HOUSING AND ECONOMIC ADJUSTMENT

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This paper is part of a programme that examines the determinants of house prices regionally across New Zealand, informing issues of community adjustment to shocks and of local authority adjustment to changing property rating values. Sections 1-5 are complete; Section 6 is still preliminary. The paper is released at this stage to coincide with paper presentations to the NZAE conference (June 2003), to the Centre for Housing Research Aotearoa New Zealand (CHRANZ, June 2003), and to the NZGS conference (July 2003). We wish to thank CHRANZ, the Lincoln Institute of Land Policy and the Foundation for Research Science and Technology (programme on *Understanding Adjustment and Inequality*) for funding assistance. We also wish to thank Quotable Value New Zealand and Jason Timmins for their immense help in obtaining the data and our other Motu colleagues, particularly Dave Maré, for their insightful comments. All errors and/or omissions remain our responsibility.

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ABSTRACT

Housing is the most important component of wealth for many New Zealanders. Its location is fixed and its value is influenced by economic and other factors specific to that location. Hence when people live in owner-occupied homes their wealth is strongly associated with their local economic conditions. Housing is also a major factor in influencing migration decisions and, hence, regional mobility. To shed light on the behaviour of the New Zealand housing market, we examine the dynamic and long run responses of house values across spatial communities and across time to economic variables that impact on the local economy. We use a specially constructed QVNZ-sourced database for house prices and house sales, and a range of explanatory variables constructed consistently across TLA and Regional Council levels.

1 INTRODUCTION

Housing is the most important wealth component for many New Zealanders. Housing trends affect people's welfare in direct and indirect ways and housing construction is an important component of economic activity. It is imperative to understand the long-run determinants and the dynamics of the housing market for a number of economic and social policy-related reasons. At least five reasons stand out.

First, the location of housing is fixed and its value is influenced by both aggregate economic factors (e.g. interest rates) and by economic and other factors specific to that location (e.g. localised industry shocks and localised demographic trends). As a result of these localised influences, when people live in owner-occupied homes, their wealth is associated with their local economic conditions. Understanding the determinants of house values therefore assists in understanding a major determinant of individuals' and families' wealth dynamics over time.

Second, other aspects of people's well-being - their incomes and the state of their local community (including locally-funded services) - are linked to the same local economic conditions. People may wish to migrate from economically-depressed to expanding regions. However, a number of studies have found that people's ability and willingness to move from one region to another is dependent, in part, on the wealth they can derive from their existing housing asset, relative to that required to purchase housing in another region.[2] Understanding the economics of the housing market therefore assists in understanding an important aspect of regional mobility.

Third, rental rates are positively related to house values (Savage, Kerr and Toplis, 1989). Where an area faces a positive economic shock with resulting house price increases, rentals are likely to rise. Individuals and households who rent rather than own their dwelling face a decrease in their well-being and may have to seek accommodation elsewhere, possibly in the same labour market (but in an alternative, and probably less desirable, location) or possibly in another labour market. The latter entails working individuals having to seek alternative employment.

[2] See, for instance, the analysis by Glaeser & Gyourko (2001) of the asymmetric reaction of house prices and population (through internal migration) to positive and negative changes in local economic conditions in the rustbelt of the United States. See also the analysis of Bate *et al* (2000) of the link between internal migration and housing in the United Kingdom.

Fourth, the ability of the building industry to service localised needs is of importance. If bottlenecks appear in the supply of new houses in the face of strong localised demand, the effect can be a localised overshooting of house prices above fundamentals (i.e. above long run equilibrium) that can exacerbate the magnitude of some of the effects already discussed (Capozza, Hendershott, Mack and Mayer [CHMM], 2002).

Fifth, the dynamics of the housing market impact strongly at the macroeconomic level, affecting aggregate expenditure patterns and fiscal revenues. Changes in housing wealth impact on consumption expenditures that influence aggregate demand and output directly and consumer price inflation indirectly. These effects flow through to monetary policy responses, with a feedback to housing and other markets through consequential interest rate changes.

For all these reasons, a research programme that analyses the determinants both of the long run trends and of the dynamics of house price movements will be useful in informing policy as well as increasing our general understanding of the housing market. This study is an initial contribution to that programme.

2 BACKGROUND AND PAPER OUTLINE

Internationally, considerable work has been conducted on the determinants of house prices at aggregate and regional levels. We do not provide a detailed description of this literature here. Instead, we summarise the literature's findings with regard to key house price determinants arising from supply and demand forces as follows:

2.1 Individual house characteristics:

- Number of bathrooms (Can, 1992);
- Lot size (Can, 1992);
- Presence of fireplace (Can, 1992; Dubin, 1992);
- Garage size (Can, 1992; Dubin, 1992);
- Presence of air-conditioning (Can, 1992; Dubin, 1992);
- Presence of a basement (Can, 1992);
- Detached dwelling (Dubin, 1992);
- Presence of a patio (Dubin, 1992);

- Previous purchase price (Genesove & Mayer, 2001).

2.2 Neighbourhood and amenity characteristics:

- Neighbourhood quality index, e.g. deprivation index (Can, 1992);
- Local construction costs (CHMM, 2002);
- Land supply index, i.e. vacant land (CHMM, 2002);
- Coastal versus inland situation (cited by CHMM, 2002);
- Location/distance from city centre (Case & Mayer, 1996; Dubin, 1992);
- School assessment score (Case & Mayer, 1996);3
- Crime rate (Case & Mayer, 1996);
- House permits issued (Case & Mayer, 1996);
- Average/median per capita income (O'Donovan & Rae, 1997; CHMM, 2002);
- Real income growth (CHMM, 2002);
- Unemployment rate (O'Donovan & Rae, 1997).

2.3 Demographic variables:

- Population (CHMM, 2002);
- Percentage change in population (CHMM, 2002);
- Adult population, >21 years (Mankiw & Weil, 1989);
- Population aged <15 years (O'Donovan & Rae, 1997);
- % of residents aged 35-60 years (Case & Mayer, 1996);
- % residents in manufacturing (Case & Mayer, 1996).

2.4 Macroeconomic variables:

- User cost of capital, and hence nominal interest rates, inflation rate, tax rates (CHMM, 2002; O'Donovan & Rae, 1997);
- Leverage, i.e. debt/equity (Genesove & Mayer, 2001);
- Price of investment in new dwellings (GSDD4, 1983);

[3] Note the effect of this variable on house prices could be negative in a dynamic sense if the percentage of school age children in the population is declining.

- Real disposable income (GSDD, 1983);
- Stock of existing dwellings (GSDD, 1983; O'Donovan & Rae, 1997);
- Growth in M3, pre financial deregulation (GSDD, 1983);
- Aggregate consumption (O'Donovan & Rae, 1997);
- Occupied dwellings per person (O'Donovan & Rae, 1997);
- Commodity prices (O'Donovan & Rae, 1997);
- Labour market conditions (O'Connor & Healy, 2002).

There has been a body of international work that has examined the dynamics of house prices across regions and across time. A recent study that does so, combining determinants of dynamics with long-run house price determinants, is the study of CHMM (2002). That study, which forms a methodological basis for our current and future analytical work, isolates key factors (some amenable to policy action) that may cause lagged adjustment to fundamental values in house prices. Factors are isolated that may cause house prices to overshoot their long-run fundamentals. Each of these types of dynamic adjustment is likely to lead to economic inefficiencies (i.e. to resources being directed to ends which are not of the highest potential value). An important finding of CHMM's work is that the cost of building new houses, including the regulatory costs and delays faced by developers in responding to an upsurge in housing demand, can be instrumental in causing the overshooting phenomenon.[5] Downward shocks to regional fortunes can have an even greater (downward) effect on house prices, since falling demand for housing in the locality is not matched by any fall in supply, even over moderately long time horizons (Glaeser & Gyourko, 2001).

New Zealand work analysing the determinants of house prices is limited. At the aggregate level, the Reserve Bank of New Zealand's modelling programme has led to econometric modelling of the nation-wide "price of existing dwellings". GSDD (1983) found that in the long run, the price of existing dwellings was determined by the price of investment in dwellings (i.e. a Tobin's 'q' relationship, with a unit elasticity) modified by the impact of real disposable income (a significant positive effect) and the stock of dwellings (a significant negative effect). The Tobin's q relation and the effect of the stock of existing dwellings is consistent with theoretical priors; the disposable income effect may reflect the presence of

[4] Grimes, Spencer, Duggan & Dick.

[5] Glaeser & Gyourko (2002) demonstrate that such restrictions can also lead to house prices in certain localities being permanently above the cost of constructing new dwellings.

liquidity constraints, especially given that the relation was estimated prior to financial liberalisation.

The latter aspect is supported by the dynamics that included a strong effect of the change in real M3 money balances (essentially bank deposits) on the rate of change in existing dwelling prices. The dynamics are particularly interesting. The coefficient on the lagged dependent variable has a coefficient of 1.843, indicating that any transitory shock impacting on house prices in one period (e.g. because of a rise in real bank deposits and hence in funds available for house lending) had an even greater effect in the following quarter. The sum of coefficients on the three lagged dependent variables, however, was less than unity indicating a stable, albeit overshooting, adjustment process.

O'Donovan and Rae (OD&R, 1997) conduct the only comprehensive disaggregated econometric analysis of New Zealand house prices. They model aggregate house prices in New Zealand and also model house prices at a 14-region level.[6]

Their aggregate long-run house price model is based on the utility-maximising theoretical model that Pain & Westaway (1996) used to model the UK housing market. This model yields a long run aggregate house price equation to be estimated of form:

$$g \equiv p^h/p^c = \theta(ch/c)-\gamma/[(r - \dot{g} + \delta)/(1+r)] \qquad (2.1)$$

where: g is the real house price (p^h/p^c), c is aggregate real non-housing consumption, c^h is aggregate consumption of real housing services which is assumed to be a constant proportion (θ) of the real housing stock (h) at each point of time, p^h is an index of nominal house prices, p^c is an index of nominal consumer prices, r is the after-tax real interest rate, a dot signifies rate of change, and δ is the depreciation rate. The expression in square brackets is the user cost variable (UC).

OD&R estimate a slightly modified version of the theoretical equation as follows:

$$\log (g) = f[\log(c^h/c), UC, Z] \qquad (2.2)$$

where Z is a vector of additional factors.

Because of their sample period (which extends from 1976 to 1995), OD&R face the problem that the user cost variable is frequently negative, especially prior to financial liberalisation in 1985. Further, credit was rationed prior to this time. For these reasons, they model a proxy for the after-tax real interest rate (R) as:

[6] The 14 regions correspond to the 16 Regional Councils, with the Nelson, Marlborough and Tasman regions amalgamated into one region.

$$R = (1 - D)(1-t)(i-\pi) + r_0D \qquad (2.3)$$

where D is a dummy variable = 1 prior to 1985:1 and 0 otherwise, i is the 90-day bank bill rate, and r_0 is estimated freely (coming out at a sensible 3¼%). Expectations of consumer price inflation are assumed to equal last year's inflation rate (π). The authors proxy $\dot{g}$, the expected rate of change of the relative price of houses to consumer prices, by the average rate of change of g over the past five years (this works considerably better than the change in g over the past year).

Two other factors (in Z) which are added are: AGE, which is the log of the proportion of the population <15 (although ideally they would like the proportion of population aged 20-35, representing the pool of likely first home buyers[7]); and ROOM, which equals the log of the number of occupied dwellings per person which takes account of the decline in average number of people per dwelling from 3.4 in 1975 to 2.9 in 1996.[8]

Their estimation uses semi-annual, seasonally adjusted house prices proxied by Quotable Value New Zealand's house price series, which measures average prices of freehold house sales adjusted for the quality-mix of sales in each survey period.[9] θ is taken to equal 0.024 to ensure that the nominal value of imputed plus actual rent equals the official estimate in the base year of 1991/92.

In their equation explaining the long run (equilibrium) determinants of real house prices, each variable is statistically significant with negative coefficients on each of (c^h/c) and UC, and positive coefficients on each of AGE and ROOM. These signs are as expected.

The OD&R short-run adjustment equation (i.e. explaining adjustment of house prices to their equilibrium) is driven primarily by the deviation between actual and equilibrium house prices last period. The equation (which explains 75% of the variance of house price changes) has a number of novel features. First it has a form that specifies that house prices rise in response to disequilibria (i.e. where house prices are below equilibrium) but do not fall in response to disequilibria (where they are above equilibrium). Periods of

[7] See Mankiw and Weil (1989) on the importance, in the United States, of including the population aged 20-30 years (key household formation years) as a determinant of house prices. They find also that use of the population aged over 20 years performs almost as well as the population aged 20-30 years; however, inclusion of total population performs poorly in their regression estimates.
[8] ROOM is calculated from census data & official annual estimates; i is the 90 day bank bill interest rate; π uses CPIIGST being the CPI excluding interest and GST; average income tax rate is total wage and salary tax receipts as a proportion of household disposable income (although presumably this should be as a proportion of gross income).
[9] Unit root tests show all variables to be non-stationary, i.e. I(1). Further, the long run equation has an R^2 of 0.938 and passes a test for co-integration indicating a statistically appropriate long run relationship.

above-equilibrium house prices are generally equilibrated through a longer-term process of waiting for trends in other variables (e.g. consumer prices) to evolve so as to remove the disequilibria.[10] Second, the coefficients on lagged house prices in the equation indicate the presence of short-run overshooting of house prices (consistent with the previous New Zealand work cited).[11]

At the regional level, OD&R find that semi-annual house price changes tend to be highly correlated across most regions (mostly $0.5<r<0.8$, where r is the correlation coefficient). The exception is the West Coast which has very low correlations with other regions ($r<0.35$ for all except for one case). However, in a statistical test of whether the equilibrium house prices evolve similarly over time, they find only two cases (out of a possible 91 combinations) where regions move in tandem with each other.[12] Thus regional house-price cycles move together, but long-run trends do not. The latter result does not deny the presence of some variables affecting long-run house prices similarly across regions; it does, however, indicate the existence of additional region-specific factors that cause divergences in long run house prices across regions over time.

OD&R are unable to estimate a model of similar form to the aggregate model for each region owing to a dearth of quality regional data. Instead they model each region's house price relative to the national average. Factors assumed to influence this relativity include relative "gross regional product" (GRP) per person and relative unemployment rates. The latter variable may have both a direct effect on house prices through potential migration, etc and also an indirect effect by influencing liquidity constraints. OD&R also include the effect of agricultural prices[13] relative to consumer prices; and relative populations.

For the 14 regions' long-run house price equations, OD&R find that relative GRP per capita has a significant positive effect on relative house prices in eight regions; relative unemployment rates have a significant negative effect in nine regions; relative population has a significant positive effect in 6 regions; and commodity prices have a significant effect in 11 regions with positive effects in nine of those regions and negative effects in Auckland and

[10] This result is consistent with pro-cyclical movements in the number of house sales and with the negative correlation between days on the market and house price inflation.

[11] A third novel feature is that the short run equation is estimated econometrically by the Least Absolute Deviations (LAD) method because standard OLS places undue weight on extreme observations when the data generation process is non-normal. A graph in the paper shows major spikes in annual house price inflation potentially indicating non-normality. Another graph in the paper shows the spectrum of real house price growth with a major cycle of 8 years and a minor cycle of 2 years.

[12] Based on a co-integration test regressing one region's house prices on those of another region.

[13] The agricultural price series uses commodity weights of meat (40%), dairy (35%), wool (25%).

Wellington (as expected given that the equation is explaining house prices relative to the national average).

Interestingly, OD&R find that the estimates for the Bay of Plenty are often counter-intuitive, and speculate that this may be because that region has different influences on it from elsewhere, perhaps because it is the "retirement Mecca" of New Zealand.

This work at both the aggregate and the regional levels, taken in conjunction with recent international work at the regional level, informs our own approach as detailed below. Our work extends that of OD&R by examining house price developments both at Regional Council (RC) and Territorial Local Authority (TLA) levels. At each of these levels we analyse the properties of house prices over time, including short-run and long-run relationships between house price movements across different areas.

In dealing with Regional Councils, we amalgamate Nelson, Marlborough and Tasman councils (each of which corresponds to a single Territorial Local Authority (TLA)), so being consistent with one of our main sources of regional economic data: the National Bank of New Zealand's Regional Economic Activity Indices. This allows us to examine the long run economic determinants of house prices over time; we present preliminary estimates on these determinants in this paper. Future work will refine these estimates and analyse short-run house price determinants in more detail.

Our smallest unit of analysis for this study is the TLA of which there are 74 in New Zealand.[14] Henceforth, we drop the Chatham Islands from the analysis (due to its small size) and refer to New Zealand's 73 TLAs. Examples of TLAs are: Whangerei District (population 70,600), Manukau City (population 307,100), Rangatikei District (population 15,300), Hurunui District (population 10,300) and Dunedin City (population 120,300). From these examples, the populations of TLAs differ considerably from one another, as do their areas.

Data at the TLA level are being compiled which will enable us to test the hypothesis that economic and demographic shocks impacting at the geographical level influence house prices within that TLA. In rural districts, for instance, we expect that relevant commodity prices will have an impact on incomes and the desirability of housing in that area. In TLAs within Auckland, international inward migration may have a significant impact on house prices. In tourist areas, short-term international arrivals may have an impact. In some cases we will have information on shocks measured at the TLA level (e.g. the value of

[14] Data for house prices and sales are also available - but have yet to be utilised - at smaller levels of analysis; i.e. at area unit and mesh-block level.

agricultural and other land in that TLA); in others, our explanatory variables will be at a higher level of aggregation (e.g. nominal interest rates, which are set nationally). Explanatory variables may include variables that are determined outside the country (e.g. commodity prices) or within the country but outside the region (e.g. government policy-induced shocks). In each case, the shocks will be taken to be exogenous to the individual TLA.[15] Testing the impact of these variables on TLA-level house prices is left to future work.

In the next section we describe the theoretical approaches underpinning our subsequent empirical work. These approaches are based principally on Pain and Westaway (1996) and CHMM (2002).

Section 4 describes our data on house prices and house sales in some detail. This is the first paper to use a new dataset on these variables, obtained from QVNZ. We document aspects of the data that are relevant both for the current analysis and for future users of the data.

In section 5, we test for long-run and dynamic co-movement of house prices across regions. In testing for dynamic co-movement across regions, we examine both contemporaneous and lagged effects, the latter indicating causality in a temporal sense. This testing indicates whether house prices across New Zealand (or across parts of New Zealand) move together both cyclically and in the long term.

Section 6 presents initial estimates of the long-run (equilibrium) determinants of real house prices at RC level. Key conclusions regarding factors analysed in sections 5 and 6 are signposted in section 7, which also summarises our intentions with regard to future work in this research programme.

3 THEORY

Our theoretical approach to estimating house prices builds on the work of Pain and Westaway (PW, 1996) and CHMM (2002). PW formulate the consumer problem as one where each household allocates its lifetime wealth over housing services and non-housing consumption in each period of life and over its bequest. Using standard forms of the utility function and aggregating over individuals, this results in an equation explaining real house prices as follows (using previous variable definitions):

$$p^h / p^c = f_1[(c^h/c), UC] \qquad (3.1)$$

[15] I.e. not within the control of agents within that TLA.

where $c^h = \theta h$

In this specification, p^h is the quality-adjusted price of housing. In practice, house prices are observed for bundles of housing and related services. These services include house-specific services. The services also include the amenity and location value of living in a particular locality. In section 2, we summarised relevant components of these characteristics that have been found significant in hedonic regressions under the headings "Individual house characteristics" and "Neighbourhood and amenity characteristics".

Our house sales price data is not quality-adjusted. We can include the unadjusted real sales price (here denoted p^u) as the dependent variable as follows. Let the real unadjusted price be a function of the real quality-adjusted price plus a vector of house-specific attributes (ZHOUSE) and a vector of locality-specific attributes (ZLOCAL). Each element of ZHOUSE and ZLOCAL is measured in such a way (for the following exposition) that the anticipated effect of that element on the unadjusted sale price is non-negative. Thus (with anticipated signs indicated below):

$$p^u/ p^c = f_2[\underset{+}{(p^h/ p^c)}, \underset{+}{\text{ZHOUSE}}, \underset{+}{\text{ZLOCAL}}] \qquad (3.2)$$

Each of ZHOUSE and ZLOCAL may contain elements that are fixed over time but that vary cross-sectionally (e.g. latitude of the locality). Other elements may vary over time (e.g. changing house quality or changing amenities within a locality.) Both sets of information can be included in a panel regression of real sale prices, although the former can also be handled through the inclusion of TLA fixed effects if poor proxies are available or if the effect of that particular element is not of interest. Rearranging (3.2) and inserting in (3.1) yields:

$$p^u/ p^c = f_3[\underset{-}{(c^h/c)}, \underset{-}{\text{UC}}, \underset{+}{\text{ZHOUSE}}, \underset{+}{\text{ZLOCAL}}] \qquad (3.3)$$

In PW's approach, the non-housing consumption term (c) reflects the influences of lifetime wealth of a household living in the relevant area. We can disaggregate the c^h/c term (recalling that $c^h = \theta h$), including the real housing stock variable (h) separately from the factors influencing lifetime income, and hence c. Denoting the vector of factors determining current and future real incomes in the relevant area as ZINCOME (with the elements of the vector specified so that the anticipated effect of that element on income is non-negative) we arrive at the following long-run equation determining real unadjusted house sale prices:

$$p^u/ p^c = f_4[h, \text{ZINCOME}, \text{UC}, \text{ZHOUSE}, \text{ZLOCAL}] \qquad (3.4)$$

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The stock of housing (h) in each area is determined jointly with house prices in the (very) long run. However the housing stock only changes slowly over time and hence is a predetermined variable over short to medium time horizons. By contrast, the house price is an asset price and so is a "jump" variable, reflecting the influence of new information, for instance within ZINCOME. Consistent with this observation, OD&R found that their single equation estimates of house prices based on (3.1) gave very similar results to the full system of results which included equations also for consumption and for housing investment. On this basis, we restrict our attention to a single-equation approach rather than estimate a full systems approach.

The adjustment path of house prices (including the degree of lagged adjustment and the degree of overshooting, if any) will, however, be influenced by sales and supply-related factors (i.e. factors that influence the time path, and turnover, of h). Thus (local) costs of constructing new houses, the degree of vacant land available for housing within a TLA and regulatory efficiency (e.g. in processing building permits) may all help determine dynamic house price adjustment to the long-run equilibrium. In future work, we will test for these effects in our adjustment equations using methods that allow for asymmetric adjustment depending on whether house prices are above or below equilibrium.

Following Glaeser and Gyourko (2002) we will also test whether a vector of such variables (denoted ZCONSTRUCT) influences the long run sale price over the relevant time horizon.[16] If ZCONSTRUCT is measured so that elements have a positive effect on house construction costs, the estimation equation becomes:

$$p^u / p^c = f_5[h, \text{ZINCOME}, \text{UC}, \text{ZHOUSE}, \text{ZLOCAL}, \text{ZCONSTRUCT}] \qquad (3.5)$$

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We henceforth denote the equilibrium (estimated) value of the log of the <u>real</u> long-run house price in (3.5) as P*. Turning to the dynamics for P*, we will utilise the framework of CHMM, who term P* "the fundamental value" of housing in an area.

[16] For instance, taking an extreme, if building permits were impossible to obtain in a certain desirable area, a premium pertaining to that area could exist permanently. Note that the construction component is only one element of the full sale price - the other component being the land price; thus a marginal increase in local construction costs may have no discernable effect on local sale prices (of the dwelling plus land) if an increase in the value of the dwelling (through a Tobin's Q relationship) is offset by a compensating decline in the land price attached to that dwelling, leaving the occupant's dwelling choice unaltered in the face of the variables in (3.4). This is a matter for empirical testing.

Actual logarithmic values of real (quality unadjusted) house prices, P, are hypothesised to adjust over time (indexed by t) to the fundamental value as in (3.6):

$$\Delta P_t = \alpha\Delta P_{t-1} + \beta(P^*_{t-1} - P_{t-1}) + \gamma\Delta P^*_t \qquad (3.6)$$

The specification of (3.6) is broad enough to allow for partial adjustment (through α), adjustment to disequilibria in the housing market (through β) and immediate adjustment to fundamentals (through γ). The relative values of α, β and γ in each region determine the degree of lagged adjustment and/or overshooting behaviour relative to fundamentals in that region. CHMM demonstrate that as the serial correlation coefficient, α, increases, the amplitude and persistence of house price cycles tends to increase. As the reversion coefficient, β, increases, the frequency and amplitude of the cycle tends to increase.

Following CHMM, we allow the serial correlation and reversion parameters in the dynamic equation for each region themselves to be functions of sales, construction and related variables specific to a region. Indexing regions by k, we specify the dynamic equation for each region's house prices as:

$$\Delta P_{kt} = (\alpha + \Sigma_i\alpha_i(Y_{kit} - Y^*_i))\Delta P_{k,t-1} + (\beta+ \Sigma_i\beta_i(Y_{kit} - Y^*_i))(P^*_{t-1} - P_{t-1}) + \gamma\Delta P^*_t \qquad (3.7)$$

In (3.7) the Y_i are independent variables influencing adjustment of house prices [elements of Y_i may also appear in the long run equation (3.5)]; and Y^*_i represents the mean value of Y_i. In this specification, for instance, a region, k, that has a value of Y_{kit} greater than Y^*_i will have faster reversion of prices to fundamentals than the mean speed of reversion if β_i is positive.

In operationalising (3.7), there is an issue as to whether the mean value should be time invariant as postulated by CHMM in (3.7). For variables that are trending over time, this specification will imply a gradual raising or lowering of the partial adjustment and reversion parameters. In some cases this may be economically sensible. For example, if sales within each region are increasing over time, this may lead to faster reversion towards fundamentals over time across all regions. On the other hand, if the Y_i reflects real construction costs, one would expect these to rise over time (as real incomes rise) without any necessary effect on new housing starts (especially if labour productivity is improving at a similar rate).

We consider that the most robust way of specifying the Y_i variables is to choose forms of the variables that do not trend significantly over the sample period, so that the sample mean is a reasonable baseline against which to measure deviation of actual movements from the norm. Thus in our examples above, we may prefer to use sales divided by number of houses in the region, or to use some measure of real unit labour costs in construction.

In determining the Y_i variables, we will follow CHMM in choosing variables that influence housing market activity both in terms of sales of existing dwellings and new construction. We also include variables that may be linked to market "euphoria". Unlike CHMM, we have quarterly data for house sales in each region for the whole period of our estimation and so can test the dynamic influence of this variable.[17] We also have data for building consents (albeit not for the full period) that we can employ. Variables that appear in ZCONSTRUCT are theoretically relevant to the dynamics and will also be tested; the changes of variables which appear in ZINCOME will be tested in keeping with CHMM's hypothesis that changes in such variables may be linked to short term "euphoria".

Before estimating (3.5) and the dynamic equations for house price adjustment to fundamentals (3.6 or 3.7) we undertake a detailed time series examination of the sale price variables (section 5). One of the key components of this examination is to test whether house prices across regional councils and TLAs "move together" in a statistical sense over both the short run and over the long run. If they do move together in the long run, the implication is that (3.5) can be estimated solely using RC or TLA fixed effects plus national time series variables. If they do not move together over the long run, locally varying time series variables (which are not co-integrated with one another) must be included within (3.5) to explain house prices within each area. We can then test which variables within h, ZINCOME, ZHOUSE, ZLOCAL, ZCONSTRUCT and UC are relevant in driving the different price outcomes across different areas. OD&R's results indicated that house prices do not evolve similarly over time across different regions in New Zealand. However, our work covers a quite different time period, adopts a different frequency (quarterly rather than half-yearly) and uses different data to their work. It is therefore important to test these time series properties prior to embarking on our theoretically-based estimation.

4 HOUSING MARKET DATA

We use QVNZ data for median residential house sales prices at the Territorial Local Authority (TLA) level. For some of our analysis, we aggregate these data to Regional Council (RC) level using the correspondence shown in Table 1. (Table 1 also defines the

[17] CHMM used population as an imperfect proxy for sales. However house sales are much more likely to capture dynamic effects than is a slow-moving variable such as population.

abbreviations used for each RC and TLA.) In this correspondence, each TLA is allocated once (and only once) to each RC.[18] Data are also available for mean residential house sales price data and for the number of sales each quarter in the relevant area.

In smaller TLAs, as shown in Table 2 (3rd column) the number of sales per quarter can be low (e.g. as low as 16 in some quarters), while in larger TLAs, sales are normally in the hundreds each quarter. This means that the data (both median and mean) are "noisier" in small TLAs (i.e. contains greater variability in quarter to quarter movements) than in larger TLAs and RCs. Neither the median nor the mean data is uniformly less noisy than the other; however, on balance, the median data displays a little less variability than does the mean data (i.e. it appears to be less susceptible to sales of one, or a few, very high price houses). For this reason, we use the median data in what follows.

All sales price and activity data are available quarterly for the 88 quarters from March quarter 1981 [1981(1)] to December quarter 2002 [2002(4)].[19] We have checked through all 7,656 sales price observations (88 quarters each for 73 TLAs plus 14 RCs). In a few cases, there are major changes in prices that are reversed in the following quarter (or, occasionally, two quarters). These observations are likely to be due to measurement error or to small sampling in those cases (i.e. to situations where only a small number of sales occurred in that quarter).

In order to purge the data of extreme movements we have compiled a database that cleanses the data of major quarterly real sales price changes.[20] Where the real sales price increased by more than 33.3% or decreased by more 25%,[21] that observation has been inspected and where a reversion in value takes place subsequently, the "offending" quarter's sale price has been smoothed through use of a linear interpolation between the previous and

[18] In fact, definitional boundaries for TLAs are driven mainly by history and by human geography, while RC boundaries are driven mainly by physical geography (water catchments), with the result that some TLAs span more than one RC. We have allocated TLAs to RCs based on the implicit allocation indicated in the Statistics New Zealand map, *New Zealand Cities and Districts*.

[19] In using this data, we had to construct the final five observations for the Selwyn TLA (with the last four observations missing from our QVNZ data-source and the previous observation clearly incorrect). To construct these 5 observations we ran a regression of Selwyn house sales prices on a constant plus the sales prices of the 5 contiguous TLAs (Hurunui, Waimakariri, Christchurch City, Banks Peninsula and Ashburton) from 1981(1) - 2001(3), and then used the sales price values in these 5 TLAs to construct values for Selwyn for the missing observations. This process is considered to give a consistent estimate of Selwyn prices over these 5 quarters, but imparts less quarterly variability to Selwyn observations over these five observations than occurs prior to 2001(4).

[20] "Real sales price changes" refers to the area's median sales price/CPII, where CPII is the CPI excluding interest and credit charges (these charges are no longer included in the CPI, although they were in earlier years). All references to the CPI henceforth use this definition.

[21] I.e. where the ratio of the price in period t to period t-1 is greater than 4/3 or less than 3/4.

subsequent sales prices for that area. As Table 2 shows, most such smoothing adjustments occurred for areas in which there were relatively few sales. In 42 of the 73 TLAs and in 13 out of the 14 RCs, no smoothing adjustments were made. In a further 15 TLAs, only one or two observations were smoothed; 13 TLAs and one RC had three to eight observations smoothed (i.e. fewer than 10% of their observations) while 10, 12 and 13 observations were smoothed respectively in Otorohonga, MacKenzie and Grey. Even after these smoothing adjustments, TLAs with relatively few sales still have considerably greater quarter-to-quarter variability in their real median sales prices, as shown in Table 2.[22]

Quarterly variability in the data is potentially both helpful and harmful to aspects of our empirical work. To the extent that quarterly variability reflects responses to economic developments, the variability will assist in discriminating between the causes of house price movements. However to the extent that it arises from measurement issues, the variability may disguise some relationships. This latter aspect is likely to be more problematic for interpreting the dynamics of house price movements (i.e. house price movements from quarter to quarter) rather for interpreting the long run determinants of house prices across different areas. We have no reason to believe that house price levels or long-run trends are in any way distorted by the nature of the data that we have obtained.

Table 2 (1st column) presents the nominal median sales price for each TLA and RC for 2002 (calendar year average of 4 quarters). Median prices vary from $49,000 in each of Kawerau and South Waikato to $342,000 in Auckland City. At the RC level, prices vary from $63,000 on the West Coast to $282,000 in Auckland region. Figure 1 illustrates the potential for widely divergent nominal price trends, graphing the nominal sales prices for Auckland City and Kawerau TLAs. The ratio of the two series was 1.4 in 1981 and 7.0 in 2002.

The second column of Table 2 presents the average percentage change in <u>real</u> sales price from 1981 to 2002 (calendar years). At the RC level, variation in the real sales price over the 22 years varies from a minimum of -27% (Southland) to a maximum of 111% (Auckland), indicating major divergences in sales price growth over the period. At the TLA level, the variation is even greater with minimum real growth of -50% (Kawerau) and a maximum of 152% (Auckland City). At the TLA level, 15 areas had negative real sales price growth while six had growth in excess of 100% (i.e. the <u>real</u> price had at least doubled). The 15 negative cases are predominantly rural, while the cases with a doubling in real prices were

[22] The cross-sectional TLA correlation coefficient between average sales and standard deviation of quarterly real sales price changes is -0.67; and that between number of quarters with sales <50 and the standard deviation of real price changes is 0.66.

in or around major cities plus two tourism-related areas: Thames-Coromandel and Queenstown.

Figure 2 graphs real house prices[23] in the TLAs at the heart of New Zealand's five major urban areas. The period for which the data are available is one of considerable variation in economic policy frameworks. These frameworks ranged from the "interventionist" regime from 1981-1984 to the subsequent "market-based-regime" with a major transition period covering 1984-1991. The early regime was characterised by high international trade restrictions (Lattimore, 2003), high degrees of regulation of economic activity, and tax and expenditure regimes that were designed to favour certain sectors over others. The latter regime attempted to open up markets to international competition, to deregulate domestic markets and to implement a fiscal regime that was broadly neutral across sectors. Macroeconomic policy also evolved from one of high fiscal deficits accompanied by high inflation (and loose monetary policy) to greater fiscal stringency and monetary policy targeting low inflation, again with a significant period of transition to these outcomes (Evans *et al*, 1996). It is reasonable to expect that these major policy changes impacted on different parts of the country in different ways, potentially affecting regional house prices differently.

Differential price movement across regions is illustrated in Figure 2. At the start of this period, the three major North Island cities (Auckland, Wellington and Hamilton) had house prices that were closely grouped together, with the South Island cities (Christchurch and Dunedin) in a separate group below those of their northern counterparts. Over the following ten years, Wellington and Auckland prices grew almost in lock-step with one another, while Hamilton and Christchurch converged to form a second group, and Dunedin lagged behind all four. In the second half of the sample, Auckland moved further ahead of all other cities, with Hamilton once again opening up a small gap over Christchurch.

Figures 3 - 5 graph real house prices at the RC level, demonstrating different patterns. Figure 3 graphs the prices for two, mainly rural, North Island RCs: Northland and Manawatu-Wanganui. While some similarity in patterns is evident at times, the overall picture is one of divergence, especially after 1993. By contrast, in Figure 4, two neighbouring North Island RCs (Waikato and Bay of Plenty) exhibit apparent close co-movement over the entire sample. Figure 5 demonstrates that close co-movement is not restricted to neighbouring regions: two largely agriculturally-based regions, Hawkes Bay and Canterbury (one North Island, one South Island) also tend to have prices moving together over time. The

[23] "House prices" henceforth refers to the median residential house sales price for the relevant area.

data also indicate that neighbouring TLAs within the same region sometimes move closely together, but at other times do not. To illustrate, figure 6 indicates a high degree of co-movement between Hamilton and its neighbouring rural/urban fringe TLA, Waikato. By contrast, Waikato and South Waikato show little co-movement (figure 7).

A major task of this research programme is to analyse what factors determine the degree of co-movement of prices across RCs and TLAs. Section 6 begins this task; section 5 applies statistical tests to examine whether regions move together over both the short term and the long term.

Before embarking on this analysis, we observe from inspection of data patterns in Table 2 and as described above, that areas with strongly growing real prices over 1981 - 2002 are mainly urban while areas with declining real prices are mainly rural. Based on this observation, coupled with an observation that urban house prices normally exceed rural house prices, one hypothesis to test, using just the real house price data, is that areas with initially high prices (in 1981) had subsequent faster price growth than initially lower-priced areas.[24] If this hypothesis were upheld, it would imply a diverging level of real house prices over time across the country.

We test this hypothesis over three time periods: 1981 - 2002 (whole sample), 1981 - 1991/92 (first half of the sample[25]), and 1991/92 - 2002 (second half of the sample). The first half of the sample conveniently covers the period from prior to the economic reforms that began in 1984, to the final major policy changes of 1991 (the social welfare benefit cuts and the Employment Contracts Act). In policy terms, the second half of the sample is a relatively settled period. Thus our tests indicate whether the reforms themselves were associated contemporaneously with relatively high price areas becoming even higher priced (in relative terms); and/or whether post-reform economic developments had such effects.

Table 3 details the results of regressions testing this hypothesis over each of the sample periods, at each of the TLA and the RC levels. The dependent variable in the regression is the growth rate of the real house price and the independent variable is the start of period real price level. For TLAs, there are 73 cross-sectional observations for each of the three regressions; for RCs there are 14 cross-sectional observations. The table details the

[24] Statistically, we test the null hypothesis that initial house price levels have no influence on subsequent house price growth.

[25] The 1991/92 year is the mean of the 4 quarters from September 1991 to June 1992, being the exact mid year of the sample.

coefficient on the price level term (the constant is not reported but is included in each equation), its t-statistic, significance level (p-value) and the R^2 of the equation.

The results indicate that over the whole sample, those TLAs and RCs with high initial prices (in 1981) had a higher rate of price growth than those areas with lower prices. These results (at both the TLA and RC level) imply a divergence in relative house prices over time. Breaking the sample in half yields an interesting finding. Over the first half of the sample (at each of TLA and RC level) there is no significant relationship between price growth and initial price level. By contrast, there is a strongly significant positive relationship over the second half of the sample. For whatever reason (e.g. opportunities set in train by the newly reformed economy, or changing world patterns of production, or changing personal preferences, etc) it is in the post-reform period that the house price divergence is most marked.

We can interpret the coefficients in the RC equation over the second half of the sample as follows: House prices in a region with an initial house price of $100,000 in 1991/92[26] are estimated to have grown through to 2002 at an annual rate 1.41% faster than house prices in an area with an initial house price of $90,000.

We have tested whether this result is driven solely by an "Auckland effect" given that evidence already presented shows quite different house price behaviour in Auckland relative to the rest of New Zealand. To do so, we re-ran the RC regression excluding Auckland from both sub-periods. In the first sub-period, there is again no statistically significant association between initial house price and subsequent growth (the slope coefficient is -0.08 with a t-statistic of 0.26). In the second sub-period, we again find a statistically significant association (at the 5% level) with a slope coefficient of 0.42 and a t-statistic of 2.20.

Interpreting the coefficients in the second sub-sample (excluding Auckland) house prices in a region with an initial house price of $100,000 in 1991/92 are estimated to have grown through to 2002 at an annual rate 1.33% faster than house prices in an area with an initial house price of $90,000. This result indicates that the divergence finding in the second sub-sample is not specific to Auckland, although the effect is slightly stronger in magnitude when Auckland is included in the analysis.

[26] Measured in June 1999 values. This value is close to the median RC price for 1991/92.

5 TIME SERIES ANALYSIS

In this section, we build on the data analysis above, focusing on the behaviour of real house prices. We examine the long run and short run links between house prices across RCs and across TLAs, and examine the dynamic nature of house price[27] developments within each region.

5.1 Long run analysis

In analysing the long-run properties of the house price series, we examine two aspects of the data. First, we analyse the time series properties of the individual house price series. This can demonstrate whether prices are trending over time in a deterministic fashion and can indicate whether shocks to prices have transitory or permanent effects. Second, we can test whether, in the long term, price series across different regions move together in response to shocks hitting each region.

5.1.1 Univariate time series properties

First, we examine the time series properties of the house price data. We test whether the effects of shocks on house prices are transitory or permanent. If the former, the series are stationary (possibly around a deterministic trend), i.e. integrated of order zero [I(0)]; if the latter, the series are non-stationary (possibly with drift), i.e. integrated of order one [I(1)].[28]

If price series in different regions are stationary, they move together in the long run, with deterministic divergence if and only if they have different deterministic time trends. If price series across different regions are non-stationary, they may or may not move together. In general, they will not do so. However, if two series are co-integrated then some linear combination of the series is stationary. In this special case, the price in one region moves in tandem with some proportion of the price in another region. In some contexts, co-integration of two series is taken to imply that the two series move together.[29] However, that is not normally the case. If the coefficient in the co-integrating vector relating the log of two series is not equal to unity then even though some combination of the two series is co-integrated, the levels of the two series will still drift apart over time in response to random permanent shocks.

[27] Unless otherwise stated, henceforth "house prices" refers to real house prices. This concentration on real house prices enables us to abstract from changes in inflation trends over the sample.
[28] It is possible that the changes in the series themselves could be non-stationary, in which case the order of integration of the levels series would be greater than one. However, as expected with real price data, the statistical tests indicate that none of the series is integrated of order greater than one.
[29] For instance, OD&R test whether pairs of house price series are co-integrated, presumably with this in mind.

For two (log) price series to move together over the long term (i.e. for the ratio between them to converge to a constant in the long run), the coefficient in the co-integrating vector must equal one.

Table 4 tests for the order of integration of the RC house price series. The four columns test for stationarity for each series respectively in: levels with deterministic trend and constant, levels with constant only, 1st difference with constant, and 1st difference without constant. The first figure in each cell is the p-value on the test to reject the null hypothesis of a unit root. A second figure is included in a cell only if the p-value of the first figure <0.100 and the p-value on the Trend (1st column) or Constant (3rd column) <0.100 [this second p-value is given as the second figure in these cases]. If the results in a cell are significant at the 1%-10% level, this is indicated in shaded print[30]. Testing stops where all figures in a cell are significant at 1%.

Overall the tests indicate that 1 series is I(0) with a deterministic trend [RC12]; another series [RC08] may be I(0) with no deterministic trend; 12 or 13 series are I(1), 5 of which may have drift ($0.01<p<0.10$ on the constant in these 5 cases); the remainder have no drift. On the basis of these tests, we consider it prudent to treat all series in subsequent empirical work as I(1), potentially with drift (especially since the region with a clear I(0) result is West Coast (RC12) which has a high standard deviation of quarterly returns, so the test may exaggerate the stationarity of the actual series).

Since we conclude that the RC price series are generally I(1), and these series are aggregations of TLA series, we adopt a maintained hypothesis in subsequent work that TLA price series will also be I(1).

5.1.2 Long run co-movement

Second, we test, at the RC level, whether the ratio of each combination of pairs of house price series is stationary. If so, we can conclude that the pair of house price series is co-integrated with a coefficient of unity in the co-integrating vector.[31] In that case, we conclude that economic and other shocks impact similarly on the two regions' house prices in the long run and so the two house price series move together over time. If we reject stationarity of the price ratio, the implication is that the two prices are influenced differently from one another by at least one non-stationary explanatory variable.

[30] Red print in colour.

[31] Because we are imposing the unit coefficient, we use standard unit root test values rather than the modified test statistics appropriate for co-integration tests involving estimated coefficients.

Table 5 presents the p-value on the Augmented Dickey-Fuller (ADF) test for unit root in the levels of Ln(Real Median Sales Price)$_i$ - Ln(Real Median Sales Price)$_j$ between all possible pairs (i, j) of RCs (i.e. a test of whether the two series are co-integrated with coefficient of 1). The figures in the bottom left of the table present the tests without deterministic trend; the figures in the top right of the table allow for a deterministic trend to be present. In this latter case, even if co-integrated, the two series will drift apart in a deterministic fashion if the trend is non-zero, but given this drift, shocks will impact similarly on each of the regions.

A bold figure in the bottom left of the table denotes a p-value on the ADF < 0.100; italics in bottom left denotes $0.100 < p < 0.200$. A bold figure in the top right of the table denotes a deterministic trend significant at 10% level where $p < 0.100$; italics in the top right denotes ADF and trend both have $p < 0.200$ and one of the coefficients has $p > 0.100$.

Without allowing for a deterministic trend and using a 10% significance level for the test, only 19% of the 91 RC pairs are co-integrated[32]. Co-integration is much more common between RCs within the South Island, with 50% of South Island pairs co-integrated; only 8% of North Island pairs are co-integrated; 20% of North-South Island pairs are co-integrated. These results indicate that house prices across RCs exhibit different long run behaviours across New Zealand, although more long run co-movement is observed in the South Island which may be more homogeneous economically and demographically than is the North Island.

If a deterministic trend is allowed for, and if we lessen the stringency of the test to a p-value of 20%, we find 52% of RC pairs are co-integrated. Now 90% of South Island pairs are co-integrated, 44% of North Island pairs are co-integrated and 49% of North-South Island pairs are co-integrated. Even with this less stringent test, approximately half of all pairs have house prices diverging over the long term.

Table 5 also indicates, where the deterministic trend is significant, the value of that trend. This value can be interpreted as the rate at which the house price of the first-named series rises relative to that of the second-named series in the absence of other shocks. Each pair includes the lower-numbered RC (which is normally the more northern RC) first. Of the 30 significant time trends, 19 are positive indicating generally faster house price growth in northern relative to southern regions of the country. It is possible that as incomes rise, prices

[32] With coefficient of one; this qualification is taken as implicit henceforth. This is a considerably higher number of cases than OD&R found, but still consistent with their finding that the majority of pairs are not co-integrated.

in warmer and/or sunnier areas rise in relative terms implying that "warmth" may be a characteristic with income elasticity greater than one.[33] We can test whether there is a time varying coefficient on factors relating to climate and/or latitude within our vector of ZLOCAL variables in our subsequent work.

Tables 6 - 18 present the same set of co-integration tests for TLAs within each RC (excluding RC05 / Gisborne where the RC is identical to the TLA). The results in these tables indicate the extent to which TLAs within RCs move with one another in the long run. Here we see considerably more long-term co-movement than at the nation-wide level.

The median number of TLAs within RCs that are co-integrated at the 10% level without deterministic trend is 48%, while the median figure is 93% with deterministic trend at the 20% level (Table 19). By comparison, recall that the corresponding figures for co-movement between RCs were 19% and 52% respectively.

These results imply greater commonality of the effects of shocks on house prices within RCs than across RCs. The findings here are useful for informing our subsequent econometric work. We should not expect regional house prices (either across RCs or TLAs) to be determined in a similar fashion solely by national variables or by regional variables that are co-integrated with one another. Some degree of region-specific variation in the explanatory variables (or else region-specific responses to national variables) will be required.

5.2 Dynamic analysis

Three aspects of dynamic movements in house prices are of interest: dynamics in the univariate house price series; contemporaneous correlations between price changes across regions; and intertemporal correlations between regions which can be interpreted as "causal" movements (in a temporal sense) from one region to another. Together these aspects provide information about the nature of house price adjustment and the spatial responsiveness of house prices to shocks.

5.2.1 Univariate dynamics

First, we examine the univariate dynamics of real house prices to discover whether shocks in one quarter have an effect on subsequent quarters' price movements within the same region. House prices are an asset price. Standard asset pricing results suggest that quarterly changes in asset prices should not be able to predict subsequent quarterly price changes ("weak form efficiency"). If they could do so, an expected profitable strategy is available to

[33] This phenomenon seems to be observed in some other developed, temperate countries (e.g. US and UK).

the investor to buy (or sell) an asset and then to sell (or buy) it subsequently. Efficient markets should have prices adjust instantaneously so that such expected profit strategies disappear.

However, housing is unlike a financial asset in that individual houses have some degree of uniqueness and each house is not freely traded in a liquid market. This feature may allow for partial adjustment of house prices to fundamentals or possibly to overshooting of prices to fundamentals (as in CHMM, 2002, discussed above). In the former case, a univariate regression of quarterly house price changes in a region on lags of itself should produce a positive coefficient; in the latter case, the coefficient will be negative.

To test the dynamics of regional house prices, we regress the quarterly change in the log of each RC real house price on a constant and four lags of itself (Table 20). The results indicate that one of the 14 regions (RC02) exhibits positive 1st order autocorrelation of real price changes (i.e. partial adjustment), albeit only at the 8% significance level. Nine of the 14 regions exhibit negative autocorrelation of price changes over one and/or two quarters at the 10% significance level (indicating overshooting); seven of these cases are significant at the 5% significance level. Two regions exhibit positive annual autocorrelation (i.e. at the 4th lag) at the 5% level indicating a seasonal effect. (One RC exhibits negative annual autocorrelation at the 9% level, possibly indicating some degree of seasonal overshooting.) In each of the three equations where the 4th lag is significant, addition of further lags results in no further additional significant variables. Thus we can be confident that for most RCs price changes follow a first, or occasionally a second order process, with little seasonality in the dynamics except possibly in two or three cases.

Two regions, RC02 and RC03 (Auckland and Waikato) have significant positive constant terms. This result is in keeping with Table 4, where these were the only two regions with significant constant terms at the 5% level in the unit root test on differences in the log of real house prices.

The tendency towards an overshooting process in the majority of regions could possibly be explained by noisiness in the data caused by measurement (or other) errors in one period being unwound in the subsequent period. The fact that the RC with most quarterly sales (RC02: Auckland) has a positive partial adjustment coefficient is consistent with this explanation. However, as shown in Table 2, other regions also have large numbers of quarterly sales, particularly RC13 (Canterbury), RC09 (Wellington), RC03 (Waikato), RC08 (Manawatu-Wanganui) and RC14 (Otago). Four of these five regions exhibit significant negative first or second order autocorrelation. Further, the overshooting result is consistent with previous New Zealand research cited earlier (GSDD and OD&R) and with some cited international research (CHMM) making the "error" hypothesis less persuasive, at least as the sole cause of the negative auto-correlation.

A related explanation is that the composition of housing may shift in response to shocks. For example, following a negative shock, the "best" houses may be taken off the market and only lower-quality homes are sold. In this case, the observed median (and mean) house sale price would dip sharply immediately following the shock. In subsequent quarters, "better" houses may be placed back onto the market as owners come to assess the permanence of the shock. In that case, house prices in subsequent quarters would rise relative to the first quarter's depressed price, albeit without re-establishing earlier levels. This hypothesis can be tested indirectly in subsequent empirical work when we come to test the impact of sales levels on the dynamics of house price adjustments to fundamentals.

5.2.2 Contemporaneous correlations

Shocks may impact similarly on regions to a greater or lesser extent in the short term than in the long term. Regions that do not have house prices moving together in the long term (i.e. which are not co-integrated) may nevertheless show significant short-term co-movement. Conversely, regions that have co-integrated house prices, may display quite different short run dynamics.

Table 21 presents contemporaneous correlation coefficients for quarterly changes in the log of real house prices across RCs. Of the 91 correlations, 56 are significant at the 5% level and 70 are significant at 10% (i.e. 62% and 77% of correlations are significant at the 5% and 10% levels respectively). Only two of the 91 correlations were negative and neither of these was significantly different from zero.

We have also calculated the contemporaneous correlation coefficients for all pairs of 73 TLAs. At this level, of the 2,628 correlations, 461 are significant at the 5% level and 691 are significant at 10% (i.e. 18% and 26% of correlations are significant at the 5% and 10% levels respectively). Table 22 examines the degree of correlation of TLA house price changes within RCs. The results indicate that TLAs within RCs are no more correlated with each other in terms of short-term price movements than are TLAs nationally. The major exception is Auckland where 17 of 21 potential correlations are significant at the 10% level. This lack of short-run co-movement by TLAs within RCs and relatively high degree of correlation between RCs, contrasts with the long-run co-movement results where TLAs within RCs tend to exhibit greater co-movement than do the RCs between themselves.

The RC results imply that short-term house price movements are influenced by similar factors across the country as a whole (i.e. across RCs), but with significant local variation. National shocks therefore appear to impact across the country but, from our earlier long run results, are not sufficient to explain nation-wide disparities in house price outcomes. Accordingly, we might expect our subsequent empirical work to indicate widespread effects of a national variable (such as interest rates) on house prices across regions, with additional region-specific variables being important in determining long-run house price developments.

5.2.3 Causality tests

As well as contemporaneous correlation, it is possible that price developments in one region impact subsequently on prices in other regions. Intuitively, for instance, we may expect that price developments in an agriculturally-based TLA (potentially reflecting agricultural price movements relevant to that TLA) may subsequently impact on price developments in a neighbouring urban TLA. Conversely, price developments in an urban TLA may subsequently impact on a neighbouring urban fringe TLA where new housing development may occur in response to neighbouring increased demand.

To examine whether such impacts occur, we use Granger Causality Tests (GCTs) to estimate whether one region's price developments helps explain future price developments in another region over and above the explanation afforded by the second region's own history for its price outcomes.[34] In operationalising this approach, we must first decide on the number of lags to include in the test. The results in Table 20 indicate that most regions can be characterised by at most a second-order autoregressive structure. Thus two lags should suffice in the test. However, a further three regions had some significant 4th order autocorrelation. We therefore test the robustness of our results by also using a four-lag structure.

Table 23 presents the results for RCs using both lag structures. In each case, 182 GCTs are presented (i.e. causality tests in each direction for each of the 91 RC pairs). With two lags (four lags), 48 (45) significant results at the 10 per cent level are found; 134 (137) results are not significant. Across the two lag structures, 118 insignificant results are consistent across the two options and 29 significant results are consistent; 19 (16) significant

[34] When we talk about "causality" here we mean that price developments in one region statistically help to explain subsequent price developments in another region; we do not necessarily imply that the second region's price changes are attributable to the first region's price change (although this may be the case).

results in the two lag (four lag) case are insignificant with four (two) lags. While the results of Table 20 indicate a preference for the two-lag option, the four-lag option is less likely to give false indications of causality, albeit at the loss of power in the test (exhibited by the slightly fewer cases of causality indicated).

With no clear preference between the two, we list in Table 24, the number of times (under each lag structure) each region "causes" others, and the number of times each region "is caused by" others. The average across the two cases is also indicated, as is the average per region under each lag structure.

This table indicates some interesting results. First, Auckland (RC02) is not influenced strongly by other regions; nor does it have a strong causative influence. Second, regions with the strongest influence on others are agricultural (especially sheep and beef) based regions: Hawkes Bay (RC06) and Canterbury (RC13), followed by Nelson-MT (RC11) and Taranaki (RC07), in turn followed by Manawatu-Wanganui (RC08) and Southland (RC15). Third, there are four regions that receive material causation from others: Northland (RC01), Waikato (RC03), Taranaki (RC07) and Nelson-MT (RC11). By contrast, Bay of Plenty (RC04) and Southland (RC15) receive very little, if any, influence from others. In addition, Hawkes Bay (RC06), Wellington (RC09) and the West Coast (RC12), as well as Auckland, receive relatively little influence from others.

These results[35] are consistent with what may be viewed as "conventional wisdom" that agricultural developments have an influence over time on economic outcomes in other parts of the country. Auckland and Wellington regions, however, are moderately insulated from these effects, but at the same time do not have major causative influence on other regions. Their economies (or, at least, their house prices) appear to be influenced by different factors than those in other regions.

We have also conducted GCTs for all combinations of TLAs (in each direction) within RCs. We do not present the results here since: (a) they contain a great deal of detail; and (b) no consistent pattern of results was found. Only two of the RCs had more than one third of the GCTs significant at the 10% level. One was largely rural (Nelson-MT with 58% tests significant) and one was largely urban (Auckland with 45% significant).

We found instances both of city causing rural, and rural causing urban. An example of the former is WTKI and COTA both causing DUNE (with no causality in the

[35] If interpreted to mean that price developments in "caused by" regions are, in part, attributable to prior price developments in "causal" regions.

other direction). An example of the latter is NAPI causing CHAW (with no causality in the other direction). Overall, there was no clear pattern of urban causing rural or vice versa. This is not necessarily surprising, since prices in neighbouring TLAs may be jointly and contemporaneously determined by similar shocks (as demonstrated in the long run analysis), reducing the prospects of finding significant intertemporal causation.

5.3 Time series analysis conclusions

We summarise the main findings of our time series analysis as follows:

- Most real RC house price series are non-stationary [I(1)] indicating that there are permanent effects of price shocks hitting RCs. Some price series have a deterministic trend embedded in them indicating that real prices are trending (generally upwards) in those RCs even in the absence of economic shocks.

- In general, RC house prices do not move closely together in the long term, even after allowing for the influence of deterministic time trend effects. Greater long-term co-movement is observed across the South Island than across the North Island or between the two islands. House prices in northern RCs tend to be trending upwards relative to prices in southern RCs.

- There is greater evidence of long-term co-movement across TLAs within RCs than between RCs, possibly indicating similar house price effects of shocks impacting within RCs.

- There are some indications of house price over-shooting in a majority of RCs in response to shocks; whether this is due to compositional or other factors is an open question.

- There is a much higher degree of contemporaneous correlation (short-run co-movement) across RCs than is the case for long-run co-movement. However, there is considerably less short-run co-movement across TLAs within RCs and nationwide both relative to RC short-run co-movement and relative to long-run TLA co-movement.

- Agricultural regions (especially sheep- and beef-based regions) appear to have price developments that precede developments in a number of other regions.

- Wellington and Auckland are relatively immune to these influences. Conversely neither has a strong short run influence on other regions' prices, indicating that their economies are moderately separable from other regions over short time horizons.

6 LONG RUN RESULTS

6.1 Outline and data

Our analysis of long-run determinants of RC real house prices takes the theoretical approach outlined in equation (3.5) as the starting point. As discussed, our house price data is unadjusted sales price data deflated by the CPI (excluding interest and credit charges). We enter this variable in logarithmic form and denote it as LPZZ for region ZZ.

Our income variable for each region is the National Bank of New Zealand Regional Economic Activity Index (LBNZZ)[36]. Each of these series is available quarterly from 1981(1)-2002(4). LBNZZ is included in logarithmic form (so the coefficient can be interpreted as an elasticity).

Our user-cost (UC) index is based on that used by OD&R. Like OD&R, we include the UC only from 1985(1) onwards, being the period following financial liberalisation; an estimated constant term is used to proxy financial conditions from 1981-1984. We use the 90-day bank bill rate (i90) as our interest rate (implicitly allowing the margin between 90 day rates and mortgage rates to be reflected in the constant term of the equation[37]) and use the latest annual CPI inflation rate (π)[38] to proxy general inflation expectations. Both these aspects are as in OD&R.

There is one material modification and some minor modifications to the OD&R UC variable. The main modification is that the tax component is omitted, both for theoretical and practical reasons. The theoretical reason is that, in New Zealand, mortgage interest is not tax-deductible (unlike many other countries), nor are capital gains from housing taxed. If loan finance is the marginal source of finance for housing then there is no tax relief on the housing loan and no tax to pay on the housing services. Thus no tax rate should appear in the UC variable. If, however, other taxable investment opportunities constituted the marginal source of finance for funding housing then the tax rate should be entered into UC, since the opportunity cost is taxed.[39] This would then lead us into the practical problem that different borrowers/investors face different tax rates and the relationship of these tax rates to each other

[36] This data is sourced directly from the National Bank of New Zealand Limited. We thank the NBNZ for making this data available for the full period. The data is available over a shorter period from the Bank's website: www.nbnz.co.nz .
[37] We also allow the depreciation term to be reflected in the equation's constant term.
[38] For this purpose we use the CPI excluding interest and credit (as elsewhere in this paper) and also excluding the effect of the imposition and subsequent increase of GST, which caused upward shifts in the price level but which are unlikely to have had a major effect on forward-looking inflation expectations.
[39] This discussion reflects the non-neutral treatment of housing in the New Zealand taxation system.

has varied over time. Entering a single tax rate into the equation (even if allowed to vary over time) would not adequately capture the taxation effect for different individuals. For these two reasons (especially the theoretical reason) we omit the taxation term.

The first minor modification is that we drop the denominator term (1+r), but given that $r \cong 0$, this makes very little difference to the UC measure. Doing so enables us to place both the depreciation term and the gap between mortgage and 90-day rates into the equation constant.

The second minor modification is our calculation of $\dot{g}$ (the expected rate of real house price change). OD&R use real house price developments over the previous five years to calculate this variable. We use the past four years (using the average of the first and fourth years) to calculate this variable. Doing so enables us to use the 1981-1984 data for our first post-liberalisation observation in 1985(1). A related, and more important, modification is that, since our analysis is region-specific, we calculate $\dot{g}$ for each region ($\dot{g}ZZ$ for region ZZ). Thus regional UCs differ from each other. This approach is consistent with theory, since expected capital gains in a region (which we assume are related to past experience) should influence region-specific house prices. The sensitivity of results to the inclusion or exclusion of $\dot{g}ZZ$ in the UCZZ term will be tested in future work.

Combining these effects, our user cost index for region ZZ from 1985(1) - 2002(4) is defined as:

$$UCZZ = i90 - \pi - \dot{g}ZZ \tag{6.1}$$

Each UCZZ is entered in level form in the house price equation so the coefficient can be interpreted as a semi-elasticity. For the period prior to 1985(1), we enter a constant term [=1 from 1981(1)-1984(4) and 0 otherwise] which is freely estimated for each RC. This term is denoted UCD.

We are currently lacking direct data on other variables appearing in (3.5) relating to the stock of houses (h) in each RC and elements of ZHOUSE, ZLOCAL and ZCONSTRUCT.[40] Of these variables, h is theoretically most important.

The stock of houses is a slow-moving variable, so almost certainly contributes little to quarter-by-quarter or even to year-by-year house price developments. However the trend element in the variable is likely to be important as a long run influence on house prices. We attempt to capture the housing variable as follows.

[40] We expect to have greater access to relevant data for later papers in this research programme.

For the period 1990-2002, we have QVNZ annual data on the number of valuation assessments in each region. Assessments are generally undertaken within TLAs on a three-yearly cycle so there are discrete jumps in the number of assessments at certain points. We smooth these jumps by passing a Hodrick-Prescott (HP) filter through each region's series to proxy the trend number of assessments.[41] This filtered series is used as our proxy for the number of houses in each region from 1990(4) - 2002(4).

Prior to 1990(4), we use a proxy based on the number of house sales. We have data on the number of house sales in each region for each quarter of our analysis. House sales numbers are highly volatile, but it is reasonable to expect that over long periods, sales numbers in any area are related to the stock of houses in that area. The trend in house sales should therefore be positively related to the trend in house numbers. We capture the trend component in house sales by passing an HP filter through the series of quarterly house sales[42] and then scale the resulting series so that the 1990(4) estimate of the filtered series equals that derived from the assessments data. The resulting combined variable is entered in logarithmic form and is denoted LASZZ for region ZZ.

There may be some weaknesses in these derived data as a measure of the housing stock.[43] For this reason, we also include a quadratic time trend (TIME and $TIME^2$) in the equation to supplement (or supplant) LASZZ. The quadratic time trend may also proxy effects within ZHOUSE, ZLOCAL and ZCONSTRUCT if any of these vectors include variables that in part are deterministic functions of time.

For each RC, we therefore initially estimate an equation of form:

$$LPZZ = \alpha_0 + \alpha_1 LNBZZ + \alpha_2 UCZZ + \alpha_3 UCD + \alpha_4 LASZZ + \alpha_5 TIME + \alpha_6 TIME^2 \qquad (6.2)$$

The key parameters of interest, and expected signs given the theoretical derivation in section 3, are: α_1 (+), α_2 (-), and α_4 (-).

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[41] We first transform the annual data to quarterly data using linear interpolation between December quarters and then use the standard HP quarterly smoothing parameter of $\lambda = 1600$.

[42] In order to capture the trend in this variable, we use a larger value (14400) for λ than the commonly chosen parameter (1600). This is because we are using a volatile flow variable (sales) to capture a relatively stable stock variable (house numbers) [14400 is commonly chosen to smooth monthly flow data]. The resulting series, by visual inspection, behaves much more like a stock series than does a series generated using the lower smoothing parameter.

[43] The series used here, based on spliced data from the assessments and sales data does, however, perform better than a series based on the sales data alone over the whole period. Another approach to formulating a housing stock variable is to aggregate building consents data over time, but this data is again only available for the 1990s. This approach will be investigated in future work.

6.2 Long run results: OLS

Table 25 presents the results of estimating (6.2) as an unrelated set of individual OLS equations. If we treat the UCD term as part of the UCZZ term (which conceptually it is), we have four I(1) variables plus a constant and quadratic time trend in each equation. For each equation, we test whether the variables for that region are co-integrated by testing the residual for a unit root, using an ADF test with the critical values estimated by Davidson and MacKinnon (1993).[44] We also present the R^2 and standard error (s.e.) for each equation. A number of key results stand out.

First, the coefficient on LNBZZ is in all cases positive with a median of 1.23. While t-statistics do not have conventional significance levels in the presence of integrated series, the result that all of the 14 t-statistics exceed 2.0, with 11 exceeding 3.0, implies an important effect of regional economic conditions on regional real house prices. A 1% rise in real economic activity results in at least a 1% rise in real house prices in the majority of regions. Given the presence of time trends in the equation, this result cannot be attributed to a secular (deterministic) growth component.

Second, the UCZZ term is negative in all cases. In eleven cases the "t-statistic" is greater than 2.0 and in 9 cases it exceeds 3.0. The median value of the α_2 coefficient is -0.0075, implying that a 1 percentage point increase in the real user cost of capital results in a long run fall in real house prices of approximately 0.8%.

Third, our proxy for the real housing stock, LASZZ has the expected negative coefficient in 13 of the 14 equations, 7 of which have "t-statistics" greater than 3.0. At least half the coefficients on each of TIME and $TIME^2$ have t-statistics >3.0 indicating that the quadratic time trend components are helpful in explaining real house price developments in some regions. Whether this is because they are supplementing the LASZZ variables as proxies for the housing stock or whether they are proxying for effects within ZHOUSE, ZLOCAL and/or ZCONSTRUCT is unknown. The results in relation to the housing stock are not quite as robust across RCs as for the other variables, but still indicate that our proxy for the housing stock in each RC appears reasonable.

Fourth, nine of the equations are co-integrated at the 5% level, six of which are co-integrated at 1%. The remaining five equations, while failing to reject the null hypothesis of a

[44] Critical values are: -5.27 (1%); -4.73 (5%); -4.45 (10%) using τ_{ctt} with m=4. Note that our assessment that the LBNZZ, UCZZ and LSHPZZ terms are I(1) is based on previous work and is still subject to formal testing here.

unit root in the residual, nevertheless have moderately high ADF statistics (the minimum absolute value being -3.12) [45]. Overall, these results suggest that we have picked out the major, if not the exclusive, long run determinants of real house prices at the RC level. The standard error of the equations varies from 0.0323 to 0.0776, with the median standard error indicating an average error of approximately 4%.

6.3 Long run results: panel

The 14 RC real house price equations can be estimated as a panel using SUR (seemingly unrelated regressions) estimation. In this estimation we restrict the coefficients on each of α_1, α_2 and α_4 to be identical across each region. The results give the "average" effect on real house prices across New Zealand of each of regional economic activity, the user cost of capital and the housing stock.[46] One advantage of estimating the equations in this manner is that much more precise estimates of the parameters of interest are obtained.

We find long run estimates (t-statistics in parentheses) as follows:

α_1:	0.9968	(19.87)
α_2:	-0.0106	(20.43)
α_4:	-0.6381	(11.03)

The panel results indicate that a 1% increase in regional economic activity boosts real house prices by 1%, while a 1% increase in the housing stock lowers real house prices by just over 0.6%. A one percentage point increase in the user-cost of capital is estimated to decrease long run real house prices by 1.06%.

As anticipated, the results are precisely determined, with t-statistics ranging from 11.03 – 20.43. The median standard error rises only slightly to 0.0462. These results are still preliminary and subject to testing in future work. Nevertheless, they appear plausible in terms of the theoretical specification and are consistent with the single equation estimates already presented.

[45] The nature of the test is that we are testing for rejection of a unit root; we are not testing for rejection of stationarity. Based on the nine RCs that reject a unit root, it is reasonable to interpret the remaining five ADFs as consistent with the presence of stationarity in the residuals.

[46] The estimates reported here are not weighted for region size. Future work will investigate the effects of doing so.

7 CONCLUSIONS AND FUTURE WORK

Our major time-series conclusions are presented in section 5.3, while the panel results in section 6.3 are a reasonable summary of our (still preliminary) findings with respect to real house prices at the RC level. In addition to these results, we reiterate the results of our convergence/divergence tests (section 4). Here we found higher-priced regions experiencing faster house price growth than did lower-priced regions since 1991, but not before that date.

Future work will conduct additional testing of the long run RC equations as a panel dataset. We will then estimate the dynamic adjustments to long-run values for the RCs. It is at this stage that we expect to observe impacts of local regulatory and related factors on house price developments.

Following completion of the data-derivation work for TLAs, the long-run and dynamic estimates will be estimated at that level of disaggregation. We expect that the impact of economic and other shocks should be pronounced at this level. For instance, based on the effects on house prices of regional economic activity indicated at the RC level, we anticipate that shocks to commodity prices, tourist flows and migration will impact heavily on (at least some) TLA house price developments. Local regulatory and related factors are also likely to be important at this level of disaggregation.

Finally, in this research programme, we will draw out the implications of our empirical work for policy issues and for further related research. One aspect of this related research is anticipated to be an examination of the links between house prices and the house rental market at a disaggregated level. Another aspect could be to use the valuation data, which is available at mesh-block level, to analyse the effects on wealth distributions at a micro-level arising from house price developments. A further issue to examine is the effect of house price developments on certain groups considered important for social policy (e.g. children, especially in low-income households, and the elderly). Finally, policy changes, such as changes to school zoning boundaries, can be analysed at this level, so increasing our understanding of the housing market effects of other public policy decisions.

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9 TABLES

Table 1: RC/TLA Correspondence and Name Definitions

RC Abbreviation	RC Name	TLA Abbreviation	TLA Name
RC01	Northland	FARN	Far North District
		WHAN	Whangarei District
		KAIP	Kaipara District
RC02	Auckland	RODN	Rodney District
		NSHO	North Shore City
		WTKR	Waitakere City
		AUCK	Auckland City
		MANU	Manukau City
		PAPA	Papakura District
		FRAN	Franklin District
RC03	Waikato	THAM	Thames-Coromandel District
		HAUR	Hauraki District
		WKAT	Waikato District
		MATA	Matamata-Piako District
		HAMI	Hamilton City
		WAIP	Waipa District
		OTOR	Otorohanga District
		SWKA	South Waikato District
		WTOM	Waitomo District
		TAUP	Taupo District
RC04	Bay of Plenty	WBOP	Western Bay of Plenty District
		TAUR	Tauranga District
		ROTO	Rotorua District
		WHAK	Whakatane District
		KAWE	Kawerau District
		OPOT	Opotiki District
RC05	Gisborne	GISB	Gisborne District
RC06	Hawke's Bay	WROA	Wairoa District
		HAST	Hastings District
		NAPI	Napier City
		CHAW	Central Hawke's Bay District
RC07	Taranaki	NEWP	New Plymouth District
		STRA	Stratford District
		STAR	South Taranaki District
RC08	Manawatu-Wanganui	RUAP	Ruapehu District
		WANG	Wanagnui District

		RANG	Rangatikei District
		MANA	Manawatu District
		PALM	Palmerston North City
		TARA	Tararua District
		HORO	Horowhenua District
RC09	Wellington	KAPI	Kapiti Coast District
		PORI	Porirua City
		UHUT	Upper Hutt City
		HUTT	Lower Hutt City
		WELL	Wellington City
		MAST	Masterton District
		CART	Carterton District
		SWRP	South Wairarapa District
RC11	Nelson-MT*	TASM	Tasman District
		NELS	Nelson City
		MARL	Marlborough District
RC12	West Coast	BULL	Buller District
		GREY	Grey District
		WEST	Westland District
RC13	Canterbury	KAIK	Kaikoura District
		HURU	Hurunui District
		WMAK	Waimakariri District
		CHRI	Christchurch City
		BANK	Banks Peninsula District
		SELW	Selwyn District
		ASHB	Ashburton District
		TIMA	Timaru District
		MACK	Mackenzie District
		WMAT	Waimate District
RC14	Otago	WTKI	Waitaki District
		COTA	Central Otago District
		QUEE	Queenstown-Lakes District
		DUNE	Dunedin City
		CLUT	Clutha District
RC15	Southland	SOUT	Southland District
		GORE	Gore District
		INVE	Invercargill City

**Nelson-Marlborough-Tasman [officially regions 16-18; there is no RC10]*

NB: TLAs are generally denoted by the first four letters of their name. TLA names starting with "Wai" have the first 3 letters shortened to W. Directional and spatial epithets (North, East, South, West, Central, Upper) are shortened to N, E, S, W, C, U respectively. The only exceptions to the above naming conventions (to avoid duplication or to use conventional abbreviations) are: Waitakere (WTKR), Western Bay of Plenty (WBOP), Lower Hutt (HUTT), South Wairarapa (SWRP), Waitaki (WTKI).

Table 2: Sales Price & Sales Summary Statistics

	2002 Average Sales Price ($000)	Real % Price Change: 1981-2002	Average No. Quarterly Sales	No. Qtrs with Sales <50	No. of Data Smoothing Adjustments	Std Dev Qtly Real % Price Changes
FARN	174	66	159	0	1	9.1
WHAN	152	34	342	0	0	4.5
KAIP	140	71	67	27	2	9.7
RODN	245	128	329	0	0	4.2
NSHO	299	81	996	0	0	3.8
WTKR	209	87	897	0	0	3.5
AUCK	342	152	1740	0	0	3.4
MANU	257	95	1073	0	0	4.1
PAPA	212	64	167	0	0	7.9
FRAN	190	89	146	0	0	7.0
THAM	196	114	25	0	0	5.9
HAUR	115	58	77	4	2	8.6
WKAT	127	68	108	0	2	8.9
MATA	131	39	108	0	0	7.8
HAMI	176	45	584	0	0	3.2
WAIP	162	47	154	0	0	5.3
OTOR	95	28	21	88	10	10.7
SWKA	49	-42	114	1	0	8.4
WTOM	67	-16	32	86	5	11.9
TAUP	175	66	245	0	1	6.9
WBOP	194	85	135	0	0	6.9
TAUR	199	35	560	0	0	4.0
ROTO	136	27	387	0	0	5.0
WHAK	167	37	125	0	0	7.4
KAWE	49	-50	40	63	2	9.9
OPOT	118	23	24	88	7	11.4
GISB	100	2	168	0	0	5.6
WROA	61	-29	26	88	7	12.0
HAST	142	35	256	0	0	4.5
NAPI	154	34	286	0	0	4.0
CHAW	96	13	48	45	2	9.1
NEWP	117	14	371	0	0	4.9
STRA	69	-13	38	76	2	11.4
STAR	72	-6	115	0	0	10.1
RUAP	52	-34	55	41	3	9.8
WANG	77	5	253	0	0	5.1
RANG	55	-33	136	5	4	11.7
MANA	100	19	116	0	0	7.7
PALM	136	20	377	0	0	4.1
TARA	62	-15	84	2	0	10.1
HORO	83	13	171	0	0	6.2

KAPI	176	83	255	0	0	5.5
PORI	195	93	206	0	0	7.3
UHUT	159	48	186	0	0	4.3
HUTT	178	74	510	0	0	4.5
WELL	268	110	838	0	0	3.7
MAST	108	29	130	0	0	6.3
CART	109	47	33	85	2	9.7
SWRP	121	86	50	48	1	11.4
TASM	174	57	179	0	0	6.8
NELS	173	44	270	0	0	5.3
MARL	137	34	220	0	0	5.1
KAIK	132	81	16	88	8	13.2
BULL	56	41	59	21	8	11.2
GREY	87	60	79	9	13	11.8
WEST	68	15	36	78	8	13.0
HURU	123	88	41	70	6	12.5
WMAK	147	63	182	0	0	5.3
CHRI	160	66	1941	0	0	2.6
BANK	162	126	67	15	0	9.9
SELW	148	56	57	27	6	8.1
ASHB	90	14	122	0	1	6.6
TIMA	87	-2	249	0	0	5.7
MACK	69	0	29	80	12	12.1
WMAT	61	-20	26	88	8	12.6
WTKI	65	-12	127	0	1	10.3
COTA	126	19	99	3	3	10.3
QUEE	296	143	101	6	1	8.9
DUNE	103	24	747	0	0	4.1
CLUT	50	-19	84	1	6	11.7
SOUT	74	8	113	0	1	13.6
GORE	59	-40	70	10	1	11.2
INVE	65	-31	395	0	0	4.8
RC01	157	46	568	0	0	5.2
RC02	282	111	5349	0	0	2.7
RC03	166	61	1658	0	0	3.5
RC04	168	38	1270	0	0	3.0
RC05	100	2	168	0	0	5.6
RC06	142	32	616	0	0	3.0
RC07	106	12	524	0	0	4.5
RC08	98	12	1191	0	0	4.1
RC09	203	87	2206	0	0	3.0
RC11	162	46	669	0	0	3.2
RC12	63	24	173	0	7	8.5
RC13	146	58	2727	0	0	2.7
RC14	117	38	1158	0	0	4.1

RC15	66	-27	578	0	0	4.8

Notes to Table 2: Smoothing adjustments to house price data were made as follows [year(qtr)]:

FARN	2000(1)
KAIP	1988(2) 2000(1)
HAUR	1983(1) 1983(2)
WKAT	2000(4) 2002(3)
OTOR	1982(3) 1983(2) 1984(1) 1984(2) 1986(3) 1988(1) 1996(2) 1998(2) 2000(3) 2001(3)
WTOM	1983(1) 1984(2) 1985(4) 1986(1) 1993(2)
TAUP	1984(4)
KAWE	1999(2) 2000(4)
OPOT	1986(3) 1987(1) 1992(3) 1996(4) 2000(2) 2001(3) 2002(3)
WROA	1990(4) 1997(1) 1997(2) 1998(3) 1999(2) 2000(4) 2001(4)
CHAW	1994(4) 1995(3)
STRA	1992(2) 1999(1)
RUAP	1995(4) 1997(2) 1998(4)
RANG	1982(3) 1982(4) 1998(2) 1998(4)
CART	1982(4) 1993(4)
SWRP	2001(3)
BULL	1983(1) 1983(3) 1985(1) 1986(1) 1993(1) 1994(3) 1999(3) 2000(4)
GREY	1981(4) 1982(2) 1983(2) 1983(3) 1984(1) 1984(2) 1994(3) 1995(2) 1995(4) 1998(4) 2000(2) 2000(3) 2002(1)
WEST	1981(4) 1984(1) 1984(4) 1986(1) 1991(4) 1993(1) 2000(4) 2001(2)
KAIK	1981(4) 1984(4) 1993(1) 1996(4) 1998(1) 1998(2) 1998(4) 1999(4)
HURU	1981(4) 1985(2) 1988(2) 1991(2) 1993(1) 1998(4)
SELW*	1981(1) 1981(3) 1982(1) 1987(4) 1992(1) 1992(2)
ASHB	2001(1)
MACK	1981(1) 1981(4) 1982(2) 1983(2) 1983(3) 1984(2) 1984(3) 1984(4) 1989(2) 1992(3) 1998(2) 1998(3)
WMAT	1981(1) 1981(3) 1988(1) 1989(2) 1995(4) 1996(1) 1997(4) 2001(3)
WTKI	1999(4)
COTA	1995(2) 1995(3) 2000(4)
QUEE	1986(4)
CLUT	1982(3) 1986(3) 1987(4) 1991(3) 1999(2) 2002(1)
SOUT	1984(1)
GORE	1997(3)

*In addition, the values for SELW 2001(4)-2002(4) were inferred from neighbouring TLAs as described in the text.

Table 3: Test of Relationship Between Initial House Price & Later Growth

Area	Period	Coefficient*	t-statistic	p-value	R^2
TLA	Whole Sample	0.79	3.17	0.00	0.12
	1st Half	0.13	0.97	0.34	0.01
	2nd Half	0.42	4.60	0.00	0.23
RC	Whole Sample	1.03	2.16	0.05	0.28
	1st Half	0.08	0.29	0.78	0.01
	2nd Half	0.53	3.41	0.01	0.49

*"Coefficient " reports the value for β in the cross-sectional regression:

$\%\Delta P = \alpha + \beta P_0 + \varepsilon$

where: $\%\Delta P$ is the percentage change in the real house price over the relevant period, P_0 is the real house price at the start of the relevant period, and ε is an error term (assumed to have the standard properties)

Table 4: UNIT ROOT TESTS on Ln (Real Median Sales Price)*

Region	Level (Trend & Constant)	Level (Constant)	1st Diff (Constant)	1st Diff
RC01	0.898	0.921	0.000	0.000
RC02	0.767	0.852	0.000 0.016	0.000
RC03	0.649	0.881	0.000 0.037	0.000
RC04	0.810	0.869	0.000	0.000
RC05	0.507	0.209	0.000	0.000
RC06	0.857	0.884	0.000	0.000
RC07	0.682	0.375	0.000	0.000
RC08	0.122	0.046	0.000	0.000
RC09	0.661	0.805	0.001 0.075	0.000
RC11	0.592	0.689	0.000 0.068	0.000
RC12	0.006 0.004			
RC13	0.473	0.283	0.000 0.062	0.000
RC14	0.210	0.569	0.000	0.000
RC15	0.802	0.422	0.000	0.000

*p-value for augmented Dickey-Fuller test using Shwartz Information Criterion to select lag length.

The four columns test for stationarity for each series respectively in: levels with deterministic trend and constant, levels with constant only, 1st difference with constant, and 1st difference without constant. The first figure in each cell is the p-value on the test to reject the null hypothesis of a unit root. A second figure is included in a cell only if the p-value of the first figure <0.100 and the p-value on the Trend (1st column) or Constant (3rd column) <0.100 [this second p-value is given as the second figure in these cases].

Table 5: Unit Root (Co-integration) Tests on Ln(Real Median Sales Price) Between Pairs of Regions without deterministic trend (bottom left) & with deterministic trend (top right) [p-values]

	RC01	RC02	RC03	RC04	RC05	RC06	RC07	RC08	RC09	RC11	RC12	RC13	RC14	RC15
RC01	-	0.79	0.78	0.38	0.73	0.59	0.24	0.86	0.60	0.80	0.61	0.97	0.81	0.86
RC02	0.31	-	*0.16*	0.50	0.50	0.77	**0.00**	0.07	*0.14*	0.56	**0.04**	0.79	0.57	0.77
RC03	0.40	0.40	-	*0.01*	**0.07**	0.21	**0.09**	0.52	0.45	0.09	*0.06*	0.76	0.59	0.64
RC04	*0.14*	0.36	**0.01**	-	**0.07**	0.51	*0.19*	0.67	0.53	0.41	0.24	0.74	0.62	0.46
RC05	0.82	0.83	0.52	0.42	**-**	**0.00**	0.00	0.74	0.73	0.65	**0.04**	**0.09**	**0.03**	**0.00**
RC06	0.31	0.46	*0.16*	0.27	**0.09**	-	**0.00**	0.62	0.71	0.13	0.08	0.87	0.65	**0.00**
RC07	0.69	0.76	0.83	0.55	**0.00**	0.42	-	0.46	0.79	0.33	*0.15*	0.29	**0.06**	**0.00**
RC08	0.86	0.86	0.83	0.74	0.42	0.69	*0.18*	-	0.47	*0.17*	**0.00**	*0.10*	**0.00**	0.53
RC09	*0.16*	0.45	0.31	0.21	0.55	0.25	0.49	0.48	-	0.69	0.16	0.87	0.41	0.71
RC11	0.57	0.70	0.72	0.36	0.63	**0.03**	0.48	0.35	0.33	-	0.01	0.89	0.00	**0.08**
RC12	0.26	*0.19*	**0.03**	**0.08**	**0.04**	**0.02**	**0.09**	**0.01**	**0.05**	**0.00**	-	*0.00*	0.00	**0.06**
RC13	0.29	0.91	0.57	**0.07**	0.40	*0.12*	0.29	0.35	0.59	0.38	**0.00**	-	0.02	0.93
RC14	0.49	0.52	0.42	0.34	0.66	0.30	0.44	0.71	*0.14*	**0.00**	**0.00**	**0.00**	-	**0.03**
RC15	0.90	0.59	0.68	0.75	0.39	0.71	0.36	0.22	0.23	0.36	0.39	*0.12*	0.57	-

Where each of the trend and the ADF is significant at $p<0.200$ (top right of the table) the trend coefficient is indicated below. For instance, the Auckland region (RC02) has had trend growth in its real median sales price of 0.05% per quarter relative to the Waikato region (RC03).

Significant Trend	Coefficient	[p-value:]	Significant Trend	Coefficient	[p-value:]
RC02 - RC03	0.0005	[0.05]	RC02 - RC07	0.0019	[0.00]
RC02 - RC08	0.0013	[0.00]	RC02 - RC09	0.0004	[0.01]
RC02 - RC12	0.0013	[0.01]	RC03 - RC04	0.0003	[0.11]
RC03 - RC05	0.0012	[0.00]	RC03 - RC07	0.0012	[0.01]
RC03 - RC11	0.0008	[0.01]	RC03 - RC12	0.0005	[0.14]
RC04 - RC05	0.0010	[0.01]	RC04 - RC07	0.0007	[0.02]
RC05 - RC06	-0.0015	[0.00]	RC05 - RC12	-0.0008	[0.07]
RC05 - RC13	-0.0009	[0.02]	RC05 - RC14	-0.0009	[0.01]
RC05 - RC15	0.0024	[0.00]	RC06 - RC07	0.0018	[0.00]
RC06 - RC15	0.0034	[0.00]	RC07 - RC12	-0.0006	[0.17]
RC07 - RC14	-0.0008	[0.02]	RC07 - RC15	0.0019	[0.00]
RC08 - RC11	-0.0005	[0.03]	RC08 - RC12	-0.0015	[0.00]
RC08 - RC13	-0.0009	[0.01]	RC08 - RC14	-0.0013	[0.00]
RC11 - RC15	0.0019	[0.01]	RC12 - RC13	-0.0004	[0.20]
RC12 - RC15	0.0019	[0.01]	RC14 - RC15	0.0022	[0.00]

Table 6: Unit Root Tests - Northland Region (RC01)

	Far North	Whangarei	Kaipara
Far North	-	**0.00**	**0.00**
Whangarei	**0.00**	-	**0.00**
Kaipara	**0.00**	*0.13*	-

Significant Trend	**Coefficient**	**[p-value:]**	**Significant Trend**	**Coefficient**	**[p-value:]**
FARN - WHAN	0.0008	[0.04]	FARN - KAIP	-0.0010	[0.01]
WHAN - KAIP	-0.0014	[0.00]			

Table 7: Unit Root Tests - Auckland Region (RC02)

	Rodney	North Shore	Waitakere	Auckland	Manukau	Papakura	Franklin
Rodney	-	**0.01**	**0.00**	*0.19*	*0.00*	0.00	**0.00**
North Shore	**0.00**	-	0.01	**0.00**	*0.14*	0.00	0.30
Waitakere	**0.00**	**0.05**	-	0.41	*0.14*	*0.02*	0.41
Auckland	0.33	0.61	0.74	-	**0.09**	**0.04**	0.51
Manukau	**0.00**	*0.18*	*0.10*	*0.19*	-	**0.00**	**0.00**
Papakura	**0.02**	**0.00**	**0.01**	0.37	**0.02**	-	**0.00**
Franklin	**0.06**	*0.10*	*0.15*	0.58	*0.11*	**0.00**	-

Significant Trend	**Coefficient**	**[p-value:]**	**Significant Trend**	**Coefficient**	**[p-value:]**
RODN – NSHO	0.0007	[0.01]	RODN – WTKR	0.0005	[0.02]
RODN – AUCK	-0.0005	[0.03]	RODN – PAPA	0.0020	[0.00]
RODN – FRAN	0.0009	[0.01]	NSHO – AUCK	-0.0015	[0.00]
NSHO – MANU	-0.0004	[0.06]	NSHO – PAPA	0.0006	[0.05]
WTKR – MANU	-0.0003	[0.11]	WTKR – PAPA	0.0005	[0.11]
AUCK – MANU	0.0006	[0.03]	AUCK – PAPA	0.0017	[0.00]
MANU – PAPA	0.0016	[0.00]	MANU – FRAN	0.0006	[0.05]
PAPA – FRAN	-0.0009	[0.01]			

Table 8: Unit Root Tests - Waikato Region (RC03)

	Thames	Hauraki	Waikato	Hamilton	Matamata	Waipa	Otorohanga	S.Waikato	Waitomo	Taupo
Thames	-	**0.00**	**0.00**	**0.02**	0.24	0.72	**0.00**	**0.01**	**0.00**	**0.00**
Hauraki	0.29	**-**	0.00	0.00	**0.00**	0.00	**0.00**	**0.00**	**0.00**	0.00
Waikato	**0.00**	**0.00**	-	0.01	0.00	0.00	**0.00**	**0.01**	**0.02**	0.00
Hamilton	0.44	**0.00**	**0.00**	-	0.00	0.00	*0.02*	**0.00**	**0.00**	0.11
Matamata	0.39	**0.00**	**0.00**	**0.00**	-	0.00	*0.00*	**0.00**	**0.00**	0.23
Waipa	0.30	**0.00**	**0.00**	**0.00**	**0.00**	-	*0.01*	**0.00**	**0.00**	0.01
Otorohanga	0.22	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	-	**0.02**	**0.00**	**0.00**
S.Waikato	0.77	0.69	0.94	0.70	0.71	0.76	0.32	-	**0.00**	**0.02**
Waitomo	0.78	0.41	0.30	0.26	0.38	0.31	**0.00**	**0.00**	-	**0.00**
Taupo	*0.18*	**0.00**	**0.00**	**0.02**	**0.07**	**0.00**	**0.00**	0.86	0.24	-

Significant Trend	Coefficient	[p-value:]
THAM – HAUR	0.0031	[0.00]
THAM - HAMI	0.0011	[0.01]
THAM – SWKA	0.0049	[0.00]
THAM - TAUP	0.0021	[0.00]
HAUR - OTOR	0.0017	[0.00]
HAUR – WTOM	0.0043	[0.00]
WKAT – SWKA	0.0040	[0.00]
HAMI - OTOR	0.0007	[0.17]
HAMI – WTOM	0.0032	[0.00]
MATA – SWKA	0.0051	[0.00]
WAIP - OTOR	0.0008	[0.13]
WAIP – WTOM	0.0034	[0.00]
OTOR – WTOM	0.0024	[0.00]
SWKA – WTOM	-0.0020	[0.00]
WTOM – TAUP	-0.0031	[0.00]

Significant Trend	Coefficient	[p-value:]
THAM – WKAT	0.0016	[0.00]
THAM – OTOR	0.0034	[0.00]
THAM – WTOM	0.0064	[0.00]
HAUR – MATA	0.0007	[0.09]
HAUR – SWKA	0.0045	[0.00]
WKAT – OTOR	0.0011	[0.05]
WKAT – WTOM	0.0024	[0.00]
HAMI - SWKA	0.0041	[0.00]
MATA - OTOR	0.0008	[0.11]
MATA – WTOM	0.0041	[0.00]
WAIP - SWKA	0.0047	[0.00]
OTOR – SWKA	0.0029	[0.00]
OTOR – TAUP	-0.0014	[0.01]
SWKA – TAUP	-0.0035	[0.00]

Note: Franklin (which lies partly in Waikato region) is co-integrated at the 10% level (excluding trend) with Hauraki, Waikato, Waipa, Otorohanga. It is co-integrated at the 20% level (allowing for deterministic trend) with all Waikato TLAs other than Hamilton.

Table 9: Unit Root Tests - Bay of Plenty Region (RC04)

	Western BoP	Tauranga	Rotorua	Whakatane	Kawerau	Opotiki
Western BoP	-	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**
Tauranga	0.22	-	0.24	*0.02*	0.37	*0.00*
Rotorua	0.67	0.22	-	**0.00**	0.78	0.00
Whakatane	**0.00**	**0.01**	0.69	-	0.88	**0.00**
Kawerau	0.98	0.99	0.98	0.99	-	**0.02**
Opotiki	**0.00**	**0.00**	**0.00**	**0.00**	0.80	-

Significant Trend	**Coefficient**	**[p-value:]**
WBOP – TAUR	0.0017	[0.00]
WBOP – WHAK	0.0011	[0.02]
WBOP – OPOT	0.0023	[0.00]
TAUR – OPOT	0.0007	[0.15]
WHAK – OPOT	0.0018	[0.00]

Significant Trend	**Coefficient**	**[p-value:]**
WBOP – ROTO	0.0030	[0.00]
WBOP – KAWE	0.0080	[0.00]
TAUR – WHAK	-0.0005	[0.14]
ROTO – WHAK	-0.0013	[0.00]
KAWE – OPOT	-0.0035	[0.00]

Table 10: Unit Root Tests - Hawke's Bay Region (RC06)

	Wairoa	Hastings	Napier	Central Hawke's Bay
Wairoa	-	**0.00**	**0.00**	**0.00**
Hastings	*0.15*	**-**	0.00	**0.00**
Napier	*0.17*	**0.00**	-	**0.00**
Central Hawke's Bay	**0.02**	0.25	0.27	-

Significant Trend	**Coefficient**	**[p-value:]**
WROA – HAST	-0.0041	[0.00]
WROA – CHAW	-0.0026	[0.00]
NAPI – CHAW	0.0024	[0.00]

Significant Trend	**Coefficient**	**[p-value:]**
WROA – NAPI	-0.0039	[0.00]
HAST – CHAW	0.0022	[0.00]

Table 11: Unit Root Tests - Taranaki Region (RC07)

	New Plymouth	Stratford	South Taranaki
New Plymouth	-	**0.00**	0.00
Stratford	**0.00**	-	**0.00**
South Taranaki	**0.00**	**0.00**	**-**

Significant Trend	Coefficient	[p-value:]	Significant Trend	Coefficient	[p-value:]
NEWP – STRA	0.0013	[0.01]	STRA - STAR	-0.0026	[0.00]

Table 12: Unit Root Tests - Manawatu-Wanganui Region (RC08)

	Ruapehu	Wanganui	Rangatikei	Manawatu	Palm. North	Tararua	Horowhenua
Ruapehu	-	**0.00**	*0.00*	**0.00**	**0.01**	**0.00**	**0.00**
Wanganui	**0.06**	-	**0.02**	**0.00**	**0.00**	0.30	0.67
Rangatikei	**0.00**	*0.14*	-	**0.00**	**0.00**	**0.00**	0.24
Manawatu	0.31	*0.11*	0.22	**-**	0.00	0.26	0.09
Palm. North	0.23	0.32	0.31	**0.00**	-	0.33	0.22
Tararua	*0.19*	*0.15*	**0.00**	0.20	0.36	-	0.22
Horowhenua	0.36	0.34	0.34	**0.04**	**0.10**	*0.15*	-

Significant Trend	Coefficient	[p-value:]	Significant Trend	Coefficient	[p-value:]
RUAP – WANG	-0.0033	[0.00]	RUAP – RANG	-0.0009	[0.14]
RUAP – MANA	-0.0036	[0.00]	RUAP – PALM	-0.0026	[0.00]
RUAP – TARA	-0.0018	[0.00]	RUAP – HORO	-0.0029	[0.00]
WANG – RANG	0.0019	[0.01]	WANG – MANA	-0.0012	[0.00]
WANG – PALM	-0.0006	[0.02]	RANG – MANA	-0.0034	[0.00]
RANG – PALM	-0.0027	[0.00]	RANG – TARA	-0.0010	[0.06]

Table 13: Unit Root Tests - Wellington Region (RC09)

	Kapiti	Porirua	Wellington	Lower Hutt	Upper Hutt	Masterton	Carterton	S.Wairarapa
Kapiti	-	0.10	0.44	**0.00**	**0.00**	*0.18*	**0.00**	*0.00*
Porirua	**0.03**	-	0.24	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**
Wellington	0.38	*0.16*	-	*0.17*	**0.01**	**0.06**	**0.00**	0.03
Lower Hutt	*0.13*	**0.00**	0.60	-	**0.00**	**0.01**	0.10	**0.00**
Upper Hutt	0.51	0.34	0.65	*0.16*	-	0.02	0.10	**0.00**
Masterton	0.20	0.22	0.24	**0.03**	**0.00**	-	**0.00**	**0.04**
Carterton	*0.20*	**0.00**	0.28	**0.02**	**0.03**	**0.00**	**-**	**0.00**
S.Wairarapa	**0.03**	**0.00**	**0.00**	0.35	0.50	0.41	**0.10**	-

Significant Trend	**Coefficient**	**[p-value:]**
KAPI - HUTT	0.0010	[0.00]
KAPI - MAST	0.0012	[0.05]
KAPI - SWRP	-0.0007	[0.10]
PORI – UHUT	0.0020	[0.00]
PORI - CART	0.0020	[0.00]
WELL – HUTT	0.0008	[0.01]
WELL – MAST	0.0012	[0.02]
HUTT – UHUT	0.0015	[0.00]
HUTT – SWRP	-0.0016	[0.00]
MAST – CART	-0.0015	[0.00]
CART – SWRP	-0.0029	[0.00]

Significant Trend	**Coefficient**	**[p-value:]**
KAPI - UHUT	0.0024	[0.00]
KAPI - CART	0.0020	[0.00]
PORI - HUTT	0.0006	[0.04]
PORI - MAST	0.0016	[0.01]
PORI - SWRP	-0.0010	[0.02]
WELL – UHUT	0.0016	[0.00]
WELL – CART	0.0020	[0.00]
HUTT – MAST	0.0009	[0.03]
UHUT – SWRP	-0.0033	[0.00]
MAST – SWRP	-0.0022	[0.00]

Table 14: Unit Root Tests - Nelson-MT Region (RC11)

	Tasman	Nelson	Marlborough
Tasman	-	**0.00**	**0.00**
Nelson	**0.06**	-	*0.00*
Marlborough	**0.00**	**0.00**	-

Significant Trend	**Coefficient**	**[p-value:]**	**Significant Trend**	**Coefficient**	**[p-value:]**
TASM – NELS	0.0016	[0.00]	TASM – MARL	0.0010	[0.00]
NELS – MARL	-0.0003	[0.18]			

Table 15: Unit Root Tests - West Coast Region (RC12)

	Buller	Grey	Westland
Buller	-	**0.00**	*0.00*
Grey	**0.01**	-	**0.00**
Westland	**0.00**	**0.00**	-

Significant Trend	**Coefficient**	**[p-value:]**	**Significant Trend**	**Coefficient**	**[p-value:]**
BULL – GREY	-0.0025	[0.00]	BULL – WEST	-0.0009	[0.12]
GREY – WEST	0.0023	[0.00]			

Table 16: Unit Root Tests - Canterbury Region (RC13)

	Kaikoura	Hurunui	Waimakariri	Christchurch	Banks. Pen	Selwyn	Ashburton	Timaru	Mackenzie	Waimate
Kaikoura	-	0.00	**0.00**	**0.00**	0.00	**0.00**	**0.00**	**0.00**	*0.03*	**0.00**
Hurunui	**0.00**	-	**0.00**	**0.00**	0.00	*0.00*	**0.00**	**0.00**	*0.03*	**0.00**
Waimakariri	**0.00**	**0.00**	**-**	**0.00**	**0.00**	**0.00**	0.25	**0.00**	0.11	**0.00**
Christchurch	**0.00**	**0.00**	**0.00**	**-**	**0.00**	0.00	0.57	0.72	0.13	**0.00**
Banks. Pen	**0.00**	**0.00**	**0.02**	**0.00**	-	**0.00**	**0.00**	**0.00**	0.09	**0.00**
Selwyn	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	-	**0.00**	**0.00**	0.19	**0.00**
Ashburton	*0.13*	*0.13*	0.44	0.76	0.30	0.81	-	**0.00**	0.08	**0.00**
Timaru	0.35	0.39	0.64	0.67	0.20	0.66	0.24	**-**	0.18	0.00
Mackenzie	**0.02**	**0.01**	**0.02**	**0.02**	**0.02**	**0.06**	**0.02**	**0.09**	-	0.05
Waimate	**0.01**	0.27	**0.03**	**0.06**	**0.02**	*0.13*	**0.00**	**0.00**	**0.02**	-

Significant Trend	**Coefficient**	**[p-value:]**
KAIK – WMAK	0.0015	[0.01]
KAIK – SELW	0.0012	[0.04]
KAIK - TIMA	0.0052	[0.00]
KAIK – WMAT	0.0043	[0.00]
HURU – CHRI	0.0008	[0.07]
HURU – ASHB	0.0037	[0.00]
HURU – MACK	0.0008	[0.20]
WMAK – CHRI	-0.0005	[0.00]
WMAK – SELW	-0.0005	[0.09]
WMAK - WMAT	0.0032	[0.00]
CHRI – WMAT	0.0030	[0.00]
BANK – ASHB	0.0047	[0.00]
BANK – WMAT	0.0054	[0.00]
SELW – TIMA	0.0045	[0.00]
ASHB – TIMA	0.0020	[0.00]

Significant Trend	**Coefficient**	**[p-value:]**
KAIK - CHRI	0.0012	[0.02]
KAIK – ASHB	0.0043	[0.00]
KAIK – MACK	0.0012	[0.15]
HURU – WMAK	0.0011	[0.02]
HURU – SELW	0.0006	[0.15]
HURU – TIMA	0.0052	[0.00]
HURU – WMAT	0.0048	[0.00]
WMAK –BANK	-0.0023	[0.00]
WMAK – TIMA	0.0037	[0.00]
CHRI – BANK	-0.0019	[0.00]
BANK – SELW	0.0014	[0.01]
BANK – TIMA	0.0065	[0.00]
SELW – ASHB	0.0034	[0.00]
SELW – WMAT	0.0034	[0.00]
ASHB – WMAT	0.0011	[0.06]

Table 17: Unit Root Tests - Otago Region (14RC)

	Waitaki	Queenstown	Central Otago	Dunedin	Clutha
Waitaki	-	0.87	0.32	**0.00**	0.00
Queenstown	0.84	-	*0.14*	0.87	0.38
Central Otago	*0.13*	0.26	-	0.94	0.00
Dunedin	*0.18*	0.68	0.42	-	**0.00**
Clutha	**0.00**	0.45	**0.00**	**0.00**	-

Significant Trend	**Coefficient**	**[p-value:]**
WTKI – DUNE	-0.0040	[0.00]
DUNE – CLUT	0.0022	[0.00]

Significant Trend	**Coefficient**	**[p-value:]**
QUEE – COTA	0.0015	[0.03]

Table 18: Unit Root Tests - Southland Region (RC15)

	Southland	Gore	Invercargill
Southland	-	**0.00**	0.28
Gore	0.87	-	0.25
Invercargill	0.90	0.12	-

Significant Trend	**Coefficient**	**[p-value:]**
SOUT – GORE	0.0079	[0.00]

Table 19: Percentage of Sub-Areas Co-integrated (with unit coefficient)

	Combinations	No Deterministic Trend; @ 10%	With or Without Deterministic Trend; @ 20%
RCs	91	19	52
Northland	3	67	100
Auckland	21	48	90
Waikato	45	53	96
Bay of Plenty	15	40	73
Gisborne	-	n.a.	n.a.
Hawkes Bay	6	33	100
Taranaki	3	100	100
Manawatu-Wanganui	21	29	81
Wellington	28	43	96
Nelson MT	3	100	100
West Coast	3	100	100
Canterbury	45	67	93
Otago	10	30	60
Southland	3	0	67

Table 20: Coefficient [& p-Value] of ∆ln (real house price) on 4 lags of itself and constant (results presented only for coefficients with p<0.100)

Lag:	RC01	RC02	RC03	RC04	RC05	RC06	RC07	RC08	RC09	RC11	RC12	RC13	RC14	RC15
(-1)	-0.43 [0.00]	0.20 [0.08]	-0.37 [0.00]		-0.23 [0.04]					-0.36 [0.00]	-0.32 [0.00]		-0.19 [0.09]	-0.35 [0.00]
(-2)								-0.32 [0.01]		-0.19 [0.09]	-0.38 [0.00]	-0.18 [0.10]		
(-3)											-0.31 [0.01]			
(-4)	0.22 [0.04]								0.27 [0.01]		-0.18 [0.09]			
cnst		0.007 [0.03]	0.008 [0.05]											
R^2	0.21	0.06	0.12	0.08	0.08	0.03	0.05	0.11	0.13	0.15	0.19	0.08	0.06	0.12
LM	0.73	0.28	0.18	0.41	0.03*	0.08	0.33	0.18	0.88	0.16	0.40	0.20	0.10	0.38

LM lists the p-value for the Breusch-Godfrey LM test for serial correlation
Despite the significant LM statistic, the DW statistic for this regression is 1.998

Table 21: Correlation Coefficients of Quarterly Changes in log of Real Sales Price: 14 Regional Councils (1981:2 - 2002:4)

	RC01	RC02	RC03	RC04	RC05	RC06	RC07	RC08	RC09	RC11	RC12	RC13	RC14	RC15
RC01														
RC02	**0.20**													
RC03	0.00	0.14												
RC04	**0.28**	**0.34**	*0.14*											
RC05	*0.16*	**0.34**	*0.16*	**0.19**										
RC06	0.11	**0.30**	**0.21**	**0.36**	**0.26**									
RC07	*0.15*	**0.30**	*0.16*	**0.34**	0.12	0.07								
RC08	0.14	**0.28**	**0.22**	**0.28**	0.12	**0.39**	**0.27**							
RC09	**0.19**	**0.52**	0.13	**0.43**	*0.16*	**0.28**	**0.29**	**0.24**						
RC11	0.13	**0.27**	-0.07	**0.30**	0.05	**0.38**	**0.22**	**0.27**	**0.25**					
RC12	0.05	0.06	**0.27**	**0.27**	**0.21**	0.13	*0.17*	0.07	0.04	0.09				
RC13	**0.29**	**0.37**	*0.17*	**0.39**	**0.38**	**0.34**	*0.17*	**0.30**	**0.30**	**0.35**	*0.14*			
RC14	-0.02	**0.23**	*0.17*	**0.25**	0.14	**0.36**	0.09	*0.18*	0.14	**0.25**	**0.19**	**0.31**		
RC15	**0.21**	**0.23**	**0.28**	**0.31**	**0.20**	**0.29**	**0.23**	**0.23**	*0.16*	*0.15*	**0.24**	**0.22**	**0.24**	

Figures in bold are significantly different from 0 at 5% significance level (1-tailed test)
Figures in italics are significantly different from 0 at 10% significance level (1-tailed test)

Table 22: % of Significant Correlations: TLAs within RCs

Region	Significant at 5%	Significant at 10%
RC01	0	33
RC02	67	81
RC03	18	33
RC04	20	20
RC05	na	Na
RC06	0	17
RC07	0	0
RC08	5	19
RC09	32	43
RC11	0	0
RC12	67	67
RC13	9	13
RC14	10	20
RC15	0	67

Table 23: Granger Causality Tests: Regional Councils X (vertical axis) Granger-Causes Y (horizontal axis); p-level indicated where p<0.100 (bold ⇒ bi-directional causality)*

2 lags	RC01	RC02	RC03	RC04	RC05	RC06	RC07	RC08	RC09	RC11	RC12	RC13	RC14	RC15
RCO1			**0.04**											**0.04**
RC02	0.01		0.04											
RC03	**0.02**						0.09			**0.01**				
RC04	0.01		0.08				0.09				0.08			
RC05	0.10							**0.09**		**0.03**			0.06	
RC06	0.00				0.00		**0.00**			0.00		0.01		
RC07	0.09				0.00	**0.02**				**0.02**				
RC08					**0.09**								0.03	
RC09	0.00		0.06									0.03		
RC11	0.01		**0.09**		**0.00**		**0.00**	0.04						
RC12		0.06												
RC13	0.01		0.07		0.05		0.01	0.01		0.01			0.02	
RC14			0.02				0.02							
RC15	**0.05**						0.00			0.01		0.07		

4 lags	RC01	RC02	RC03	RC04	RC05	RC06	RC07	RC08	RC09	RC11	RC12	RC13	RC14	RC15
RCO1			0.02							0.09				
RC02	0.01		0.01					0.09					0.06	
RC03														
RC04	0.01		0.02											
RC05										**0.07**			0.06	
RC06	0.00				0.00		**0.00**	0.02	0.08	0.00		0.05		
RC07					0.01	**0.04**				**0.03**			**0.09**	
RC08	0.07		0.07								0.03	**0.06**	0.01	
RC09		0.02						0.03						
RC11					**0.01**		**0.00**	0.02	0.02					
RC12		0.09												

RC13	0.01						0.01	**0.03**		0.01			0.05	
RC14			0.01				**0.07**		0.06		0.09			
RC15						0.06	0.00			0.00				

**Formally, a significant p denotes rejection of the hypothesis that X does not Granger-cause Y.*

Table 24: Granger-Causality Impact of RC on Other RCs

	Region "Causes" Others			Region is "Caused by" Others		
	2-lags	4-lags	Average	2-lags	4-lags	Average
RC01	2	2	2	10	5	7.5
RC02	2	4	3	1	2	1.5
RC03	3	0	1.5	7	5	6
RC04	4	2	3	0	0	0
RC05	4	2	3	5	3	4
RC06	5	7	6	1	2	1.5
RC07	4	4	4	7	5	6
RC08	2	5	3.5	3	5	4
RC09	3	2	2.5	0	3	1.5
RC11	5	4	4.5	6	6	6
RC12	1	1	1	1	2	1.5
RC13	7	5	6	3	2	2.5
RC14	2	4	3	3	5	4
RC15	4	3	3.5	1	0	0.5
Average	3.3	3.4	3.2	3.3	3.4	3.2

Table 25: Estimates of (6.2) OLS Results (constant included but not reported; "t-statistics" in brackets; *,**,* signif. at 1%,5%,10%)**

LPZZ	LNBZZ	UCZZ	UCD	LASZZ	TIME	$TIME^2$	R^2	s.e.	ADF
01	0.5568*** (2.68)	-0.0045*** (2.71)	0.0901** (2.29)	-2.0379*** (3.46)	0.0104 (1.60)	-0.0000 (0.40)	0.92 0.90+	0.0474 0.0522+	-5.89***
02	1.8197*** (10.11)	-0.0125*** (5.84)	0.0306 (0.94)	-1.0017*** (3.54)	0.0053 (1.38)	-0.0000 (1.12)	0.98 0.96	0.0378 0.0440	-3.12
03	1.0896*** (6.05)	-0.0035* (1.68)	0.0180 (0.60)	-0.0721 (0.40)	-0.0045** (2.55)	0.0000*** (2.76)	0.96 0.95	0.0352 0.0377	-5.18**
04	1.0388*** (5.91)	-0.0103*** (4.67)	0.0228 (0.58)	-3.1302*** (4.08)	0.0443*** (3.43)	-0.0002*** (3.26)	0.93 0.93	0.0429 0.0456	-3.94
05	0.8348** (2.20)	-0.0135*** (6.73)	0.1113** (2.12)	-1.0512 (1.42)	0.0151*** (2.69)	-0.0001*** (4.03)	0.74 0.71	0.0646 0.0680	-5.04**
06	2.2613*** (8.86)	-0.0050*** (2.91)	0.1446*** (4.90)	0.4834 (1.31)	-0.0083** (2.34)	-0.0000 (0.94)	0.94 0.92	0.0352 0.0394	-4.32
07	0.7962*** (3.75)	-0.0088*** (7.17)	0.1467*** (5.70)	-1.7484*** (4.14)	0.0146*** (2.93)	-0.0001*** (4.16)	0.90 0.89	0.0372 0.0389	-6.23***
08	1.0987*** (6.32)	-0.0086*** (5.81)	0.0461 (1.60)	-0.2327 (0.87)	0.0068*** (3.12)	-0.0001*** (6.60)	0.69 0.68	0.0409 0.0416	-5.88***
09	1.8826*** (11.72)	-0.0062*** (3.09)	0.0658** (2.63)	-2.2617*** (10.98)	0.0084*** (5.99)	-0.0001*** (4.75)	0.95 0.92	0.0340 0.0465	-4.03
11	0.6168** (2.48)	-0.0011 (0.73)	0.0614** (2.31)	-1.1770*** (6.12)	0.0109*** (3.20)	-0.0000*** (2.64)	0.93 0.88	0.0323 0.0412	-4.89**
12	1.8343*** (3.91)	-0.0038 (0.99)	-0.0253 (0.42)	-3.5992 (1.52)	0.0266* (1.67)	-0.0003** (2.45)	0.76 0.75	0.0776 0.0796	-6.05***
13	1.1544*** (5.77)	-0.0072*** (4.03)	0.0603** (2.08)	-0.5822* (1.84)	0.0076* (1.76)	-0.0001*** (3.34)	0.94 0.94	0.0389 0.0391	-3.77
14	1.2037*** (5.19)	-0.0086*** (4.92)	-0.0055 (0.21)	-0.1725 (0.38)	0.0044 (0.96)	-0.0001** (2.51)	0.91 0.91	0.0392 0.0399	-7.08***
15	1.0306*** (4.16)	-0.0114*** (6.91)	0.0196 (0.52)	-1.6439*** (5.60)	0.0127*** (3.81)	-0.0002*** (6.09)	0.90 0.88	0.0458 0.0497	-5.62***

+The second figures in each case in the R^2 and s.e. columns present the R^2 and s.e. for the equations estimated as a panel with coefficients on LNBZZ, UCZZ & LASZZ restricted to be equal across equations.

Figure 1: Nominal House Prices - Auckland & Kawerau

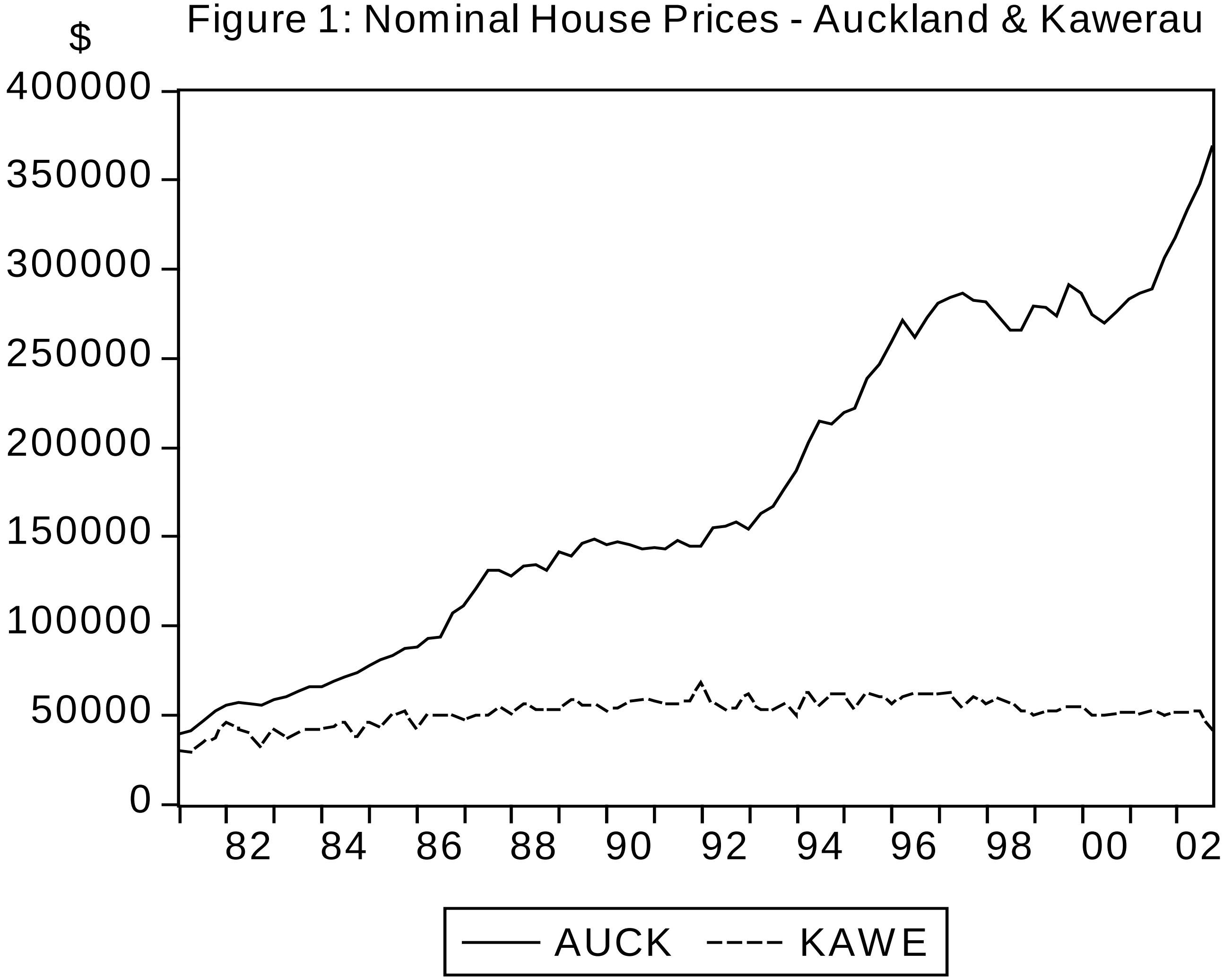


Figure 2: Real House Prices (5 Cities)

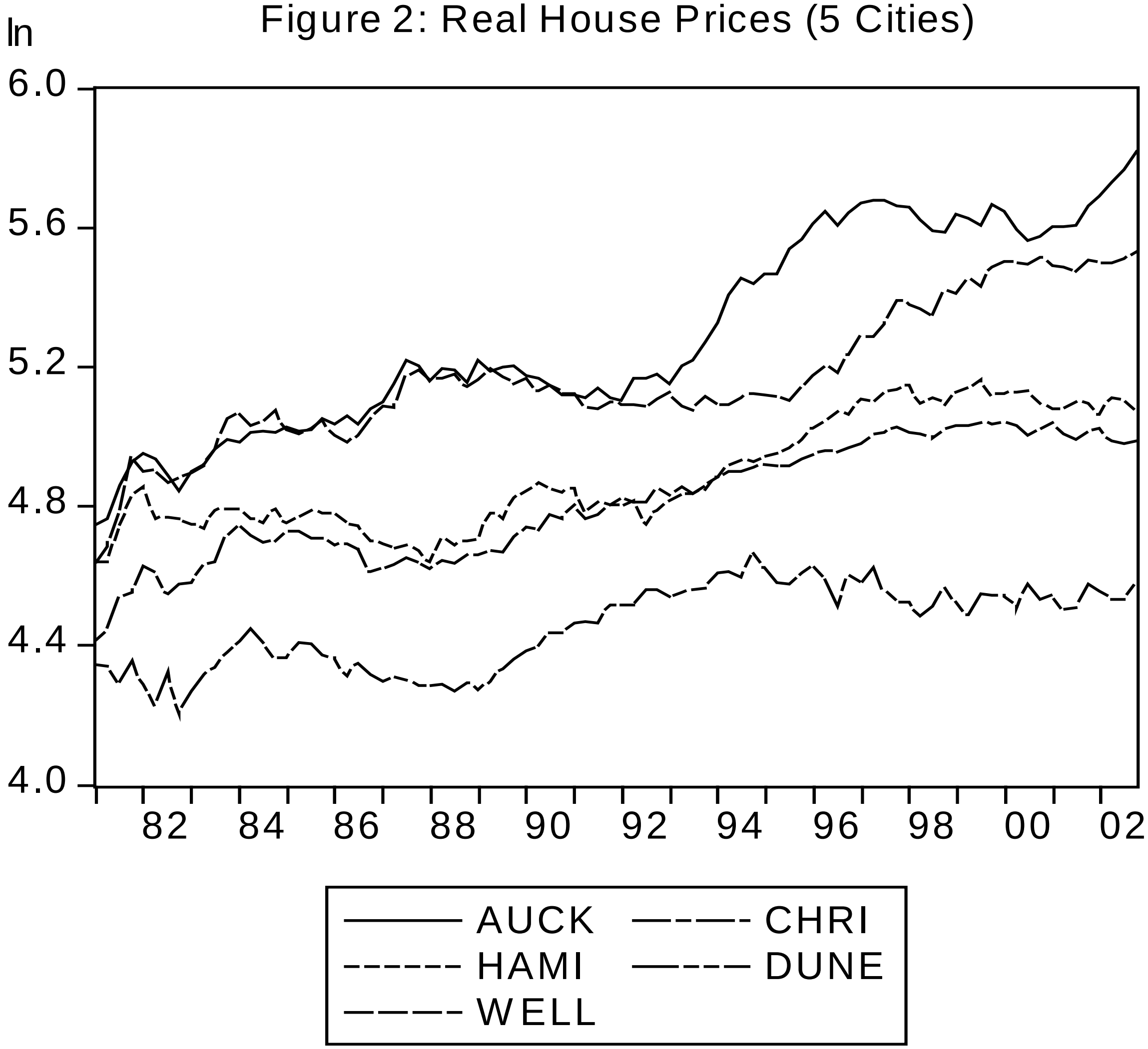


Figure 3: Real House Prices (Northland & Manawatu-Wanganui)

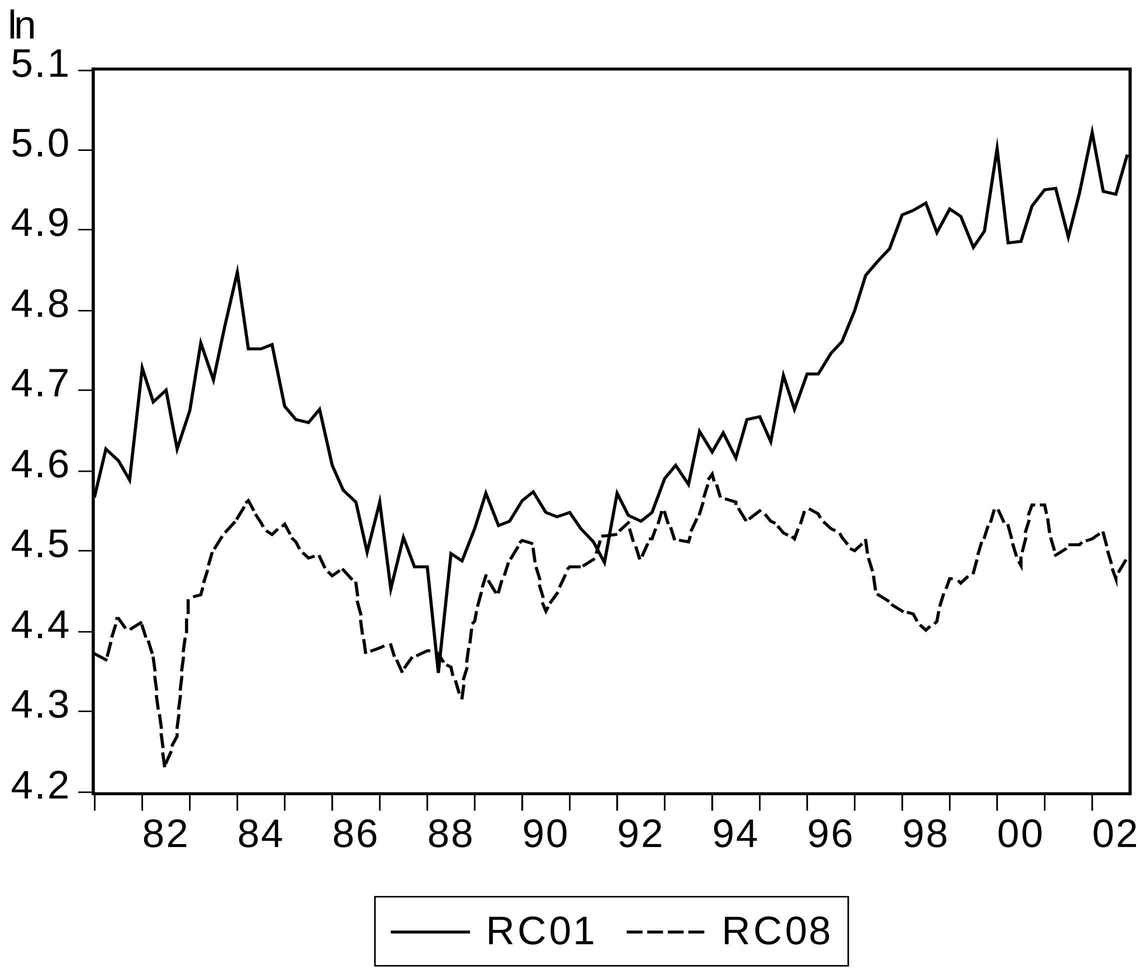


Figure 4: Real House Prices (Waikato & BOP)

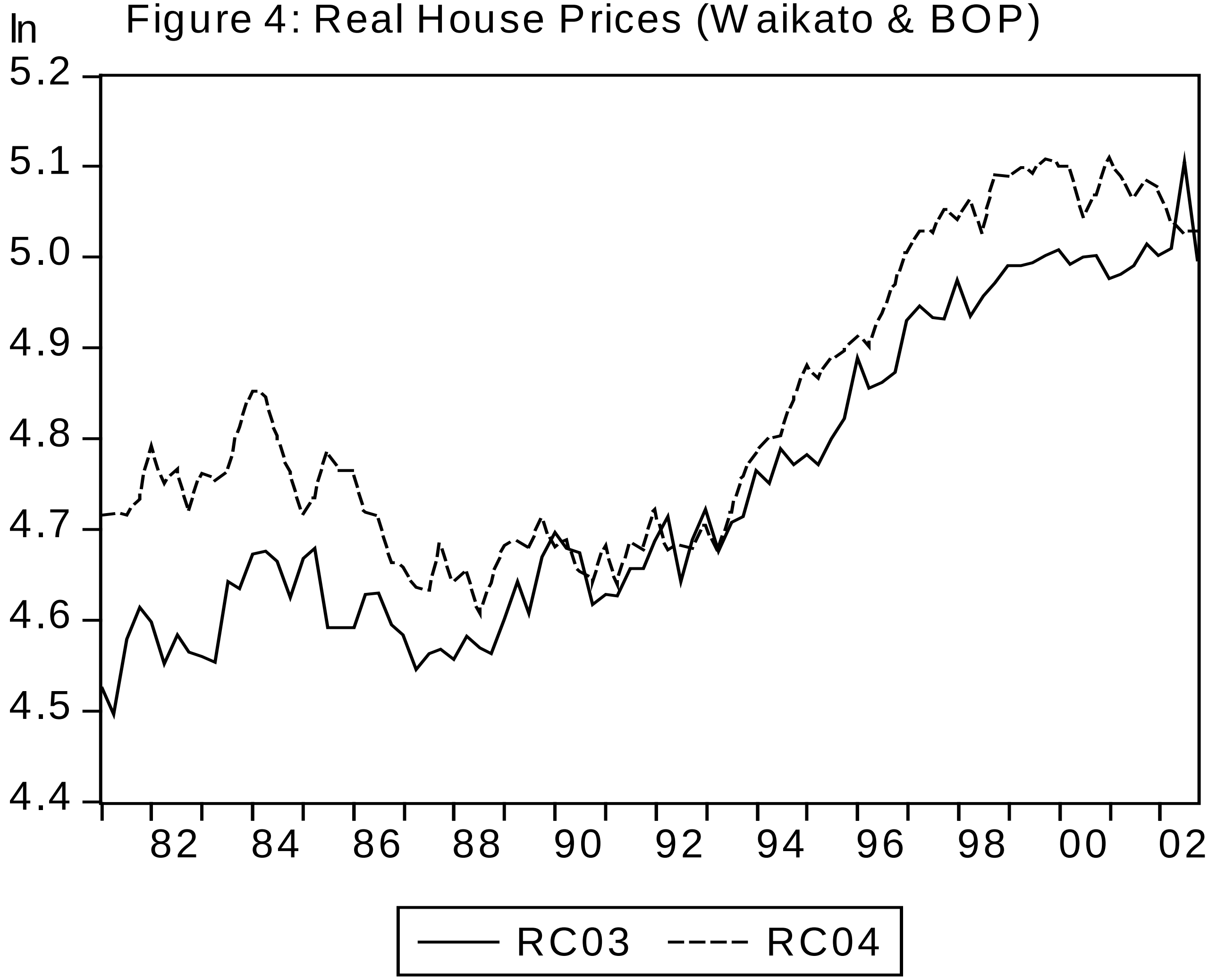
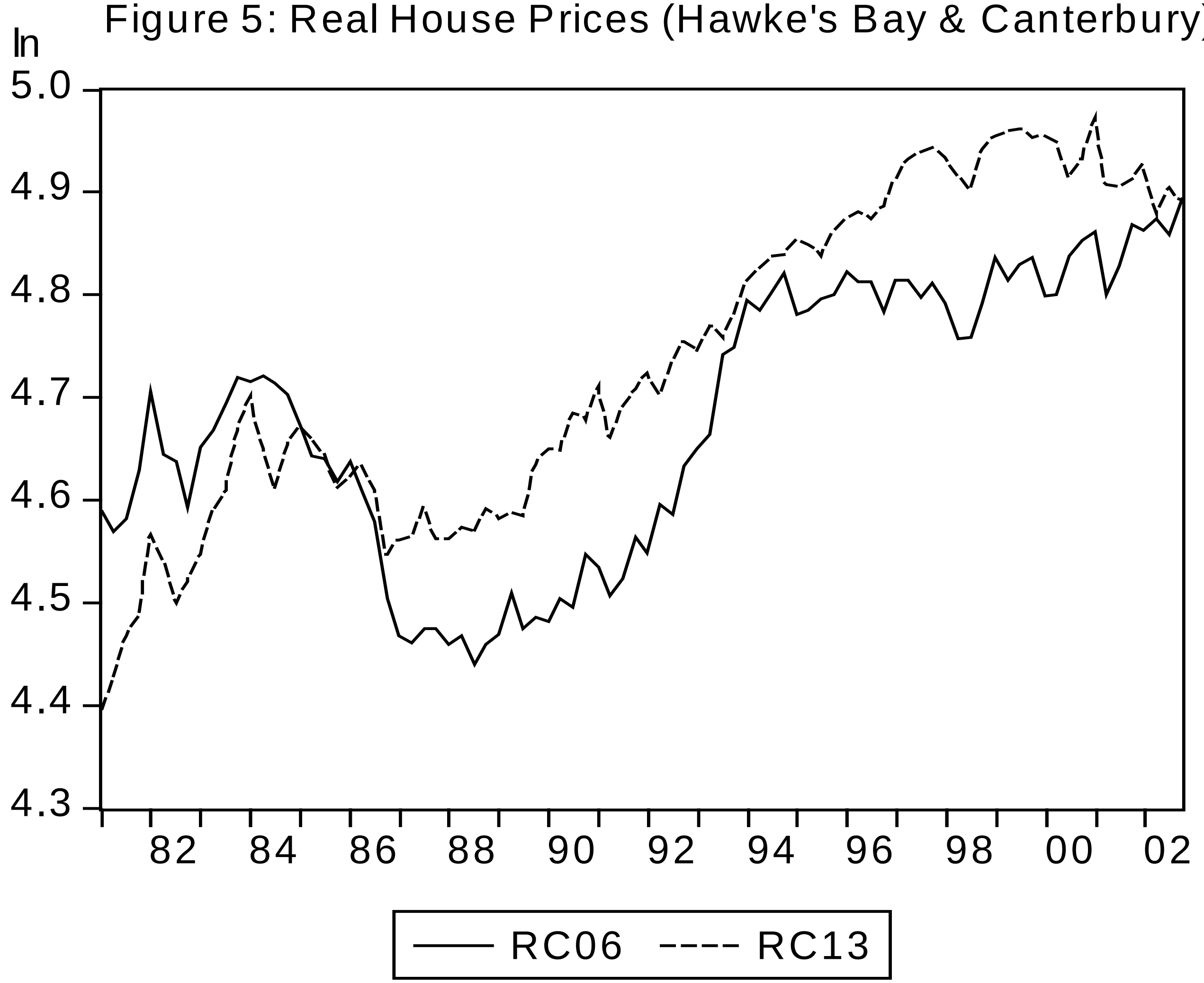
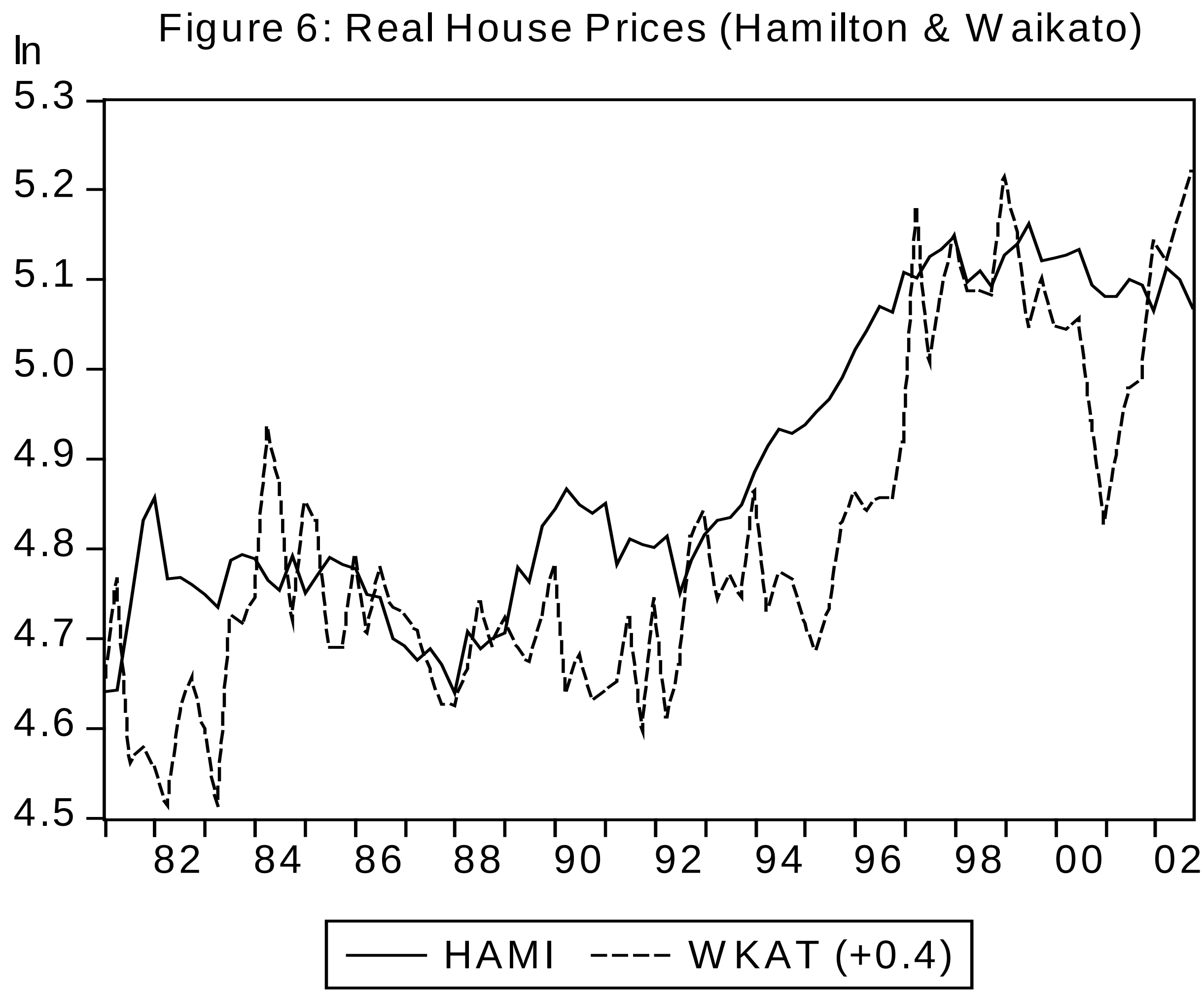


Figure 5: Real House Prices (Hawke's Bay & Canterbury)





(A constant of 0.4 is added to the Waikato real house price to better illustrate the degree of co-movement between the series.)

Figure 7: Real House Prices (Waikato & South Waikato)