for the third and fourth quarter. This procedure is more completely explained in the text.

Table (3): Descriptive Statistics – Regional Indices

	Hedonic Variables			Index Accuracy [3]			
Region *N* sample	Sale $'000 Mean *Std dev* (t)	Area sqm *Mean* *Std dev* (t)	Age years *Mean* *Std dev* (t)	*x* *Mean* *Std dev* (Z) * [4]	Level	Quarterly Difference	Annual Difference
All Regions 68,799	104.8 *63.4* *n.a.*	88.7 *32.2* *n.a.*	13.8 *11.7* *n.a.*	0.001 *0.081* *n.a.*	16.7	4.4	9.2
Region 1 5,951	92.0 *63.7* (-15.6)	75.1 *30.8* (-34.1)	19.7 *15.6* (29.3)	0.009 *0.095* (-1.081)	6.7	2.2	5.0
Region 2 9,001	125.2 *70.7* (-27.3)	92.4 *34.6* (10.2)	14.1 *10.9* (2.8)	0.010 *0.075* (-1.466)	7.1	2.6	4.4
Region 3 10,220	121.8 *100.5* (17.1)	82.2 *40.0* (-16.6)	18.8 *12.6* (40.4)	0.010 *0.077* (-2.402) *	7.6	2.4	4.2
Region 4 5,813	117.2 *55.3* (17.1)	92.5 *31.3* (9.2)	12.8 *10.0* (-8.0)	-0.004 *0.080* (-1.105)	6.0	2.8	4.3
Region 5 6,253	84.8 *28.6* (-55.2)	83.5 *23.2* (-17.9)	12.7 *9.1* (-9.6)	-0.009 *0.076* (-2.619) *	6.0	3.5	6.1
Region 6 4,139	88.9 *24.3* (-42.1)	91.5 *24.9* (7.1)	10.5 *10.3* (-20.8)	-0.007 *0.079* (-2.571) *	5.3	2.8	4.7
Region 7 2,600	77.2 *24.5* (-57.5)	88.3 *20.0* (-1.2)	9.6 *8.4* (-25.6)	-0.011 *0.068* (-1.393)	3.2	2.2	3.4
Region 8 4,995	108.5 *56.9* (4.5)	89.6 *33.9* (1.9)	15.2 *14.4* (7.0)	0.016 *0.092* (-2.691) *	6.5	2.5	4.4
Region 9 4,319	137.0 *66.8* (31.7)	107.6 *35.7* (34.8)	10.1 *10.1* (-24.0)	0.018 *0.083* (-3.532) *	6.3	2.1	3.8
Region 10 3,607	99.1 *33.0* (-10.5)	99.8 *24.5* (27.1)	10.1 *7.5* (-29.4)	-0.002 *0.080* (-0.529)	4.7	2.3	3.9
Region 11 6,604	78.9 *34.2* (-61.6)	80.6 *25.4* (-25.9)	13.4 *10.4* (-2.8)	-0.012 *0.077* (-3.075) *	5.1	2.3	4.4
Region 12 2,215	78.4 *29.5* (-42.1)	84.6 *21.1* (-9.3)	10.8 *9.5* (-15.0)	-0.005 *0.081* (-0.793)	2.9	1.8	2.8
Region 13 3,082	105.8 *33.2* (1.6)	105.7 *24.8* (38.0)	6.9 *5.9* (-64.3)	0.000 *0.092* (-0.264)	5.7	2.3	4.5

Notes:
1. The *t* statistics shown in parentheses are results for a one-sample *t* test that tests the null hypothesis that a mean for a particular variable from a region sample is the same as the mean for the aggregate sample (All Regions).
2. The variable x is the annual (fourth) difference from the relevant real log price index for time series 1988-95: $x = H_t - H_{t-4}$ where; $H_t = ETV\ \hat{c}_t - LN\left(CPI_t\right)$. *ETV* is the hedonic index procedure discussed in the text.
3. The index accuracy ratios are calculated from the OLS regression procedure used to estimate the relevant index. The figures given are the ratio of the standard deviation of a variable to the average OLS standard error for that variable. Further detail of index accuracy procedures is contained in the text.
4. The variable x was tested with the Wilcoxon signed rank nonparametric test. This tests the hypothesis that an individual region's z variable distribution is the same as the distribution for all regions. A Z score for the test is shown in parentheses. Those regions marked * indicate rejection of the null hypothesis at the 5% significance level or higher.

Table 4: Real House Price Changes – Statistical Tests for Seasonal Influences

Index Quarterly Sample	All Quarters *Mean* z [1] *std. z*	Seasonality One Sample *t* tests [2] Mean *z* for Quarter *t* t = 1 Mean *z* *(t)*	t = 2 Mean *z* *(t)*	t = 3 Mean *z* *(t)*	t = 4 Mean *z* *(t)*	One Way ANOVA [3] F *Prob.*
Aggregate Sample [4]	0.005 *0.036*	0.014 *(0.482)*	0.003 *(-0.154)*	-0.017 *(-2.259)†*	0.017 *(0.934)*	1.407 *0.264*
Region 1	0.006 *0.040*	0.026 *(0.960)*	0.001 *(-0.288)*	-0.010 *(-1.644)*	0.009 *(0.301)*	1.020 *0.400*
Region 2	0.007 *0.041*	0.020 *(0.724)*	0.004 *(-0.300)*	-0.022 *(-4.376)‡*	0.024 *(0.983)*	2.152 *0.119*
Region 3	0.007 *0.041*	0.011 *(0.223)*	0.011 *(1.368)*	0.021 *(-2.014)†*	-0.022 *(0.641)*	1.674 *0.198*
Region 4	0.003 *0.046*	0.003 *(0.000)*	-0.009 *(-1.089)*	-0.024 *(-1.462)*	0.005 *(0.067)*	3.480 *0.031*
Region 5	0.003 *0.040*	0.019 *(1.000)*	-0.004 *(-0.689)*	-0.014 *(-1.159)*	0.009 *(0.382)*	0.931 *0.440*
Region 6	0.003 *0.042*	0.015 *(1.011)*	-0.001 *(-0.487)*	-0.016 *(-1.049)*	0.013 *(0.504)*	0.871 *0.469*
Region 7	0.001 *0.041*	0.025 *(1.610)*	-0.007 *(-0.881)*	-0.018 *(-1.342)*	0.002 *(0.090)*	1.467 *0.247*
Region 8	0.009 *0.047*	0.010 *(0.025)*	0.013 *(0.276)*	-0.017 *(-1.918)*	0.029 *(0.866)*	1.203 *0.329*
Region 9	0.008 *0.045*	0.041 *(1.569)*	-0.003 *(-0.949)*	0.001 *(-0.645)*	-0.007 *(-0.842)*	1.966 *0.145*
Region 10	0.005 *0.043*	0.023 *(0.921)*	-0.001 *(-0.447)*	-0.003 *(-0.564)*	0.002 *(-0.186)*	0.560 *0.646*
Region 11	0.000 *0.037*	0.020 *(1.231)*	-0.015 *(-1.874)*	-0.010 *(-0.616)*	0.004 *(0.383)*	1.374 *0.274*
Region 12	0.004 *0.049*	0.036 *(2.409)†*	-0.016 *(-0.631)*	-0.007 *(-0.583)*	0.002 *(0.276)*	1.620 *0.210*
Region 13	0.005 *0.042*	0.027 *(1.462)*	-0.006 *(-0.103)*	-0.008 *(-0.278)*	0.005 *(0.642)*	0.989 *0.414*
Stacked Regions [5]	0.005 *0.042*	0.024 *(4.203)‡*	-0.002 *(-1.960)†*	-0.013 *(-4.940)‡*	0.009 *(0.901)*	14.646 *0.000*

Notes:

1. The variable z is the first difference from the real log price index, for Hedonic indices:
   $z = H_t - H_{t-1}$ where; H_t = Hedonic index $\hat{c}_t - LN\left(CPI_t\right)$.
2. The one sample *t* test, tests the null hypothesis that the mean for a quarterly period sample is the same as the mean for all quarters.
3. The One Way ANOVA tests the null hypothesis that the Mean *z* is the same for all quarterly period samples.
4. The aggregate sample is a composite of all regional samples for the Perth metropolitan region for the period 1988 – 95. This sample comprises a total of 29 real quarterly differences, being 7 differences for quarters 1 2 3 and 8 differences for quarter 4. The region samples 1 – 13 comprise a similar number of observations.
5. The stacked regions sample uses the real quarterly differences for all region samples. The procedure used was to stack the data for all 13 regional indices where each region has 29 real quarterly differences for the sample period. The observations for region 1 are stacked above region 2 through region 13. This creates 377 quarterly index differences for more robust tests of seasonality.

Chart 1: Real House Price Index - Aggregate Sample 1988 - 95

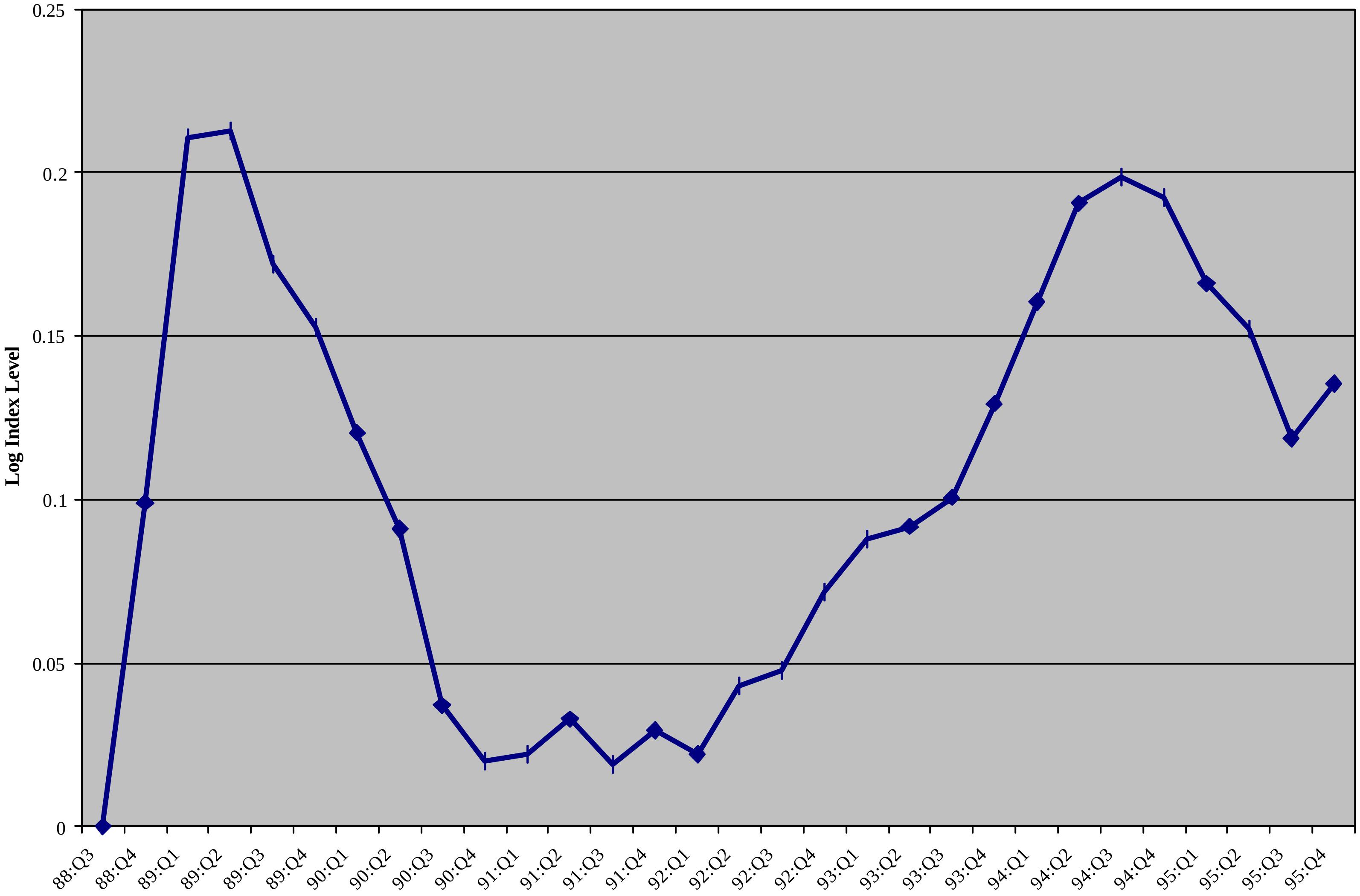

Chart 2: Volume of Transactions Aggregate Sample 1988-95