New Zealand Housing Markets: Just a Bit-Player in the A-League?

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Abstract

House price trends in each of New Zealand and Australia are frequently discussed as national level developments. Sub-national developments are also important, especially where regions display idiosyncratic trends driven either by demand factors (differential income patterns) or by supply factors (geographical or regulatory restrictions). At a broader scale, it is possible that the New Zealand housing market, or a specific regional housing market (e.g. Auckland), is part of a broader Australasian housing market. If this were the case, New Zealand house prices would converge to a broadly stable ratio of house prices in Australia. One reason this could occur is if international macroeconomic and asset price trends dominate housing market outcomes. New Zealand authorities may then be relatively powerless to control the major real determinants of house prices through regulatory or other policies. We extract the major drivers of house prices at regional levels within New Zealand and Australia to examine the degree of differentiation across regional housing markets. While some minor regional differences are apparent, the evidence points to the dominance of a single trans-Tasman housing trend.

JEL codes

R21, R31

Keywords

House price convergence; international housing markets; Australasia

Contents

1. Introduction

We examine whether a single housing market exists across multiple regions covering two countries: Australia and New Zealand. We define a single housing market as one in which a single stochastic trend determines the long run path of real house prices in all regions. This definition allows for short run deviations in prices between regions, but such deviations are stationary and so prices converge over time across regions.[1]

If such convergence is observed, there are two strong implications for policy. First, macroeconomic policies must either have been convergent across countries or they have been incapable of independently controlling real house prices (despite both countries running independent monetary and fiscal policies). Second, regional planning policies and geographical constraints must either have had identical long run effects over multiple regions or have had no long run impact on regional house price trends. Each of macroeconomic and planning policies could, however, still affect the short run path of prices relative to the long run trend.

Our initial focus is on the 72 Territorial Authorities (TAs) in mainland New Zealand. We examine the relationship of these regions both to each other and to the eight capital city housing markets of Australia (the seven state/territory capitals plus Canberra). We test whether there is more than one long run real house price trend across all these regions, and across the subset of regions within New Zealand and Australia respectively. We then examine the relationship of real house prices in New Zealand's dominant city (Auckland) with those in the three major eastern Australian cities (Sydney, Melbourne, Brisbane).

Our methodology builds on the principal components methodology outlined in Holmes and Grimes (2008). Specifically, we form the principal components of real house prices across a set of regions and test whether more than one of the principal components is non-stationary. If only one principal component is non-stationary,[2] we conclude that there is a single long run trend impacting on house prices across those regions. If more than one principal component is non-stationary, we conclude that there must be multiple housing markets across the included regions.

The principal components approach enables us to distinguish the degree to which each source of non-stationarity contributes to the variance of regional house prices. Unlike many prior

[1] Strictly, we examine the natural logarithm (log) of real house prices, so our definition requires that the long run ratio of regional real house prices (for each regional pair) converges to a constant. By 'real' house prices, we mean house prices relative to the price of other goods and services.
[2] In all cases, at least one principal component is non-stationary.

studies, we distinguish between the *statistical significance* and the *economic significance* of second and subsequent sources of non-stationarity. (On the difference between the two concepts, see McCloskey and Ziliak, 1996, and Ziliak and McCloskey, 2004). Where we find more than one statistical source of non-stationarity (i.e. more than one stochastic trend), our approach indicates the relative contributions of these trends to the observed regional price trajectories and hence indicates their economic significance.

In brief, we find ambiguous statistical evidence as to whether more than one source of non-stationarity is present in each country and across the two countries. However, the first trend (which is unambiguously stochastic) explains an overwhelming (circa 90%) of the variation across the included regions in each case. Thus even though statistically there is the possibility that regional house prices follow distinct stochastic trends, we conclude that a single macro trend is by far the major determinant of house prices within and across the two countries. This finding indicates that planning and other policies have had, at most, only a second order effect on long run local house prices. The bulk of real house price movements appear to have been beyond the control of local planners and politicians, and beyond the control of macroeconomic policy-makers.

Section 2 of the paper briefly sets out the New Zealand and Australian house price data and discusses prior treatments of house price co-movements. Section 3 discusses the principal components methodology that we use for our analysis. Section 4 examines the degree to which the 72 New Zealand TAs can be characterised as a single housing market. Similarly, we examine whether the eight Australian cities form a single national housing market. We then combine the two countries' data and examine two issues: (a) the degree to which all 80 trans-Tasman regions form a single housing market, and (b) the degree to which Auckland and the three major eastern Australian cities form a single housing market. Section 5 concludes, and relates the results to issues of regional planning and macroeconomic policy.

2. Australasian House Price Data and Prior Studies

We obtain quarterly house price data for New Zealand TAs from Quotable Value New Zealand (QVNZ, a state owned enterprise) and for Australian cities from Australian Bureau of Statistics (ABS).[3] In each case, the series are mix-adjusted (quality-adjusted) series recognised as

[3] We use the word "regions" variously to describe cities and TAs.

the official house price series for their respective country's regions.[4] The ABS data are available from 1986q2 onwards while QVNZ official data are available from 1989q4 onwards.[5] The New Zealand TA series have been backdated to 1986q2 using QVNZ's median house sale price series for each TA over 1986q2 – 1989q4.[6]

All series are expressed in real terms by dividing through by the respective country's Consumer Price Index; thus we compare real house prices both within and across countries. We make no exchange rate adjustment when comparing trans-Tasman house prices since we are examining whether the relative price of houses to other goods and services moves similarly in the long run across regions. Deflation of house prices by the Consumer Price Index facilitates this comparison across countries; an additional exchange rate adjustment would undermine this comparison (and would add considerable non-housing-related noise). Each real series is indexed to unity at 1986q2; all graphs extract the mean from the data prior to graphing.

Figures 1-3 display the (log) house price series respectively for New Zealand's TAs, Australia's cities, and for the regions of both countries combined. (The figures that include the New Zealand TAs have too many regions to label, but our primary intention is to impart a visual understanding of the degree of co-movement amongst the series.) Both within and across countries, there is a strong degree of observed co-movement in real regional house prices (especially noting that general CPI influences have already been extracted from these series). Furthermore, visual inspection indicates that the series are non-stationary; as confirmed by the statistical tests in section 4.

Closer inspection of the regional data reveals some disparities in house price growth across regions. This is most clearly seen in Figure 2 (because of the fewer series) where not only are cyclical divergences apparent, but also long run divergence is possibly indicated. Our task in section 4 is to examine whether these long run divergences indicate separate regional housing markets or whether these divergences are temporary; if they are not temporary, we examine whether the divergences are economically as well as statistically significant.

A number of prior studies have interpreted movements in regional house prices within each of Australia and New Zealand, although not across both countries. For instance, in Australia, Maher (1994) finds spatial variability in house prices both at an intra-metropolitan

[4] For analyses of methods to control for housing quality in house price indices see, for Australia: Abelson and Chung (2005) and Hansen (2009); and, for New Zealand: Grimes and Young (2010).

[5] We use data through to 2009q2, the most recent data available at date of commencement of the research.

[6] We have conducted our empirical work over both 1986q2-2009q2 and 1989q4-2009q2 (corresponding to the period for which the official QVNZ data are available). Results are robust to the change in period; we prefer to start when the Australian data begins to maximise our time coverage.

Figure 1: New Zealand TA log Real House Prices (De-meaned)

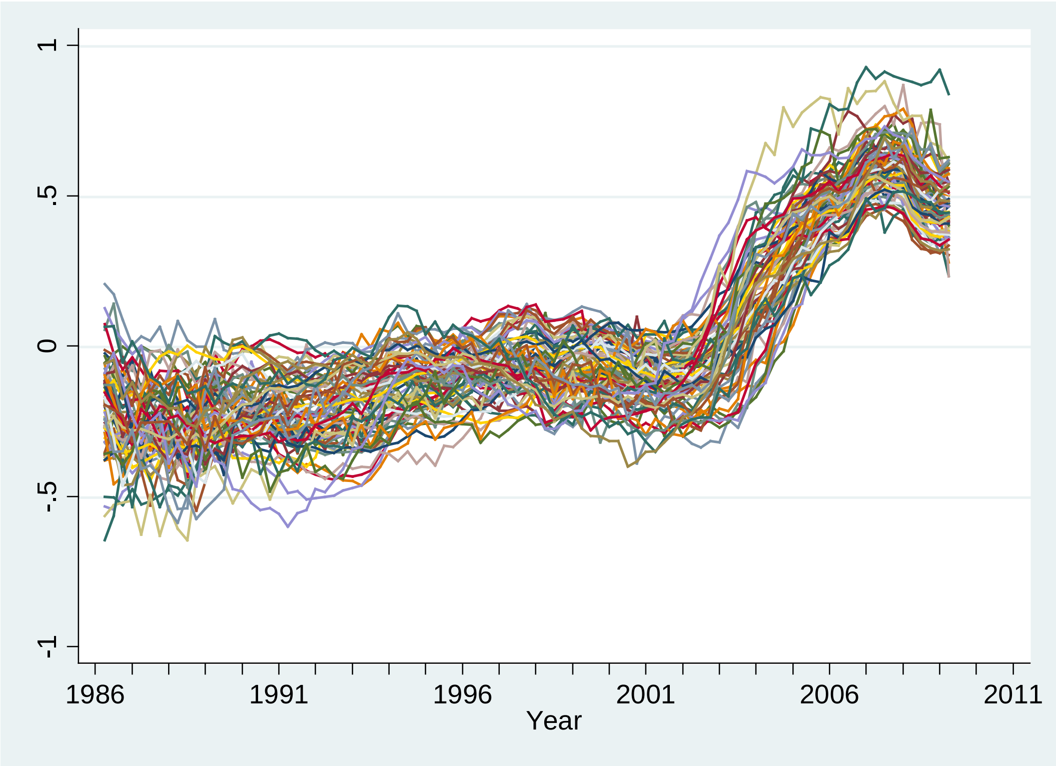


Figure 2: Australian City log Real House Prices (De-meaned)

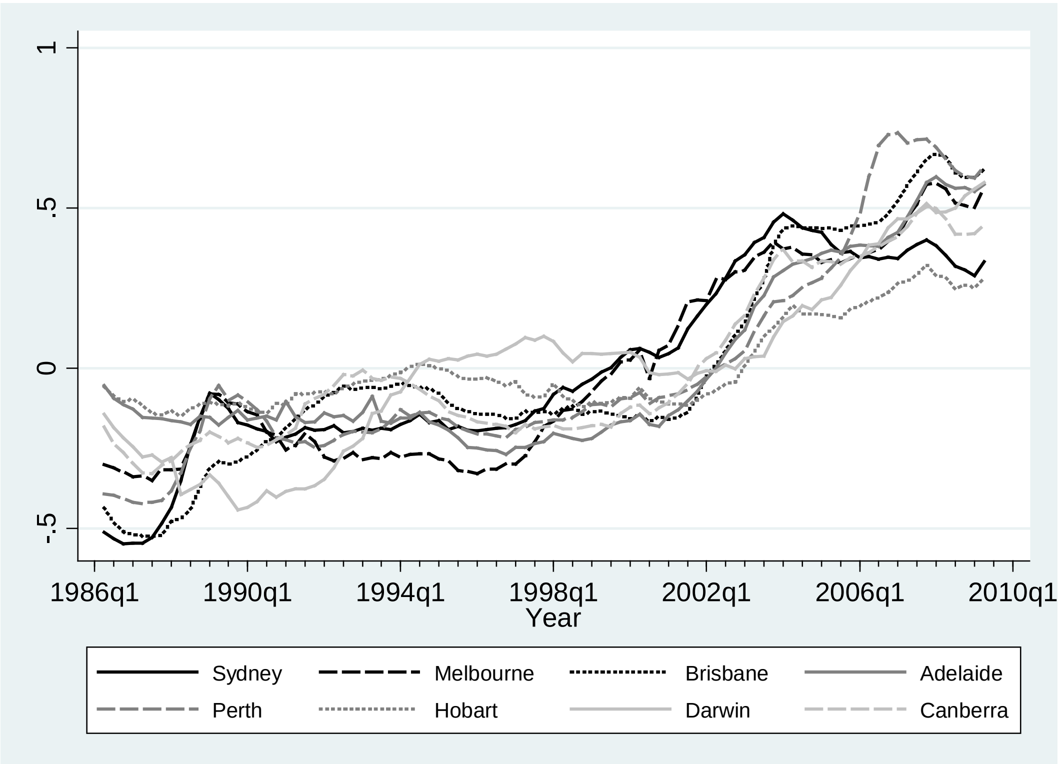
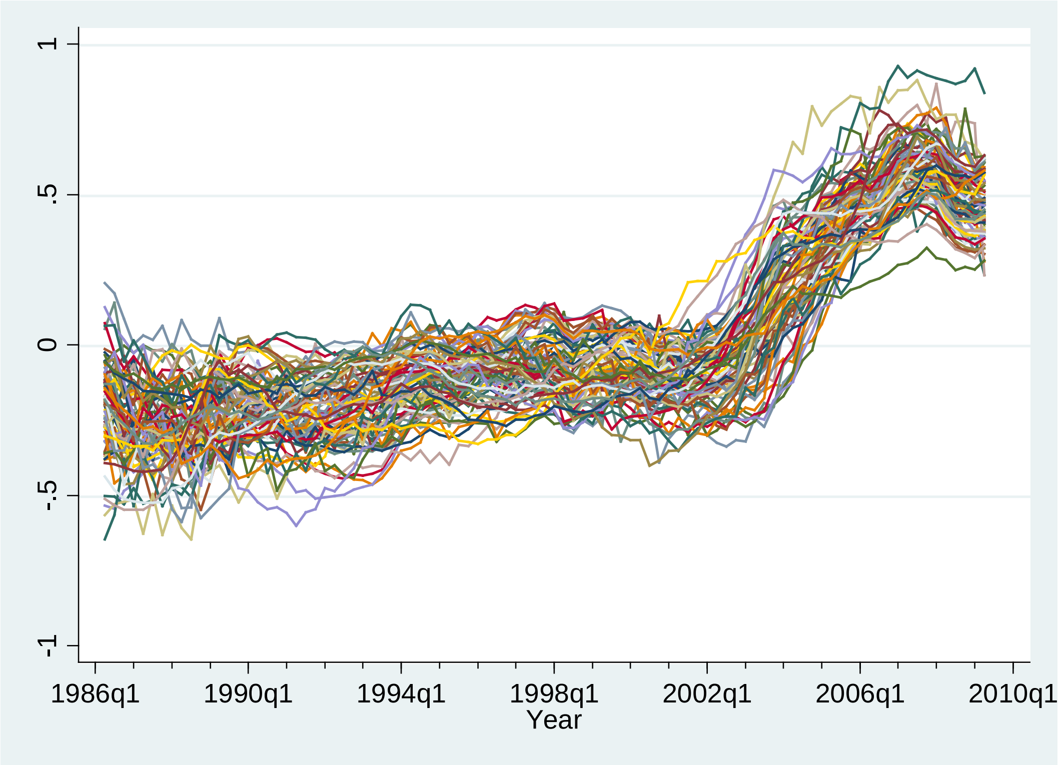


Figure 3: Australasian Regional log Real House Prices (De-meaned)



(suburban) scale and at an inter-metropolitan (city) scale. Major macro-economic structural changes, such as financial deregulation, have affected all house prices, but spatially-specific changes (e.g. due to spatial restructuring) have also affected local house prices relative to the broader trend. Within New Zealand, Grimes et al (2003) found that house prices had increased more rapidly in higher priced (generally urban) regions than in lower priced regions since 1991. Hall et al (2006), using classical business cycle methodologies, found that while regional house price cycles have often coincided with national cycles, there have also been considerable deviations in cycles across New Zealand regions.[7] Each of these studies indicates the possibility of multiple housing markets within (and hence across) each country.

None of the Australasian studies has analysed whether cycles across regions are convergent or divergent over long periods. In contrast, numerous studies for the United Kingdom and elsewhere have analysed this issue. The UK work, in particular, has examined whether there is a "ripple effect", in which a shock to house prices in one region (generally

[7] Another New Zealand study, Fraser et al (2008), assessed whether aggregate New Zealand house prices followed 'fundamentals' (determined by the present value of real disposable income) or not. They found that fundamentals explained a large portion of actual house price movements, indicating the potential for a major macro driver of house prices across all regions of the country.

London) spreads out spatially to other regions according to contiguity and/or other regions' distance from the source of the initial shock.[8]

The majority of these studies use time series techniques based on tests of cointegration across regional house price indices to examine whether the ripple effect reflects short run adjustments or whether long run divergences are apparent across regions. One problem when interpreting studies using this methodology in cases where divergence is found, is that it is often not clear how important is the divergence relative to the common trend. Statistically, all that is required to establish divergence is that some non-stationary element be present that causes one region's price to depart from another's even in a miniscule fashion. Some of the cited studies incorporate structural breaks to cater for specific divergent episodes, but these do not help in interpreting longer term divergences.

To see the practical importance of this observation, Figure 4 graphs two New Zealand TA series (for the neighbouring towns of Masterton and Carterton). Visually, it appears that the two series are affected similarly by a single stochastic trend; any divergence between them, even if permanent, is miniscule by comparison to the overall trend. However a standard unit root test on the difference between the two (log) series reveals their difference to be non-stationary.[9] A statistician might conclude that the two series are divergent, but the economically significant interpretation is that the two series move broadly together. The methodology that we describe in the next section is designed to reconcile these two approaches to interpreting the significance of co-movement versus divergence within the context of multiple time series.

3. Principal Components Methodology

Our methodology, based on principal component analysis, tests the number of stochastic trends that determine regional house prices across a set of regions. The approach enables us to test both the statistical significance and the economic significance of the derived stochastic trends.

Principal components analysis is an eigenvector based multivariate analysis technique used to decompose multiple time series in a way that all derived explanatory series, the principal

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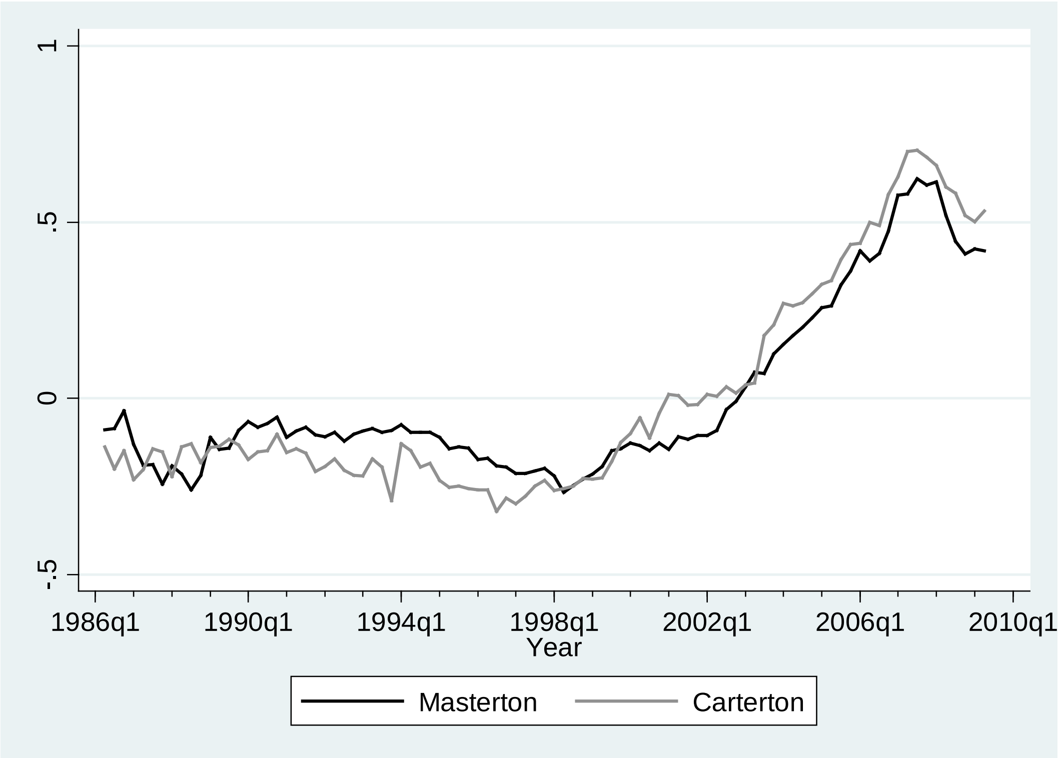
[8] For UK studies, see: Meen (1999), Cook and Thomas (2003), Cook (2003, 2005a, 2005b), Drake (2005), Holmes (2007), Holmes and Grimes (2008). For studies of other countries, see: Gallet (2004), Gros (2007), Chien (2010), Burger and Van Rensburg (2008), Clark and Coggin (2009), Mohamadou and Wang (2009).
[9] An ADF test fails to reject the null of a unit root with a p-value of 0.234.

Figure 4: Masterton and Carterton log Real House Prices (De-meaned)



components, are orthogonal to each other.[10] Starting with N series, the first principal component (PC1) is calculated as the latent variable that summarises the greatest amount of information (i.e. that minimises the sum of squared deviations) of the N original series. Each of the N series is then regressed on PC1, resulting in N residual series. The second principal component (PC2) is the latent variable that summarises the greatest amount of information across these residual series. This process continues until all the information in the N original series is summarised by N principal components.

One property of a non-stationary series is that the measured variance of the series tends to infinity as the number of periods increases. Hence the sources of non-stationarity across the regional series should be exhibited primarily in the initial principal components. We therefore expect the first principal component, and possibly one or more of the following principal components, to be non-stationary, with subsequent components being stationary. The non-stationary principal component(s) represents a shared stochastic trend(s) determining the long run regional house price paths. Testing the principal components to determine the number of stochastic trends has the advantage over the commonly used Johansen (1988) approach that we

[10] The orthogonality of the principal components has advantages for the power of the statistical panel unit root tests presented in section 4.

do not have to estimate a complete vector autoregressive system as in Johansen. Snell (1996 and 1999) demonstrates that, relative to the Johansen approach, the principal components method has greater power in determining the number of stochastic trends.

Our approach provides an eigenvector decomposition of each series, with weightings on the N principal components for each of the N series. The eigenvalue for each principal component indicates the proportion of the variation over the N series that is explained by each principal component, where the sum of the eigenvalues is N.

The eigenvectors are calculated so that the sum of squared entries in each row and each column sum to one. Each initial series can be explained as a linear combination of the N principal components, using the values across a row in the matrix of eigenvectors as weights. These weights enable us to determine whether the latent variables affect all series equally, or if there are idiosyncratic determinants of some series. Across a row, the ratio of two weights from the eigenvectors is the same as the ratio of the coefficients on the corresponding variables in the corresponding row regression. For an example displaying these properties, see the Appendix.

For each of our analyses, we de-mean all (log) house price series (i.e. subtract each series' own mean), and graph the resulting series for each region. We test each of these series for stationarity using four tests, each with and without a deterministic time trend. The four tests are: the Augmented Dickey-Fuller test (ADF), the Phillips-Perron test (PP), the Dickey-Fuller-GLS test (DF-GLS) and the Kwiatkowski, Phillips, Schmidt, and Shin test (KPSS);[11] the first three tests each have a null of a unit root, while KPSS has a null of stationarity. We examine the eight test statistics for each of the regional variables to determine whether the series is stationary or non-stationary. In all 80 cases, we can conclude that the regional real house price series are non-stationary (in a very few cases, the test results are ambiguous).

We derive the principal components for the set of series under consideration (e.g. all New Zealand regions, or a sub-set of cities, etc). In each case we plot the first three principal components to indicate the relative importance of each. (Given the nature of principal components analysis, each successive principal component explains a smaller proportion of the variance of the original series than the previous principal component.) Each of the first ten principal components[12] is tested for a unit root using the eight tests described above (i.e. each of the four tests with and without a deterministic time trend) and a conclusion is drawn on the

[11] A default of four (quarterly) lags is used where applicable.
[12] We choose the first ten components since, from the properties of a non-stationary series, the main sources of non-stationarity will be exhibited in the first few principal components.

order of integration of each principal component: stationary, non-stationary or ambiguous (where alternative test statistics indicate different conclusions).

Given the non-stationarity of the underlying series, the first principal component in each of our analyses is found to be non-stationary. We are particularly interested in testing whether any principal component beyond the first is non-stationary (indicating multiple housing markets amongst the set of regions); however, the tests on the subsequent principal components are often found to be ambiguous. In order to provide greater power, we perform a panel unit root test on the second and subsequent principal components (up to the component considered stationary by the univariate unit root tests). The principal panel unit root test that we use is the Im, Pesaran and Shin test (IPS) which has a null hypothesis of a unit root. We prefer the IPS test to other panel unit root tests such as the Levin, Lin and Chu test or the Hadri LM test (which has a null of stationarity) because the IPS test assumes individual autoregressive processes for each series within the panel; in contrast, the other tests impose a common autoregressive structure for each series. We have no reason to assume that the autoregressive processes are common across principal components and so favour the IPS test. For comparative purposes, however, we also report the Hadri test results.

These tests of stationarity indicate whether there is more than one statistically significant source of non-stationarity amongst the regional house price series. However, they do not provide an indication of economic significance. To do so, we examine the eigenvalues associated with each principal component (expressed as a proportion of the number of series). These figures indicate the economic importance of each of the sources of non-stationarity. In all cases examined in section 4, the first principal component explains over 85% of the variation in the underlying regional series; the second principal component describes less than 6% of the variation. (Rather than use arbitrary rules to "include" or "exclude" principal components beyond the first component, we prefer to report the proportion of variation explained by the principal components to indicate economic significance.)

Thus even with multiple sources of non-stationarity (defined through the statistical tests), we are able to establish that economic significance is weighted heavily towards a single macro driver. We take the analysis further by comparing the weights on the non-stationary (or ambiguous) principal components within the eigenvectors for each regional house price series. This enables us to interpret the impact of the various sources of non-stationarity on each city (see the example in the Appendix). Even though the second and subsequent non-stationary principal components may be of only second order importance, these comparisons indicate how certain regions co-move (or diverge) relative to the main macro driver.

We note here the possibility that there may be only one non-stationary principal component amongst a set of regions, but regional prices could still diverge if each region has a different weight on that component within the eigenvectors. To account for this possibility, we have also undertaken all analyses expressing each series relative to the first principal component, and then repeating the whole analysis. This approach did not reveal any difference in findings relative to the first approach and, for presentational purposes we present only the approach using the regional real house price series.[13]

4. Australasian Housing Markets

4.1. New Zealand

Figure 1 graphed the demeaned (log) real house price series for each of the 72 New Zealand TAs from 1986q2 to 2009q2. Despite the extraction of any generalised consumer price inflation effect, the series show a strong degree of co-movement, but there are also deviations between individual series about the broader trend.

Figure 5 graphs the first three principal components derived from the 72 regional series. The first of these components (PC1) displays the broad trend in the data observable from Figure 1, with a strong upward trend apparent over the period and especially during the housing boom of 2002 to 2007. The downward shift in prices associated with the global financial crisis at the end of the period is also apparent.

The second and third principal components (PC2 and PC3) broadly cycle around zero indicating little or no long term deterministic trend. Visually (and unlike PC1), it is difficult to determine whether these latter principal components are stationary or not. Table 1 presents the univariate test results for the first ten principal components. For the ADF and PP tests, the table lists p-values for rejection of the null hypothesis; for the DF-GLS and KPSS tests, the table lists whether the null hypothesis is rejected at the 0.01, 0.025, 0.05 or 0.10 levels, with a dash (-) indicating lack of significance at the 10% level.

Table 1 indicates that PC1 is non-stationary; however the results for most of the remaining principal components are ambiguous. For instance, the PP and KPSS tests indicate that PC2 has a unit root, while the ADF and DF-GLS tests reject a unit root in that variable.

[13] The discussion of the weights on PC1 in each of the analyses in section 4 shows that these weights are in each case almost identical across regions. Mathematically, this is the reason why the relative price approach gives almost identical findings to the approach based on absolute (real) price indices.

Figure 5: First 3 Principal Components from 72 New Zealand TAs

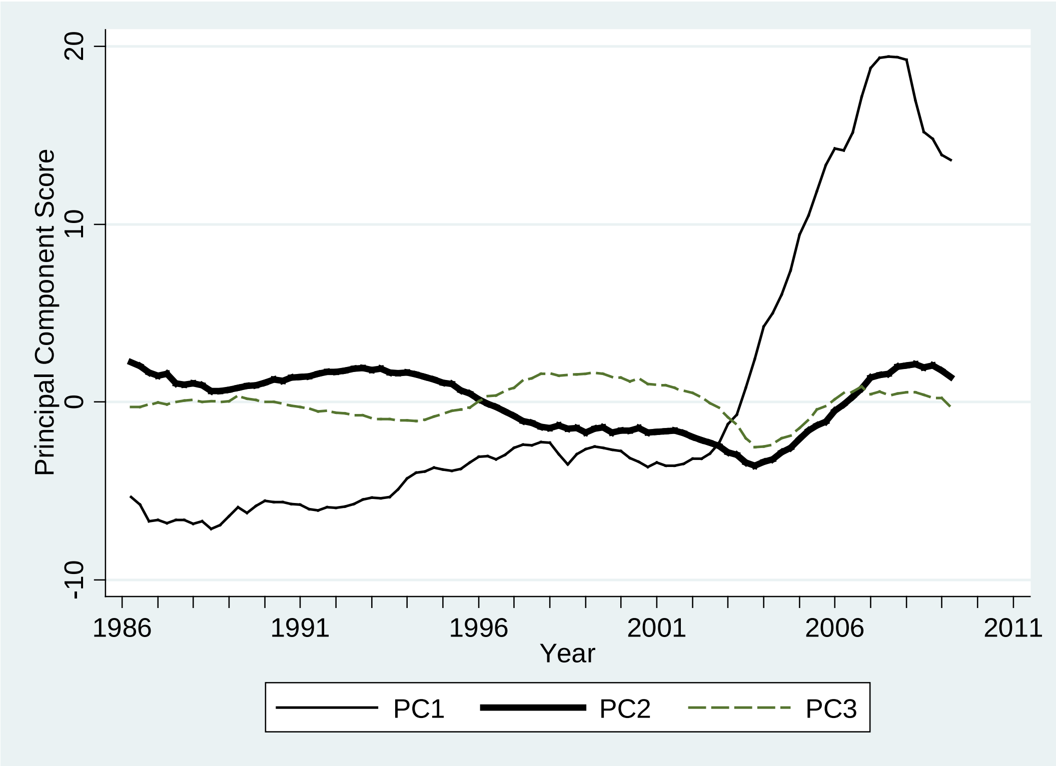


Table 1: Unit Root Tests on Principal Components for 72 New Zealand TAs*

	ADF		**PP**		**DF-GLS**		**KPSS**	
	no trend	trend	no trend	trend	no trend	trend	no trend	trend
PC1	0.4401	0.2475	0.9745	0.8136	-	-	0.0100	0.0100
PC2	0.0229	0.0028	0.6099	0.9822	0.1000	0.0100	0.0250	0.0100
PC3	0.0216	0.0981	0.3886	0.7207	0.0100	0.0500	-	0.1000
PC4	0.0866	0.2785	0.6495	0.8990	0.0100	-	-	0.0100
PC5	0.0133	0.0750	0.1264	0.5346	-	-	-	0.0500
PC6	0.0000	0.0000	0.1107	0.3088	0.0100	0.0100	-	-
PC7	0.0435	0.1540	0.0218	0.0911	-	-	-	-
PC8	0.0009	0.0028	0.0009	0.0065	0.0100	0.0500	-	-
PC9	0.0592	0.2118	0.0042	0.0217	0.0100	0.1000	-	-
PC10	0.0018	0.0129	0.0142	0.0655	-	0.0500	-	-

* The IPS test on PC2-PC10 has p-values: 0.0000 (no trend) and 0.0020 (trend). The Hadri test on PC2-PC10 has p-values: 0.0000 (no trend) and 0.0000 (trend).

Beyond PC7, the principal components appear to be stationary. Application of the IPS test to PC2-PC10 rejects a unit root amongst these principal components while the Hadri test indicates at least one source of non-stationarity beyond PC1.

The eigenvalues associated with each of the principal components demonstrate their substantive importance. The first eigenvalue accounts for 91.6% of the variance of the 72 series; the second and third account for 4.0% and 1.3% respectively (leaving just 3.1% to be explained by the other 69 principal components). The relative sizes of the eigenvalues suggest a single dominant non-stationary trend determining house prices across the 72 TAs of New Zealand. Even if we were to accept the PP, KPSS and Hadri test results and regard PC2 (for instance) to be non-stationary, visual inspection of Figure 5 would indicate that the economic importance of this non-stationarity is of second order importance relative to the non-stationarity exhibited by PC1.

We do not list all 72 eigenvectors, but summarise key results in Table 2. If all TAs placed equal weight on the dominant trend exhibited by PC1, the weight on PC1 in the eigenvector for each TA would be 0.11785 [$=(1/72)^{0.5}$]. Consistent with this calculation, the average weight is 0.1178. More importantly, there is very little dispersion around this value with a standard deviation of just 0.0035 and a range of just 0.1042 to 0.1220.

Table 2: Weightings across 72 New Zealand TAs on PC1 – PC3

	PC1	PC2	PC3
Average Weight	0.1178	0.0015	0.0001
Standard Deviation	0.0035	0.1187	0.1187
Maximum	0.1220	0.2584	0.2175
Minimum	0.1042	-0.2254	-0.2787

By contrast, the average weightings on PC2 and PC3 are near zero while the standard deviations and ranges are much greater than those of PC1. While PC1 depicts the dominant nation-wide house price trend, PC2 and PC3 (and subsequent principal components) depict inter-regional divergences. When we rank the TAs according to their weights on each of these principal components, clear patterns emerge. PC2 characterises a divergence between Auckland plus tourist resorts versus mid-North Island rural areas. Of the fourteen TAs with lowest weights on PC2,[14] seven are the constituent parts of Auckland Region, three are in the Bay of Plenty (centred on Tauranga, the fastest growing city in New Zealand over this time period), and three are South Island tourist centres (Queenstown and Nelson/Tasman).[15] By contrast, nine of the ten TAs with highest weights are rural-dominated TAs lying south of Hamilton and north of Wellington. PC3 characterises a North Island versus South Island split: 17 of the top 18 TAs are in the North Island and the bottom 9 are all in the South Island.[16]

The spatial splits associated with the eigenvectors reflect real economic factors.[17] One may interpret the weighting pattern associated with the second eigenvector as revealing the importance of regional housing demand versus supply, given the strongly growing housing demand in the "bottom" areas versus those at the "top" and the effects of supply constraints on house prices found in prior studies.[18] However, in doing so, the materiality of these effects needs to be borne in mind. The eigenvalues reveal that the nation-wide trend (PC1) dominates all others, meaning that the inter-regional forces are of only second order importance in determining a region's real housing price. This conclusion holds even if we were to consider PC2 (and possibly subsequent principal components) to be non-stationary. In economic (as opposed to statistical) terms, the impact of this non-stationarity does not detract from the finding of a nation-wide housing market that is subject to only minor inter-regional divergences.

4.2. Australia

Figure 2 depicted the path of (log real demeaned) house prices across Australia's eight federal, state and territory capital cities. As for New Zealand, there is a similarity in the time paths of house prices across cities. Figure 6 graphs the first three principal components derived from these eight series.

The first principal component displays a clear stochastic trend, while PC2 and PC3 both cycle broadly around zero. Despite this visual impression, the univariate unit root tests reported in Table 3 indicate that each of the first three principal components is non-stationary. The IPS

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[14] "Top" versus" bottom" descriptors are immaterial since the principal component and the coefficients could each be multiplied by negative one; it is the pattern of some TAs being at one end of the spectrum versus others at the opposite end of the spectrum that is important.

[15] Wellington (a major city) is the other TA in this group of fourteen.

[16] Note that, given the orthogonality of principal components, these orderings occur after controlling for factors already accounted for by PC1 and PC2.

[17] For instance, Grimes and Aitken (2004) demonstrate that commodity price outcomes impact on local housing prices.

[18] See Grimes and Liang (2009) on the price effects of land supply constraints in Auckland, and Grimes and Aitken (2010) on the importance of the housing supply elasticity for determining the magnitude of house price spikes following jumps in regional housing demand.

Figure 6: First 3 Principal Components from 8 Australian Cities

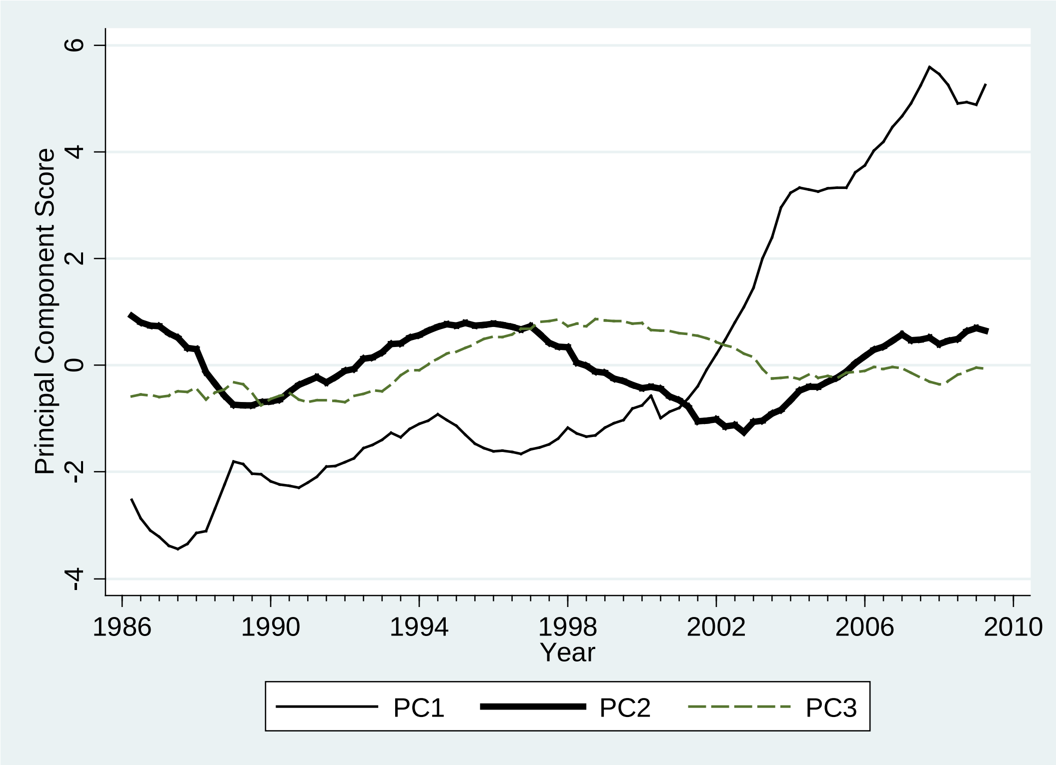


Table 3: Unit Root Tests on Principal Components for 8 Australian Cities*

	ADF		**PP**		**DF-GLS**		**KPSS**	
	no trend	trend	no trend	trend	no trend	trend	no trend	trend
PC1	0.9866	0.9426	0.9940	0.8250	-	-	0.0100	0.0100
PC2	0.0501	0.1980	0.4570	0.8518	0.1000	-	-	0.0500
PC3	0.4757	0.8499	0.6196	0.9502	-	-	0.0250	0.0100
PC4	0.0994	0.2672	0.4642	0.8307	-	-	-	0.0100
PC5	0.0083	0.0293	0.0444	0.1549	-	-	-	-
PC6	0.0131	0.0630	0.0224	0.0928	0.0100	0.0500	-	-
PC7	0.0003	0.0029	0.0254	0.1055	0.0100	0.0100	-	-
PC8	0.0020	0.0139	0.0000	0.0000	0.0100	0.0100	-	-

* The IPS test on PC2-PC7 has p-values: 0.0020 (no trend) and 0.1586 (trend). The Hadri test on PC2-PC7 has p-values: 0.0000 (no trend) and 0.0000 (trend).

test[19] without trend rejects a unit root (p=0.0020), while inclusion of a deterministic trend fails to reject a unit root (p=0.1586); the Hadri tests reject stationarity. Thus the statistical decision on whether principal components beyond PC1 are stationary or not is ambiguous.

Table 4 summarises the weighting patterns across the first three principal components. As observed in New Zealand, the weights on PC1 are tightly clustered around the mean value, whereas there is wide dispersion of weights on PC2 and PC3. The weights on these latter principal components again reflect spatial divergences that indicate differential patterns of economic development. For instance, the peripheral cities of Darwin and Hobart have high weights on PC2 (0.49 and 0.42 respectively) while Australia's two major cities, Sydney and Melbourne, have low weights (-0.59 and -0.48 respectively); the other four cities have weights clustered around zero.

Table 4: Weightings across 8 Australian Cities on PC1 – PC3

	PC1	PC2	PC3
Average Weight	0.3533	0.0005	0.0103
Standard Deviation	0.0137	0.3780	0.3778
Maximum	0.3670	0.4912	0.7266
Minimum	0.3274	-0.5850	-0.4954

The first eigenvalue establishes that PC1 explains 89.4% of the variation across the eight Australian city series whereas the second principal component explains just 4.6%; PC3 explains 3.2% of the variation. Thus while the statistical tests indicate potentially multiple sources of non-stationarity, the second and subsequent sources of non-stationarity are of second-order importance for determining regional house prices relative to the nation-wide trend.

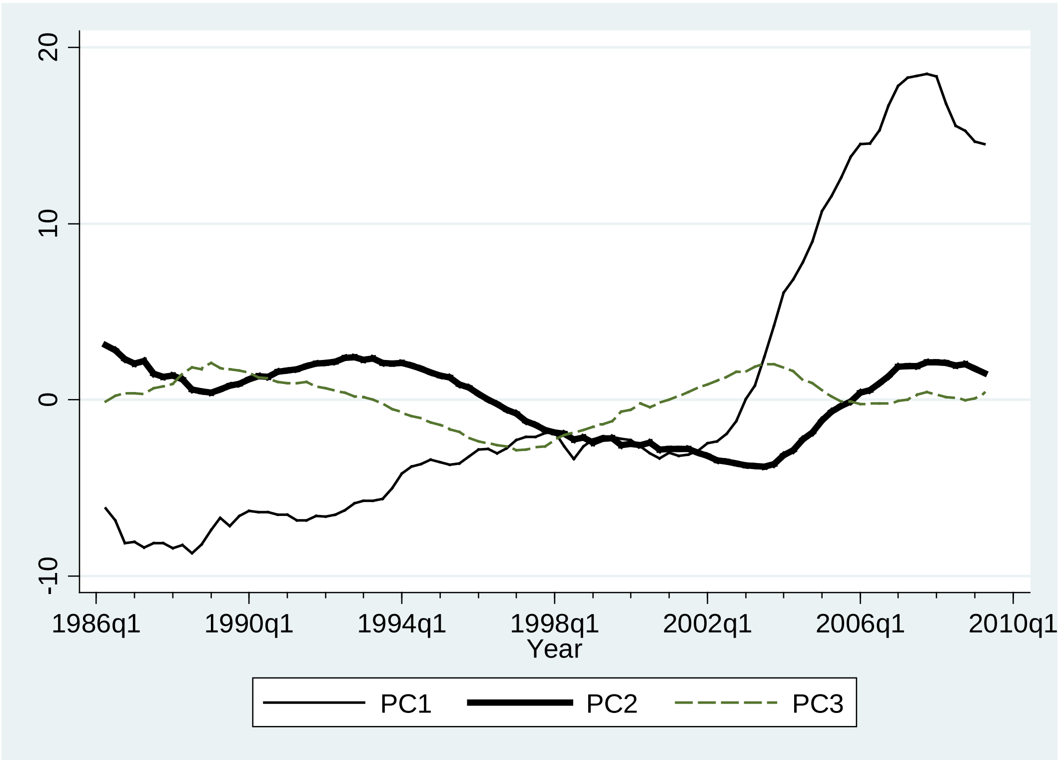
4.3. Australasia

The combined 80 Australasian regions, shown in Figure 3, again reveal a strong degree of co-movement. Figure 7 displays the first three principal components for these 80 regions; Table 5 presents the unit root tests on the first ten principal components.

[19] The IPS test omits PC8 which is unambiguously stationary.

The visual impression given by Figure 7 is similar to that given by the New Zealand and Australia figures; each of PC2 and PC3 appear broadly stationary. The univariate unit root tests give ambiguous results with regards to stationarity of PC2 through to PC7 (or even PC8).[20] The IPS test (both without and with trend) finds that these PCs are jointly stationary while the Hadri test rejects stationarity. The eignenvalues reveal that the first three principal components explain 87.7%, 5.4% and 2.2% respectively of the variation across all the series. These results are important in understanding the path of New Zealand house prices relative to those in Australia. The IPS test (our preferred panel test) indicates that there is a single non-stationary stochastic trend across Australasia. It follows that real house prices across New Zealand's regions in the long term follow those of Australia's regions; departures are only temporary.

Figure 7: First 3 Principal Components from 80 Australasian Regions



Further insight is gained by examining the eigenvectors. Table 6 provides the summary statistics for the weights on the first three principal components. For PC1, the weights are again tightly clustered, especially given that there is a single low outlier, Kawerau,[21] which has a weight

[20] The tests indicate that PC3 is possibly more likely to be non-stationary than is PC2.
[21] Grimes et al (2003) discuss the outlier status of Kawerau within New Zealand.

Table 5: Unit Root Tests on Principal Components for 80 Australasian Regions*

	ADF		PP		DF-GLS		KPSS	
	no trend	trend	no trend	trend	no trend	trend	no trend	trend
PC1	0.5300	0.3319	0.9856	0.7665	-	-	0.0100	0.0100
PC2	0.0330	0.0237	0.5721	0.9796	0.1000	0.0500	0.0250	0.0100
PC3	0.1468	0.4119	0.6533	0.9030	0.0500	-	-	0.0100
PC4	0.0016	0.0098	0.4623	0.7813	0.0100	0.0100	-	0.1000
PC5	0.0001	0.0006	0.1881	0.5626	0.0500	0.0500	-	0.0500
PC6	0.0101	0.0395	0.1318	0.3236	0.0500	0.0100	-	-
PC7	0.0003	0.0030	0.0976	0.2945	0.0500	0.0500	-	-
PC8	0.0016	0.0129	0.0234	0.0934	0.0100	0.0100	-	-
PC9	0.0002	0.0017	0.0021	0.0132	0.0500	0.0500	-	-
PC10	0.0001	0.0005	0.0000	0.0005	0.0100	0.0100	-	-

* The IPS test on PC2-PC8 has p-values: 0.0000 (no trend) and 0.0001 (trend). The Hadri test on PC2-PC8 has p-values: 0.0000 (no trend) and 0.0000 (trend).

Table 6: Weightings across 80 Australasian Regions on PC1 – PC3

	PC1	PC2	PC3
Average Weight	0.1117	0.0023	0.0008
Standard Deviation	0.0054	0.1125	0.1125
Maximum	0.1180	0.2673	0.2661
Minimum	0.0892	-0.2188	-0.2266

of 0.0892. The next lowest weights on PC1 are for Gore (a rural-based TA in southern New Zealand) and Sydney (Australasia's largest city) at 0.0977 and 0.0979 respectively. The fact that these two regions have almost identical weight on PC1 indicates the ubiquitous impact of the macro trend on disparate regions.

The weights on PC2 are equally instructive. Intuitively, we may expect the second principal component to isolate a New Zealand versus Australia divergence. Instead, one end of the spectrum is dominated by rural, mainly North Island, TAs within New Zealand,[22] while the other end is dominated by the seven Auckland TAs and four TAs in the neighbouring growth regions of Waikato and Bay and Plenty, plus Wellington, Sydney and Melbourne.[23] Thus rather than identifying a trans-Tasman split, the second principal component represents a major city versus rural divide that is not country-specific.[24]

Nor do the weights on PC3 pick out a New Zealand versus Australia divide. Melbourne and Adelaide place second and third according to these weights (behind Upper Hutt, which is within the Wellington urban area), while Darwin places lowest. Consequently, none of the first three principal components (which together explain over 95% of the variability amongst these 80 series) indicate a distinct New Zealand housing market relative to that of Australia.

4.4. Four trans-Tasman Cities

The cross-country analysis in section 4.3 included regional economies of very diverse characteristics. The divergences between house prices appear to have been driven more by a rural-urban divide than by country-specific divergences. Here we exclude the rural dimension by focusing on four cities: the three major eastern Australian cities (Sydney, Melbourne and Brisbane) plus New Zealand's major city, Auckland.[25,26] Figure 8 plots the (log real demeaned) house price series for these four cities, with the series broadly tracking each other over the period. The first three principal components are shown in Figure 9, revealing similar patterns to before: a clearly non-stationary macro trend (PC1) with PC2 and PC3 appearing to cycle around a zero mean.

The univariate unit root tests in Table 7 indicate that all four principal components may be non-stationary, or at least ambiguous. The IPS test indicates ambiguity depending on whether a deterministic time trend is included or excluded, with a strong rejection of a unit root process

[22] Regions with a weight of greater than 0.10 (from highest to lowest) are: Kawerau, Whanganui, Rangitikei, Gore, South Waikato, Tararua, Stratford, Horowhenua, Invercargill, Ruapehu, Waitomo, South Taranaki, Buller, Waimate, Wairoa and Manawatu.

[23] Regions with a weight of less than -0.10 (from lowest to highest) are: Sydney, Auckland, Waitakere, Melbourne, Rodney, Manukau, Thames, Tauranga, Wellington, Franklin, North Shore, Waikato, Papakura, Whakatane.

[24] We do not have data for rural Australian house prices. However we note that Hobart, the most rural of our Australian cities, is ranked at 22nd out of 80 regions according to its PC2 weight, placing it closer to the rural New Zealand regions than the major Australian cities.

[25] In 2008/09, the populations for the greater urban areas of these four cities were: Sydney: 4.4 million, Melbourne 3.9 million, Brisbane 1.9 million and Auckland 1.3 million (sources: Australian Bureau of Statistics and Statistics New Zealand).

[26] For the "Auckland" house price, we use the first principal component from the house price series for the 7 TAs in the Auckland Region. Similar results are found using the Auckland City house price index, which is the series used in the Appendix.

Figure 8: Four Australasian City log Real House Prices (De-meaned)

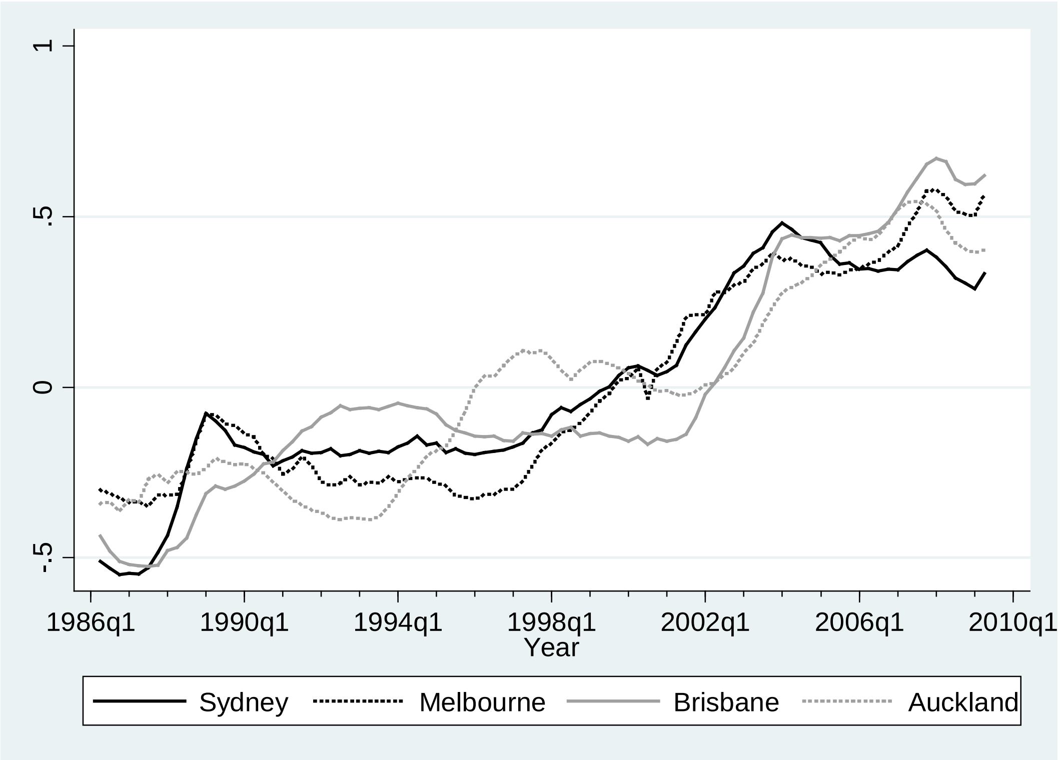


Figure 9: First 3 Principal Components from 4 Australasian Cities

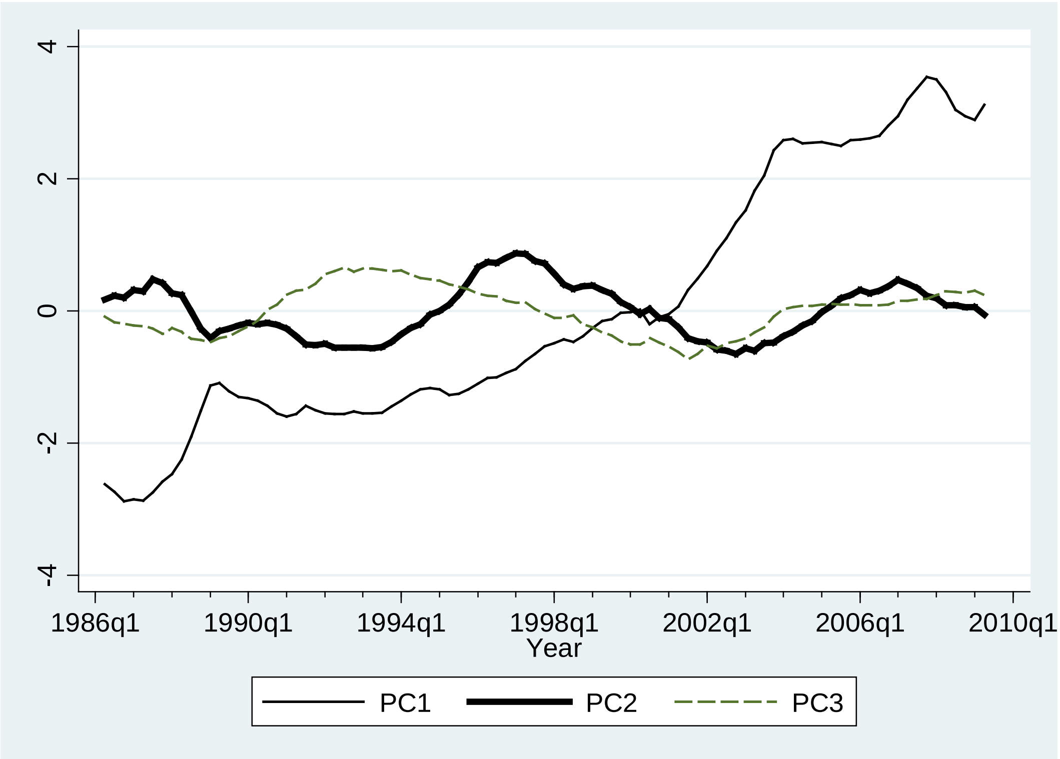


Table 7: Unit Root Tests on Principal Components for 4 Australasian Cities*

	ADF		PP		DF-GLS		KPSS	
	no trend	trend	no trend	trend	no trend	trend	no trend	trend
PC1	0.9387	0.7558	0.9499	0.7151	-	-	0.0100	0.0100
PC2	0.0464	0.1589	0.4125	0.7294	0.0100	0.1000	-	-
PC3	0.1566	0.3996	0.6703	0.9103	0.0500	-	-	0.0250
PC4	0.2038	0.7016	0.5253	0.9516	-	-	0.1000	0.0100

* The IPS test on PC2-PC4 has p-values: 0.0078 (no trend) and 0.1076 (trend). The Hadri test on PC2-PC4 has p-values: 0.0000 (no trend) and 0.0000 (trend).

across PC2-PC4 in the former case, but marginal non-rejection (p=0.1076) in the latter. The Hadri test again rejects stationarity. As in the prior cases, the economic significance of any non-stationarity (beyond the main macro trend) is limited; the eigenvalues show that the first principal component explains 91.1% of the variability across the four cities, with the second, third and fourth components explaining just 4.2%, 3.3% and 1.4% respectively.

We list the full eigenvectors in Table 8. All four cities have almost identical weights on the main macro trend (PC1). Thereafter, city-specific differences are apparent. PC2 shows an Auckland versus Australian city divergence; PC3 indicates a Brisbane factor, while PC4 shows a Sydney versus Melbourne split. While the first source of divergence from the macro trend is for Auckland versus the Australian cities, the economic significance (given the eigenvalues) is minor. Furthermore, the presence of a unit root in PC2 (the "Auckland factor") is uncertain, with four of the eight univariate tests rejecting a unit root at the 5% level (five rejections at the 10% level). Thus this source of trans-Tasman divergence may well reflect only temporary (and/or minor) departures from a common stochastic trend.

Table 8: Eigenvectors for 4 Australasian Cities

	PC1	PC2	PC3	PC4
Sydney	0.5067	-0.4155	-0.2026	-0.7277
Melbourne	0.5053	-0.3113	-0.4628	0.6585
Brisbane	0.4975	-0.0975	0.8457	0.1666
Auckland	0.4903	0.8491	-0.1717	-0.0956

5. Conclusions

Considerable attention is paid to temporal movements in house prices, both because of their intrinsic importance (for example, in affecting housing affordability) and because of what these movements signal about the impacts of local regulatory policies and/or the efficacy of macroeconomic policies. Less attention is paid to whether forces exogenous to the country are the primary determinants of such asset price movements. New Zealand, as a small country with independent monetary, fiscal and regulatory policies, provides an ideal test of the degree to which such exogenous forces are the primary driver of local real house price outcomes.

Our analysis finds a single dominant determinant of house prices across the 72 territorial authorities of New Zealand. This single stochastic trend explains 92% of the variance in (log) real regional house prices across New Zealand from 1986q2 to 2009q2. The second largest trend (which may or may not be stationary) differentiates between rural areas versus large urban and tourist areas; Auckland is not alone in the latter group, with Wellington, Bay of Plenty, Nelson/Tasman and Queenstown also represented.

Similarly, a single macro stochastic trend explains 89% of the variability amongst the house prices of the eight Australian capital cities. Thus the impacts of differing regulatory and planning policies – while potentially causing some local divergence from the national trend – are of second order importance relative to the broad macro determinants of house prices in each country.

In order to gain a better understanding of whether the main macro driver is of domestic origin or not (at least for the case of New Zealand, where Australia can be considered a 'large' neighbour), we have analysed house prices across the two countries. Mirroring the individual country test results, a single macro trend explains 88% of the variance across the 80 regions considered for the two countries. Furthermore, the next greatest source of variation is explained by a divide between rural New Zealand regions (and, to a lesser extent, Hobart) versus the urban areas chiefly represented by Sydney, Auckland, Melbourne, Tauranga and Wellington. The presence of economic forces favouring firm and population agglomeration in major cities, with accompanying population stagnation or loss in rural areas, is one explanation that can account for such an outcome.

The results suggest that city-specific regulatory and planning policies have had, at most, only a second-order effect on regional house price outcomes relative to the Australasia-wide trend. One possible explanation for this outcome would be if planning policies in the major urban areas have been in virtual lock-step with each other across the two countries. This is a possibility that we cannot rule out given that there have been calls in both Australia and New Zealand for relaxation of land supply in the each country's main centres.[27] Nevertheless, there is no evidence within our results to suggest that city-specific regulatory policies have caused one city's prices to diverge from the Australasian trend.

The results additionally suggest that, despite New Zealand's independent monetary and fiscal policies and freely floating exchange rate, these policies have been unable to shield New Zealand from a broader Australian (or global) trend with respect to real house prices. Our results do not cast doubt on the ability of an independent monetary policy to control general (goods and services) inflation, given that our house prices are expressed in real (CPI-adjusted) terms. Instead (in line with macroeconomic orthodoxy), they suggest that macroeconomic policies have not materially affected *relative* prices that are instead determined primarily by international forces.

A natural extension of our research is to analyse whether Australian real house prices are hostage to international forces in a manner similar to the observed dependence of New Zealand house prices on Australia. A second extension is to examine the economic forces that determine individual regions' departures from the macro trend (whether this trend is stationary or non-stationary). We leave these extensions to future work.

A final methodological note is in order. At the outset, we stressed the difference between statistical significance and economic significance when interpreting statistical results. Our approach to testing for stationarity enables us to distinguish between the two. One may interpret the ambiguous test results on the stationarity of the second principal component (PC2) in our four analyses as implying a unit root, thus indicating the presence of multiple housing markets within and across the two countries. However, the eigenvalues for each analysis demonstrate that PC2 explains only 4-5% of the variation amongst the regional real house price series. In this respect, over any reasonable timeframe, the substantive effect of this source of non-stationarity is small (and of course it is even smaller, in the long term, if PC2 is stationary). In terms of economic significance, we therefore conclude that a single macro driver determines the house prices for the 80 regions considered across New Zealand and Australia.

[27] For New Zealand, see recommendation 27 of 2025 Taskforce (2009); for Australia, see recommendation 6.1 of Productivity Commission (2004).

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Appendix: A Primer on Principal Components

As an example of the properties of principal components analysis discussed in section 3, consider the results of our analysis for the house prices of four regions: Auckland, Sydney, Melbourne and Brisbane. Table A1 presents the eigenvalues associated with each principal component (which sum to N=4), the second column shows the proportion of the variance of the four initial series explained by each principal component, and the final column shows the cumulative proportion of the variance explained by the principal components up to and including that principal component.

Table A1: Eigenvalues from Principal Component Analysis

	Eigenvalue	Proportion	Cumulative
PC1	3.6637	0.9159	0.9159
PC2	0.1443	0.0361	0.9520
PC3	0.1343	0.0336	0.9856
PC4	0.0576	0.0144	1.0000

Table A2 presents the four eigenvectors, demonstrating that the sum of squares sums to one for each row and column. The weighting on the first principal component is almost identical for each city, indicating a broad macro driver for all four cities; thereafter the weightings differ considerably, indicating city-specific factors. For instance, the second principal component indicates an Auckland versus Australian city component, while the third is a Brisbane-specific component.

Table A3 presents the coefficients for a regression of the Auckland house price series on the four principal components. The ratio of the two weights in bold in the matrix of eigenvectors and the ratio of the two coefficients in the regression are equal, demonstrating the congruence of the weights in the eigenvector matrix with the regression coefficients.

Table A2: Eigenvectors from Principal Component Analysis

	PC1	PC2	PC3	PC4	Sum of Squares
Auckland	**0.4934**	**0.8553**	-0.1098	0.1135	0.9999
Sydney	0.5086	-0.2224	-0.2629	-0.7892	1.0001
Melbourne	0.5025	-0.4277	-0.4568	0.5966	1.0000
Brisbane	0.4953	-0.1898	0.8427	0.0920	1.0000
Sum of Squares	0.9999	1.0000	1.0000	1.0001	

Table A3: Auckland Regression Coefficients

Auckland	PC1	PC2	PC3	PC4	Constant
Coefficient	**0.1824**	**0.3161**	-0.0406	0.0420	6.4419

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