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# An Unobserved Components Common Cycle for Australia? Implications for a Common Currency

**Viv B. Hall**
Victoria University of Wellington

**C. John McDermott**
Victoria University of Wellington

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# An unobserved components common cycle for Australasia? Implications for a common currency*

**Viv B. Hall and C. John McDermott**†

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## Abstract

An important requirement, prior to countries' adopting a common currency or maintaining an independent monetary policy, is establishing the extent to which they share a common economic cycle and how susceptible they are to region-specific shocks. For example, Kouparitsas (2001) has examined whether 8 US BEA regions are largely subject to common sources of disturbance, and assesses whether their regional cycles are consistent with a common currency area for the US. Norman and Walker (2007) conclude for 6 Australian States that the major source of the State fluctuations is shocks which are common to all States. But their variance analysis also shows that each overall State cycle is driven partly by fluctuations specific to that State, in particular for Western Australia. Findings such as these also have important implications for the relative strengths of influence of fiscal and regional policies, and of external shocks.

Using similar unobserved components methodology (e.g. Watson and Engle (1983), Kouparitsas (2001, 2002), Norman and Walker (2007), and Hall and McDermott (2008)), we establish an Australasian common cycle, and assess the extent to which the region-specific cycles of 6 Australian States and NZ are additionally important.

Our results suggest that: (1) structural breaks play an important role; (2) New Zealand's region-specific growth cycle has exhibited distinctively different features, relative to the common cycle; and (3) for every Australasian region, the region-specific cycle variance dominates that of the common cycle. Our findings on the distinctiveness of New Zealand's output and employment cycles are consistent with New Zealand retaining the flexibility of a separate currency and monetary policy.

**JEL Classification:** C32; E32; E52; F36; R11

**Keywords:** Common currency; unobserved components; Australasian common cycle; regional cycles; New Zealand; Australia

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† Author details: School of Economics and Finance, Victoria University of Wellington, New Zealand. Email addresses: viv.hall@vuw.ac.nz; john.mcdermott@vuw.ac.nz. Corresponding author: Viv Hall

## 1. Introduction

An important requirement, prior to countries' adopting a common currency or maintaining an independent monetary policy, is establishing the extent to which they share a common economic cycle and how susceptible they are to idiosyncratic shocks. Kouparitsas (2001) has examined whether 8 US BEA regions are largely subject to common sources of disturbance, and whether their regional cycles are consistent with a common currency area for the US. Norman and Walker (2007) conclude for 6 Australian States that the major source of the State fluctuations is shocks which are common to all States. But they also conclude that each overall State cycle is driven partly by fluctuations specific to that State, in particular for Western Australia, but also for New South Wales and Tasmania.

Using similar unobserved components (UC) methodology, e.g. Watson and Engle (1983), Kouparitsas (2001, 2002), Norman and Walker (2007), and Hall and McDermott (2008), we establish a common cycle for the 6 States of Australia and NZ, and assess the extent to which the State and NZ idiosynchratic cycles are additionally important[1].

The paper focuses initially on establishing the *sources* of regional economic disturbances, and then proceeds to examine potential *responses* to disturbances. Implications are drawn for whether NZ cycles and cyclical responses are consistent with NZ joining a common Australasian currency.

The specific questions we address are: (i) what is the hypothetical Australasian common cycle, consistent with well-accepted trend regional growth rates?; (ii) what are the corresponding idiosynchratic (region-specific) cycles?; (iii) how sensitive are the idiosynchratic cycles to the common cycle?; (iv) is there a distinct role for region-specific cycles, and are there related groups of these cycles?[2]; (v) what are the relative contributions of the common and idiosyncratic cycles to each region's total cycle? (vi) what are the responses of regional activity to region-specific and common shocks, and what role if any do spillover effects from one region to another play?; (vii) are our model-related findings materially different from those reported for the US by Kouparitsas (2002), for Australia by Norman and Walker (2007), and for Australasia by Grimes (2005, 2006)?; (viii) does it matter whether output or employment data are used?; and (ix) what are the implications of these macroeconomic results for an Australasian common currency, relative to those reported in Grimes (2005, 2006), and in Hall (2005)?

Data description, and evidence on bivariate co-movements are presented in section 2. Section 3 provides the specification of our UC Model. Empirical results and their implications are assessed in section 4. Section 5 concludes.

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[1] Our analysis does not include the roles of the Australian Capital Territory (ACT) and the Northern Territory (NT), nor does it assess industry structure effects. On these issues, see Grimes (2005, 2006). Using cycles in employment data for the period 1985q4 to 2002q4, Grimes (2006, p 23) establishes that only the ACT, through its predominant central government influence, has a material industry structure effect. The cycles for all other regions differ considerably from the aggregate, due to region-specific cycle movements associated with region-specific shocks. Grimes (2005, p 385) also concluded that the ACT and NT could not be considered core Australasian regions in cyclical terms.

[2] In this paper, we do not address explicitly the question of what specific factors might drive the idiosynchratic cycles. For preliminary work on specific factors that might drive New Zealand growth cycles, see Hall and McDermott (2008).

## 2. Business Cycle Fluctuations in Australasia

To provide an initial perspective on business cycle fluctuations in Australasia we focus on growth cycles using the band-pass filter method made popular by Baxter and King (1999), and the well-known Hodrick-Prescott (HP) (1997) filter. The band-pass filter uses spectral analysis theory to remove all but a band of frequencies from a time series associated with the business cycle. Choosing the bands to reflect features of the data attributable to business cycle influences (typically taken to be between 6 and 32 quarters) allows us to compare the correlations of regional activity in Australasia.

The data we use are quarterly logarithms of NZ real GDP and real state final demand (SFD) for the six Australian states: New South Wales, Victoria, Queensland, South Australia, Western Australia, and Tasmania[3]. The sample period used is 1985q3 to 2006q2. For the remainder of the paper we will refer to this GDP and SFD data as regional economic activity.

Panels A and B of Table 1 report band-pass and HP filter correlation coefficient measures, for contemporaneous regional cycle co-movements over the full sample period. Results from using the two filters are similar: the strongest co-movements involve Australia's three largest states, NSW, Victoria and Queensland; and if one leaves aside the low co-movements of Tasmania with NSW, it is New Zealand that has consistently the lowest associations with the other regions' economic activity.

But are these results sustained over sub-periods, given the major microeconomic and macroeconomic reforms initiated in New Zealand between 1985 and 1991, the significant reforms subsequently undertaken in Australia, and other key external and internal shocks to the economies of both countries? Following Norman and Walker (2007, p 368, fn 13), we use 1994q4/1995q1 as the break point for our illustrative sub-periods. Results are presented in Panel C of Table 1, for HP filtered data[4]. The co-movements amongst NSW, Victoria and Queensland are strong over both sub-periods. But it is surprising, given the strong business cycle expansions enjoyed by both Australia and New Zealand over the past decade, that the contemporaneous co-movements involving all other regions are consistently weaker over 1995q1 to 2006q2, relative to the period 1985q3 to 1994q4 [5]. For New Zealand, there is no cross correlation above .50 for either sub-period.

A bivariate perspective on persistence and lead/lag relations over the full sample can be obtained from the correlation coefficients presented in panel D. The coefficients on the diagonal of the table show the persistence of regional fluctuations. The estimates range from

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[3] New Zealand real GDP is sourced from *Statistics New Zealand*, and SFD from *Datastream*. We also conducted our analysis with the National Bank of New Zealand's aggregate economic activity index instead of real GDP. Results were consistent with those presented here for real GDP.

[4] Results using HP filtered data are reported, as the band-pass filter removes the first and last 12 observations for each sub-sample, leaving correlations from only 14 and 22 observations. These correlations could be misleading. Norman and Walker (2007, p 363, fn 6) correct for their unacceptable loss of band-pass filtered observations, by using trends to extrapolate each series beyond their start and finish point, and then allowing the band-pass filter to remove these observations.

[5] Exceptions are the somewhat higher, relatively weak correlations involving New Zealand and South Australia (.42 greater than .21), and New Zealand and Tasmania (.34 greater than .18).

0.88 in South Australia to 0.94 in Victoria and New Zealand, reflecting the strong short-term persistence in all the regional business cycles[6].

In contrast, the coefficient estimates in the off-diagonal elements are generally lower. More particularly, where the off-diagonal elements are noticeably lower than the corresponding estimates in Panel A, they show that lead/lag relationships are not material. Exceptions to this occur in the three largest states of New South Wales, Victoria, and Queensland, with the correlation of NSW leading Victoria increasing to 0.74 from a contemporaneous 0.66, and the correlation of NSW leading Queensland increasing to 0.78 from 0.67[7].

The overall impression from these bivariate correlations is therefore that the three largest Australian states have moved together relatively strongly, that this is consistent with their being core regions of an Australasian cycle, and that the business cycles of the remaining regions would appear to belong to the periphery of any common currency area at best.

However, while this bivariate data analysis is suggestive, it should not be used on its own to formally test the questions posed in the introduction. For that we need to use a structural model that can be used to identify regional responses to common and region-specific shocks. It would also seem important that this model should allow for appropriate break points in the data series.

## 3. Specification of Unobserved Components Model

To estimate the hypothetical common business cycle of Australasia we use an unobserved components model, specifically the dynamic multiple indicator multiple causes (DYMIMIC) model. Such models are popular because it is possible to specify the trend and cycle components of time series data in a flexible manner, while a range of diagnostic tools are available to test the robustness of the estimated cycle.

Since our aim is to estimate the business cycles for each of the key regions of Australasia, as well as a common or Australasian business cycle, we employ a multivariate version of the unobserved components model. This type of model has been used by Kouparitsas (2001 and 2002) to study regional business cycles in the United States, and by Norman and Walker (2007) to study state business cycles in Australia. It has also been used by Hall and McDermott (2008) to establish a New Zealand common cycle from regional economic activity data, to assess the extent to which the region-specific cycles are additionally important, and to assess the extent to which exogenous shocks can affect the common cycle and lead to regional spillover effects.

Following commonly used notation, let $y_{it}$ be the log of economic activity in region $i$. For each region, there are two unobserved components to be estimated, the trend and the cycle. Thus, let $\tau_{it}$ and $c_{it}$ be region specific trend and cycle components, so that

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[6] The full sample correlations for t+4 are much lower, and therefore show considerably less subsequent persistence. They vary from -0.09 for SA and 0.05 for Tasmania, up to 0.36 for New Zealand.

[7] For income at t+4, the correlations for NSW leading Victoria and Queensland fall to only 0.56 and 0.58, and there is no evidence of any other material bivariate lead/lag associations.

$$y_{it} = \tau_{it} + c_{it} . \tag{1}$$

The trend component, $\tau_{it}$, can be represented as a process with a unit root and deterministic drift[8]

$$\tau_{it} = \delta_{it} + \tau_{it-1} + \mu_{it} \tag{2}$$

The drift term, $\delta_{it}$, captures the trend growth rate of economic activity in region *i* at time *t*; $\mu_{it}$ is the innovation to the trend of region *i*'s activity at time *t*, which is assumed to be an independent normal random variable with mean zero and variance $\sigma^2_{\mu i}$; and the innovations, $\mu_{it}$, are assumed to be orthogonal for all *t*. Note that if , $\sigma^2_{\mu i} = 0$ then $\tau_{it}$ is a linear trend. For most regions in our sample, $\sigma^2_{\mu i}$ is very small implying our trend component is much closer to a time trend than would typically be estimated in a univariate setting, such as when a Hodrick-Prescott (HP) filter is used.

Kouparitsas (2002), Norman and Walker (2007), and Hall and McDermott (2008) all found it necessary to allow for breaks in the trend growth rate, to reflect structural changes in their economies. We also find it necessary to allow for break points in economic activity, and as explained below introduce this flexibility by adopting the break in the trend growth rates determined to be 1994q4/1995q1.

The cyclical component for region *i* is assumed to be composed of two parts, a common cycle across regions, $x_{nt}$, and a regional cycle, $x_{it}$, so that

$$c_{it} = \gamma_i x_{nt} + x_{it} \tag{3}$$

where the parameter $\gamma_i$ reflects the sensitivity of the response of activity in region *i* to the common cycle. Consequently, each region's response to the common cycle will be identical in timing and shape but different in amplitude.

The dynamics of the *common* cycle are captured by an autoregressive process of order two[9], with autoregressive coefficients $\rho_1$ and $\rho_2$. The innovation to the common cyclical component, $\varepsilon_{nt}$, is assumed to be an independent normal random variable with mean zero and variance $\sigma^2_n$ :

$$x_{nt} = \rho_1 x_{nt-1} + \rho_2 x_{nt-2} + \varepsilon_{nt} . \tag{4}$$

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[8] The Augmented Dickey-Fuller test (with a constant and a time trend) indicates that the log-levels of regional economic activity for all 7 regions contain a unit root. The unit root tests are rejected for the first difference of the log-level of economic activity.

[9] We experimented with both an AR(1) and AR(2) specification for the transition equation. The overall conclusions are not sensitive to the particular specification, but the response of regional activity might have been more interesting under the AR(2) specification, in that it allows for the possibility of the response of regional activity to increase following the initial impact before decaying away. In contrast, the AR(1) specification forces the regional responses to decay from the initial impact of the common shock. The AR(2) specification also allows the theoretical possibility of endogenous cyclical behaviour. That said, rarely do estimated parameters for AR(2) models of activity data ever produce endogenous cyclical behaviour.

The dynamics of the *regional* cycles are assumed to follow a first-order vector autoregression:

$$X_t = \Phi X_{t-1} + \varepsilon_t \tag{5}$$

where $X_t = [x_{1t}, x_{2t}, ..., x_{7t}]'$, $\Phi$ is a 7 by 7 matrix of coefficients and $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}, ..., \varepsilon_{7t}]'$ is the vector of innovations to the regional cycle, which is assumed to an independent normal random vector with a zero mean and diagonal covariance matrix $\Lambda$[10].

At this point, it is worth summarising in one place the identifying assumptions we have successively imposed earlier in the paper. First, we assume that $\mu_{it}$ and $c_{it}$ are uncorrelated at all leads and lags. When we convert the model into its state space form we impose the restriction that all innovations are assumed to be orthogonal. Moreover, by limiting ourselves to the case where innovations to a particular regional cycle do not affect any other regional cycle (that is, the variance-covariance of the regional innovations is assumed to be diagonal), then we can identify the extent of any spillovers by examining the off-diagonal elements of the $\Phi$ matrix. This identifying assumption allows us to conduct a likelihood ratio test for the null hypothesis of no spillovers. The final identifying restriction we make is that the vector measuring the sensitivity to the common cycle, $\gamma$, is normalized by setting one of its elements to unity. In all cases, we set the sensitivity of New South Wales to unity.

For estimation purposes it is convenient to re-write the model in its state space representation. Thus, after incorporating the break in trend, the measurement equation is

$$\Delta Y_t = \begin{bmatrix} \delta_{85q4,94q4} & \delta_{95q1,06q2} \end{bmatrix} \begin{bmatrix} D_{85q4,94q4} \\ D_{95q1,06q2} \end{bmatrix} + \begin{bmatrix} \gamma & I_{7\times 7} \end{bmatrix} \begin{bmatrix} \Delta x_{nt} \\ \Delta X_t \end{bmatrix} + \mu_t \tag{6}$$

and the transition equation is

$$\begin{bmatrix} x_{nt} \\ X_t \end{bmatrix} = \begin{bmatrix} \rho_1 & 0 \\ 0 & \Phi \end{bmatrix} \begin{bmatrix} x_{nt-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \rho_2 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_{nt-2} \\ X_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{nt} \\ \varepsilon_t \end{bmatrix} \tag{7}$$

where $Y_t = [y_{1t}, y_{2t}, ..., y_{7t}]'$, $\delta_{t1,t2} = [\delta_{1t1,t2}, \delta_{2t1.t2}, ..., \delta_{7t1,t2}]'$, $D_{t1,t2}$ is one for $t1 \leq t \leq t2$ and zero for all other $t$, $\gamma = [\gamma_1, \gamma_2, ..., \gamma_7]'$, $\mu_t = [\mu_{1t}, \mu_{2t}, ..., \mu_{7t}]'$, and $I_{7x7}$ is a 7 by 7 identity matrix.

Maximum likelihood methods and recursive use of the Kalman filter can be used on the state space system (6) and (7) to provide estimates for the unknown parameters and the unobservable components. Using the state space representation, maximum likelihood can be used to estimate the model with the likelihood being evaluated using the Kalman filter. In particular, we use the recursive Expectation Maximization (EM) algorithm for our estimation, details of which are presented in Watson and Engle (1983).[11]

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[10] In principle, weakly exogenous variables could be appended to both equations (4) and (5). These would be potential drivers of the common and idiosyncratic cycles, respectively. The limited length of the available time series prohibits us from doing this at present. For example, estimating equation (5) with three additional weakly exogenous variables would use up 21 degrees of freedom.

[11] For the results which follow, we set the convergence criterion on the log likelihood function at a relatively severe level of $1\times10^{-5}$. The EM algorithm then took 6,500 iterations to converge.

If no break is assumed in (6), then the estimated common cycle from the model is not stationary. Therefore, imposition of a break in the trend rate of growth seems to be material to the results. We can formally test the hypothesis of no break by using a standard likelihood ratio test that compares the value of the likelihood function of the model described by (6) and (7) to the restricted likelihood based on the assumption that (6) has only a single $\delta$ vector which is appropriate for the full sample. Such a test has a standard Chi-squared limiting distribution if we assume that the date of the break is known.

We can conduct a test of no break even if the date of the break is unknown, as is the case for the current application. To do this we estimate the break date by searching over all possible break dates and choosing the date that maximizes the value of the likelihood function, excluding the end of the sample by the customary 15 percent. The limiting distribution of the likelihood ratio test when the break date is unknown is not standard. However, tabulations of the limiting distribution are now widely available, for example as in Hall (2005, p 181).

Typically, a test of no break will not be very powerful against reasonable alternatives. However, in this case the test appears to be sufficiently powerful and evidence of break clearly manifests itself in both the formal likelihood ratio statistics and through unit roots in the estimated $\Phi$ matrix. In part the power of the no break test is coming from the very restrictive assumptions we have placed on the model. These are that we have limited ourselves to the case of iid errors, forced breaks to be common in all equations, exclude the possibility of breaks occurring in the covariance matrix of the errors, and considered breaks only in the trend variable. If one wished to relax these assumptions, then adapting the methods outlined in Qu and Perron (2007) would be a good place to start. However, the computational burden for this would be particularly heavy for our application.

To examine the hypothesis of no break in trend we considered three variations of the tests. Let $LR(\pi)$ denote the likelihood ratio statistic between the restricted and unrestricted model, where the break in the restricted model occurs at date $\pi$. The three tests we used are defined as the supremum likelihood ratio

$$\sup LR(\pi) = \sup_{\pi \in \Pi} \{LR(\pi)\},$$

the average likelihood ratio

$$AvLR(\pi) = d(\pi_L, \pi_U)^{-1} \sum_{\pi=\pi_L}^{\pi_U} LR(\pi),$$

and the exponential average

$$ExpLR(\pi) = \ln\left\{ d(\pi_L, \pi_U)^{-1} \sum_{\pi=\pi_L}^{\pi_U} \exp[LR(\pi)] \right\}$$

where $\Pi$ is the set of all possible dates (i.e. in the current application all dates excluding the first and last 15 percent of observations), $\pi_L$ and $\pi_U$ are the lower and upper possible break dates, and $d(\pi_L, \pi_U)$ is a function that yields the number of possible breaks considered, that is $d(\pi_L, \pi_U) = \pi_L - \pi_U + 1$.

The computed test statistics for the Sup $LR(\pi)$, Av $LR(\pi)$, and Exp $LR(\pi)$ are 52.2, 28.7 and 22.1, respectively. These results are higher than the 1 percent critical values of 26.7, 14.3 and 9.5 indicating that there is strong and significant evidence of a break in the trend growth rate.

## 4. Assessment of Results

### 4.1 Results from our Unobserved Components Model

**Sources of disturbances**

Our regional growth cycles need to be seen first in the context of their underlying trend growth rates, and then in terms of their common and idiosyncratic cycle components. Results are presented for the AR(2) model explained above, with the break in trend growth rates determined to be at 1994q4/1995q1[12].

*The trend regional growth rates*

Table 2 contains estimates of the (annualized) trend growth rates, $\delta_{it}$[13]. For New Zealand and all states of Australia, there is clear evidence of their trend economic growth rates being materially higher over the second half of the sample. This confirms that it is important to control for this experience when comparing the response of each regional economy to various shocks.

*What is the common cycle, and are the regional cycles sensitive to the common cycle?*

The unobserved components model decomposes the regional activity data into region-specific trend components that allow for a break after 1994q4, a common cycle, and region-specific cycles. Figure 1 shows the common cycle and region-specific cycles, expressed as percentage point deviations from each region's trend growth rate. The recession of the early 1990s, common to the U.S., Australia and New Zealand, and associated with a global monetary policy tightening, is evident in the cycles of NSW, Victoria, Western Australia, and New Zealand.

The regional sensitivities of the response of activity in region $i$ to the common cycle, that is the $\gamma_i$ parameters from (3), are reported in Table 3. The sensitivity is normalized to unity for New South Wales. The point estimates show that Victoria is somewhat more sensitive, and that Queensland, Tasmania and South Australia display approximately the same sensitivity as NSW. However, both Western Australia and New Zealand have very different sensitivities to the common cycle from those of other Australian states. The heavy concentration of mining would be the lead candidate to explain the lack of sensitivity in Western Australia. The

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[12] The date of the break is consistent with that determined by Norman and Walker (2007) for the Australian states. We checked for the possibility of different break dates and found that if the break was imposed any earlier the estimated common cycle was not stationary.

[13] For this model and data set, we can present only point estimates. This is due to insufficient sample observations. Problems in computing standard errors occur because the information matrix is not block diagonal (see Watson and Engle, 1983). Rather than the usual method of computing the standard errors, it is necessary to compute the entire information matrix for all the parameters once the parameter estimates have converged. Standard errors have, however, been reported for the 5-region, 3 exogenous variable model for New Zealand, presented in Hall and McDermott (2008, Tables, 2, 3 and 4).

reliance on primary exports could assist in explaining the lack of sensitivity in New Zealand[14], as could different policy institutions and policy responses.

Examination of the time paths and amplitudes of the idiosyncratic cycles in Figure 1 shows there is considerable diversity of cycles across regions. Western Australia has by far the strongest region-specific cycle, suggesting that its cyclical behaviour is not well explained by fluctuations in the common cycle. New Zealand also has a strong region-specific cycle through to the late 1990s, but not in the years since then. South Australia has the least distinctive region-specific cycle. The region-specific cycles of NSW, Victoria, and Queensland show considerable similarity of movement, with NSW and Victoria's movements tracking the closest. Tasmania's cycle has some distinctively different features, though not to the same extent as Western Australia.

Table 4 reports the autoregressive parameters from equation (4), which describe the response of the common cycle to a common cyclical shock. The estimated parameters inform us that the half-life of shocks to the common cycle is about 3 quarters. The shape of each region's response is forced to be identical and is one of steady decay (see Figure 2). The amplitude of each region's response to a common shock depends additionally, however, on the sensitivity parameter values reported in Table 3. The responses of Western Australia and New Zealand are clearly far more muted than those of the other regions.

*Relative contributions of the common and idiosyncratic cycles to each region's total cycle?*

The importance of idiosyncratic shocks relative to the common cycle can also be illustrated through the variances of these cyclical components, reported in Table 5. The key result is that for every region, the variance of the idiosyncratic cycle component dominates that of the common cycle. Within this overall result, Western Australia's region-specific cycle variance is particularly dominant, and for Tasmania and New Zealand these variance components are also very strong relative to the common cycle variance contributions.

Results in this area therefore reinforce the importance of region-specific cycle influences relative to those of the common cycle, and add further doubt to the existence of an Australasian common cycle that could help support the macroeconomic case for an Australasian common currency.

### Responses to disturbances

*What are the responses of regional activity to region-specific and common shocks, and what role if any do spillover effects from one region to another play?*

Table 6 reports the estimated VAR coefficients, $\Phi$, for equation (5). The estimates along the diagonal show that there is variation in the autoregressive behaviour across region-specific cycles: very strong autoregression for New Zealand and Victoria, and relative weak persistence for Tasmania. The off-diagonal values suggest there is very limited spillover of region-specific shocks either to or from New Zealand. For the Australian states, however,

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[14] Note in this context that, from bivariate examination of Australasian employment cycles, Grimes (2006, p 36) found that the agriculturally intensive nature of New Zealand's industrial structure and Western Australia's large minerals exposure could not explain those regions' materially different cycles. Rather, it was regions' 'industry cycle effect' rather than 'industry structure effect' which explained over 95 percent of each regions' region-specific cycle.

there does seem the possibility of spillovers from some of these states to others. To formally test the hypothesis of no spillovers we use a likelihood ratio test, the LR value of which is 119.2. The 1 per cent critical value taken from the asymptotic Chi-squared distribution with 42 degrees of freedom is 66.21, and so the likelihood ratio test of the null of no spillover effect is clearly rejected. The rejection would seem essentially due to spillovers amongst the Australian states.

The impulse response functions, cumulated over eight quarters, and reported in Table 7, are broadly consistent with the above findings. The values in the final column show that, except for Western Australia and New Zealand, the cumulated response of each region to a common cyclical shock is substantial. This is consistent with the evidence provided by Figure 2. The evidence from the diagonal elements shows that, except for NSW, the response of each region to its own region specific shock is also material, varying from 4.7 and 4.6 for New Zealand and Victoria, to the more modest 2.4 for South Australia. As emphasised by Norman and Walker (2007, p 370 and p 372 fn 23), assessment of results for the six Australian states require considerable caution. The results for New Zealand seem, however, to provide minimal credible evidence of spillover effects, i.e. of New Zealand's cycle responding to the region-specific shocks of the six Australian states, and of those states responding to a New Zealand-specific shock [15].

## 4.2 Results, relative to those from Kouparitsas (2001), Norman and Walker (2007), and Grimes (2005, 2006)

Kouparitsas (2001, Figure 1) has established a *common cycle* for the U.S. which has turning points that closely match those of the NBER Dating Committee; and Norman and Walker (2007, fn 19 and Figure 4) present a weighted average common cycle for Australia that has a correlation of 0.79 with a Hodrick-Prescott filtered cycle for domestic final demand. We have established an Australasian common cycle, consistent with well-accepted regional growth rate trends, but we know of no sufficiently similar Australasian cycle to compare it with.

For the U.S., Kouparitsas (2002, p 30) finds that its BEA regions are largely driven by common sources of disturbance and that they have similar responses to a common shock. In a relatively similar vein, Norman and Walker (2007, pp 360, 373) conclude for 6 Australian States that the major source of fluctuations in the states' economic activity is shocks which are common to all states. But their variance analysis (2007, p 371) also shows that each overall state cycle is driven partly by fluctuations specific to that State, in particular for Western Australia, but also for New South Wales and Tasmania. Our unobserved components results show a substantially more distinctive role for *region-specific cycles*, especially for Western Australia and New Zealand. Our variance analysis results, for the relative contributions of the common and idiosyncratic cycle components, differ markedly from those of Kouparitsas, and Norman and Walker. We establish that the region-specific cycle variance dominates that of the common cycle, for all six Australian states and New Zealand. This is especially the case for Western Australia, Tasmania and New Zealand.

Kouparitsas (2001, p 30) concludes that *spillovers* of region-specific shocks to other regions do not contribute a statistically significant share of regional-cycle variation, and Norman and Walker (2007, pp 360, 373) conclude similarly that spillovers of shocks from one Australian

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[15] This finding is consistent with those from the bivariate Granger causality test results on employment cycles reported in Grimes (2005, pp 389, 392)

state to another seem to play only a minor role. When the role of Australian state shocks potentially affecting New Zealand, and New Zealand-specific shocks potentially affecting Australian states, are examined (section 4.1 above, and Grimes (2005)), there also seems minimal evidence of material spillover effects.

### 4.3 Does it matter whether output or employment data are used?

A key finding in the work of Grimes (2005, pp 392, 395) was that from 1991 through to 2002, the New Zealand cycle had generally been as correlated with the Australasian cycle and with those of the larger Australian regions, as those Australian regions had been with each other. His finding was derived from bivariate analysis of Australasian employment data for the period 1985q4 to 2002q4.

In the context of the results reported above in section 4.1 for regional output data, Grimes' finding raises two issues for assessment: (i) would the key results from our unobserved components model using output data have been materially different if we had used employment data instead?; and (ii) are our key overall conclusions consistent with the key broad messages and the above specific finding of Grimes?

New Zealand's employment series[16] behaved very differently from the Australian state series, for the period 1986 through till 1992 (Figure 3). Structural break analysis showed that, in order to establish a stationary common cycle, two break points in the series were required, at 1991q1 and at 1992q4[17].

The unobserved components common cycle we obtain for employment is very similar to the employment growth cycles derived from aggregate Australasian employment data, using Baxter-King and Hodrick-Prescott filters (Figure 4).

A comparison of the Australasian common cycles for output and employment shows that, while there are lengthy periods during which the two common cycles move together, they behave every differently during two key periods, 1991-94 and 2003-05 (Figure 5).

The region-specific employment cycles look very different to each other and to the common cycle (Figure 6), reinforcing the key general finding from our output model that Australasian region-specific cycles have a distinct role, relative to the estimated common cycle.

However, in contrast to Grimes' finding that it is since 1991 that the New Zealand idiosyncratic employment cycle has been closely correlated with the cycle in the larger Australian regions, both our output- and employment-model analysis shows that it is only since the *late* 1990s that such a close association has been evident. The difference would not seem due to using output rather than employment data; rather to the multivariate unobserved components approach we used, instead of Grimes' bivariate Granger-causality methodology.

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[16] The quarterly seasonally adjusted series for New Zealand were sourced from *Statistics New Zealand*, and those for the six Australian states from *Datastream*.

[17] We experimented with the possibility of imposing no break or just one break. For these cases, cycle unit roots were again evident. It can also be noted that 1991q1 was one of the two break points required for the New Zealand regional output work reported in Hall and McDermott (2008).

### 4.4 Implications for an Australasian Common Currency

Kouparitsas' (2002, p 30) research provides support to the view that the U.S. is an optimum currency area, and to the notion that a common monetary policy is the ideal choice for the U.S. Essentially, this is based on his eight BEA regional cycles being largely driven by common sources of disturbance to which they have similar responses.

Grimes (2005, pp 380-381, 396; 2006, pp 23-25, 41-42) summarises key issues, and important industry structure and macroeconomic implications, which should be assessed if an Australasian common currency were to be considered[18]. In particular, his research established that it is shocks to region-specific cycles rather than industry-specific shocks which have been the dominant factor in Australasian regional cycle movements. An important implication of this is that a further major economic shock to either Australian state or NZ economic activity could lead to New Zealand's idiosyncratic cycle again diverging from that in key Australian regions, and hence require that a separate currency and monetary policy play important roles in adjusting to such shocks[19].

Our unobserved components based findings, particularly those on the distinctiveness of the New Zealand idiosyncratic cycle prior to the late 1990s, are broadly consistent with Grimes emphasis on New Zealand's having the flexibility of a separate currency and monetary policy for when "major economic upheaval" occurs again, in either Australia or New Zealand. In a "major economic upheavals" sense, though, the period since the late 1990s has been a relatively benign one for New Zealand[20].

## 5. Conclusion

We have established an output-based Australasian common cycle, consistent with well-accepted regional growth rate trends. This required allowing for a break in the trend rates at 1994q4/1995q1.

The corresponding region-specific cycles exhibit considerable diversity, with the idiosyncratic cycles of Western Australia and New Zealand being particularly distinctive and quite insensitive to a shock to the common cycle.

Variance analysis of the common and idiosyncratic cycle components establishes that for all six Australian states and New Zealand, the region-specific cycle variance dominates that of the common cycle. This is especially so for Western Australia and Tasmania, but also for New Zealand. The finding of dominance of the idiosyncratic cycle contribution is in direct contrast to the findings of Kouparitsas (2002) for US BEA regions, and Norman and Walker (2007) for the six Australian states.

We have also estimated employment-based Australasian common and region-specific cycles, to facilitate assessing our key output-based results relative to the findings of Grimes' (2005).

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[18] See also Hall (2005, pp 19-22), for conclusions and implications from a primarily macroeconomic perspective.

[19] Grimes (2005, p 396) also concludes that the more important loss could be that of exchange rate flexibility, following a New Zealand-specific shock.

[20] For an evaluation of the behaviour of the New Zealand business cycle over a period of nearly 60 years, and the role of major economic shocks, see Hall and McDermott (2007).

Our comparison of the Australasian common cycles for output and employment shows that there are lengthy periods during which the two common cycles move together. We further find that the region-specific employment cycles look very different to each other and to the common cycle, reinforcing the key general finding from our output model that Australasian region-specific cycles have a distinct role, relative to the estimated common cycle.

Our output- and employment-model analysis also shows that New Zealand's idiosyncratic growth cycle has shown little variation since the *late 1990s*. This dating is somewhat later than the year 1991 identified by Grimes (2005), but would be consistent with New Zealand's mid-1990s monetary policy tightening having been an importantly different factor, and New Zealand's cycle also having been differentially affected over 1997-98 by the Asian financial crisis and two successive summers of drought.

Our findings on the distinctiveness of New Zealand's output and employment cycles prior to the late 1990s, are consistent with New Zealand's retaining the flexibility of a separate currency and monetary policy for when "major economic upheaval" occurs again, in either Australia or New Zealand. New Zealand has been fortunate in not having experienced a major economic upheaval during the relatively short period since the late 1990s.

**Table 1**

## Regional business cycle comovement and persistence

### A. Contemporaneous correlation with band pass filter

| Income at time t | Income at time t<br>NSW | VIC | QLD | WA | SA | TAS | NZ |
|---|---|---|---|---|---|---|---|
| NSW | 1.00 | | | | | | |
| VIC | 0.66 | 1.00 | | | | | |
| QLD | 0.67 | 0.85 | 1.00 | | | | |
| WA | 0.36 | 0.69 | 0.69 | 1.00 | | | |
| SA | 0.52 | 0.40 | 0.30 | 0.41 | 1.00 | | |
| TAS | 0.14 | 0.51 | 0.49 | 0.49 | 0.48 | 1.00 | |
| NZ | 0.31 | 0.41 | 0.43 | 0.26 | 0.29 | 0.49 | 1.00 |

### B. Contemporaneous correlation with Hodrick-Prescott filter

| Income at time t | Income at time t<br>NSW | VIC | QLD | WA | SA | TAS | NZ |
|---|---|---|---|---|---|---|---|
| NSW | 1.00 | | | | | | |
| VIC | 0.66 | 1.00 | | | | | |
| QLD | 0.62 | 0.74 | 1.00 | | | | |
| WA | 0.42 | 0.60 | 0.56 | 1.00 | | | |
| SA | 0.54 | 0.45 | 0.32 | 0.35 | 1.00 | | |
| TAS | 0.25 | 0.41 | 0.36 | 0.35 | 0.47 | 1.00 | |
| NZ | 0.23 | 0.35 | 0.32 | 0.18 | 0.28 | 0.29 | 1.00 |

Note: Regional and aggregate economic activity data, natural logged and filtered using quarterly business cycle band-pass filter described in Baxter King (1999), and using filter described in Hodrick and Prescott (1997) with $\lambda = 1600$ as value for the smoothing parameter.

**Table 1 (continued)**

## Regional business cycle comovement and persistence

### C. Contemporaneous correlation with Hodrick-Prescott filter

LOWER TRIANGLE period 1985q3 to 1994q4
UPPER TRIANGLE period 1995q1 to 2006q2

| | Income at time t | | | | | | |
|---|---|---|---|---|---|---|---|
| **Income at time t** | NSW | VIC | QLD | WA | SA | TAS | NZ |
| NSW | 1 | 0.66 | 0.61 | 0.11 | 0.24 | -0.09 | 0.05 |
| VIC | 0.68 | 1.00 | 0.63 | 0.06 | 0.35 | 0.13 | 0.27 |
| QLD | 0.64 | 0.86 | 1.00 | 0.24 | 0.17 | 0.15 | 0.24 |
| WA | 0.62 | 0.84 | 0.82 | 1.00 | 0.31 | 0.14 | -0.19 |
| SA | 0.77 | 0.52 | 0.46 | 0.34 | 1.00 | 0.32 | 0.42 |
| TAS | 0.53 | 0.61 | 0.55 | 0.51 | 0.60 | 1.00 | 0.34 |
| NZ | 0.37 | 0.50 | 0.38 | 0.40 | 0.21 | 0.18 | 1.00 |

### D. Lead/lag correlation with band pass filter

| | Income at time t+1 | | | | | | |
|---|---|---|---|---|---|---|---|
| **Income at time t** | NSW | VIC | QLD | WA | SA | TAS | NZ |
| NSW | 0.92 | 0.51 | 0.48 | 0.17 | 0.46 | 0.03 | 0.23 |
| VIC | 0.74 | 0.94 | 0.74 | 0.63 | 0.47 | 0.43 | 0.42 |
| QLD | 0.78 | 0.85 | 0.93 | 0.66 | 0.38 | 0.43 | 0.47 |
| WA | 0.49 | 0.68 | 0.67 | 0.90 | 0.37 | 0.46 | 0.23 |
| SA | 0.49 | 0.29 | 0.20 | 0.38 | 0.88 | 0.31 | 0.07 |
| TAS | 0.23 | 0.51 | 0.47 | 0.51 | 0.62 | 0.89 | 0.46 |
| NZ | 0.36 | 0.37 | 0.36 | 0.27 | 0.45 | 0.47 | 0.94 |

Note: Regional and aggregate economic activity data natural logged and filtered using quarterly business cycle band-pass filter described in Baxter King (1999), and using filter described in Hodrick and Prescott (1997) with $\lambda = 1600$ as value for the smoothing parameter.

## Table 2

### Trend Parameters, $\delta_{it}$ (Annualised)

| Region | 1985q4 - 1994q4 | 1995q2 - 2006q2 | $\sigma_{\mu i}$ |
|---|---|---|---|
| NSW | 2.69 | 3.60 | 0.02 |
| VIC | 1.82 | 4.62 | 0.03 |
| QLD | 3.21 | 5.30 | 0.02 |
| WA | 3.19 | 4.88 | 0.07 |
| SA | 1.44 | 3.91 | 0.03 |
| TAS | 0.77 | 3.48 | 0.04 |
| NZ | 1.56 | 3.49 | 0.10 |

Notes: $\delta_{it}$ is the drift term. $\sigma_{\mu i}$ is the standard deviation of the innovation to the regional trend. Initial value of $\sigma_{\mu i}$ used is 0.13. All values annualised.

## Table 3

### Sensitivity to common cycle

| Region | Coefficient ($\gamma_i$) |
|---|---|
| NSW | 1 |
| VIC | 1.20 |
| QLD | 1.06 |
| WA | 0.26 |
| SA | 0.93 |
| TAS | 1.03 |
| NZ | 0.25 |

Notes: $\gamma_i$ indicates the parameter for regional sensitivity.

## Table 4

### Common cycle parameters

| Coefficient | Value |
|---|---|
| $\rho_1$ | 0.91 |
| $\rho_2$ | -0.10 |
| $\sigma_n$ | 0.007 |

Note: $\rho_1$ and $\rho_2$ are the autoregressive coefficients. $\sigma_n$ is the standard deviation of the common cycle.

## Table 5

### Variance of Cyclical Components

| Region | Common Cycle – ppt | Idiosyncratic cycle – ppt | Covariance of cycles - ppt | Overall Cycle -ppt |
|---|---|---|---|---|
| NSW | 1.29 | 5.28 | -0.62 | 5.32 |
| VIC | 1.87 | 6.09 | -0.83 | 6.28 |
| QLD | 1.45 | 5.94 | 0.22 | 7.83 |
| WA | 0.09 | 24.38 | 0.03 | 24.52 |
| SA | 1.11 | 3.39 | 0.15 | 4.80 |
| TAS | 1.37 | 10.75 | 0.74 | 13.61 |
| NZ | 0.08 | 6.53 | -0.09 | 6.43 |

## Table 6

### Regional cycle parameters

|  | $\Phi$ |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| **region** | NSW | VIC | QLD | WA | SA | TAS | NZ |
| NSW | **0.59** | 0.29 | 0.27 | -0.06 | 0.08 | -0.09 | 0.03 |
| VIC | -0.01 | **0.92** | 0.02 | 0.01 | -0.13 | 0.01 | 0.09 |
| QLD | -0.18 | 0.06 | **0.54** | 0.17 | 0.06 | 0.04 | 0.07 |
| WA | -0.70 | 0.38 | 0.81 | **0.53** | 0.40 | 0.02 | -0.06 |
| SA | -0.18 | 0.27 | 0.16 | -0.11 | **0.73** | 0.05 | 0.01 |
| TAS | -0.61 | -0.05 | 0.58 | 0.01 | 0.46 | **0.26** | 0.00 |
| NZ | -0.16 | 0.06 | 0.00 | 0.01 | -0.15 | -0.01 | **0.95** |

## Table 7

### Responses of regional economic activity, to region-specific and common shocks Values in Accumulated QPC

Decomposition method: Cholesky - DOF Adjusted

| Response of region after 8 quarters | Shock to region |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | NSW | VIC | QLD | WA | SA | TAS | NZ | Common |
| NSW | -0.45 | 2.96 | 1.69 | 0.21 | -0.65 | -0.26 | 1.19 | 2.89 |
| VIC | -2.12 | 4.63 | 0.99 | 1.09 | -1.83 | -0.02 | 1.47 | 3.47 |
| QLD | -3.44 | -0.45 | 2.63 | 1.37 | 0.97 | 0.91 | 0.64 | 3.05 |
| WA | -8.21 | -0.01 | 2.60 | 4.14 | 3.10 | 2.30 | 0.51 | 0.74 |
| SA | -1.90 | 0.53 | -0.97 | -1.36 | 2.43 | 0.60 | 0.68 | 2.67 |
| TAS | -4.00 | -2.73 | -0.09 | -0.27 | 2.94 | 3.62 | 0.03 | 2.97 |
| NZ | -0.31 | -0.28 | -0.31 | 1.14 | -2.53 | -0.61 | 4.70 | 0.71 |

## Figure 1: The Australasian Common and Region-specific Output Cycles

New South Wales

Victoria

Queensland

South Australia

Tasmania

Western Australia

New Zealand

## Figure 2: Response of Regional Activity to Common Shock

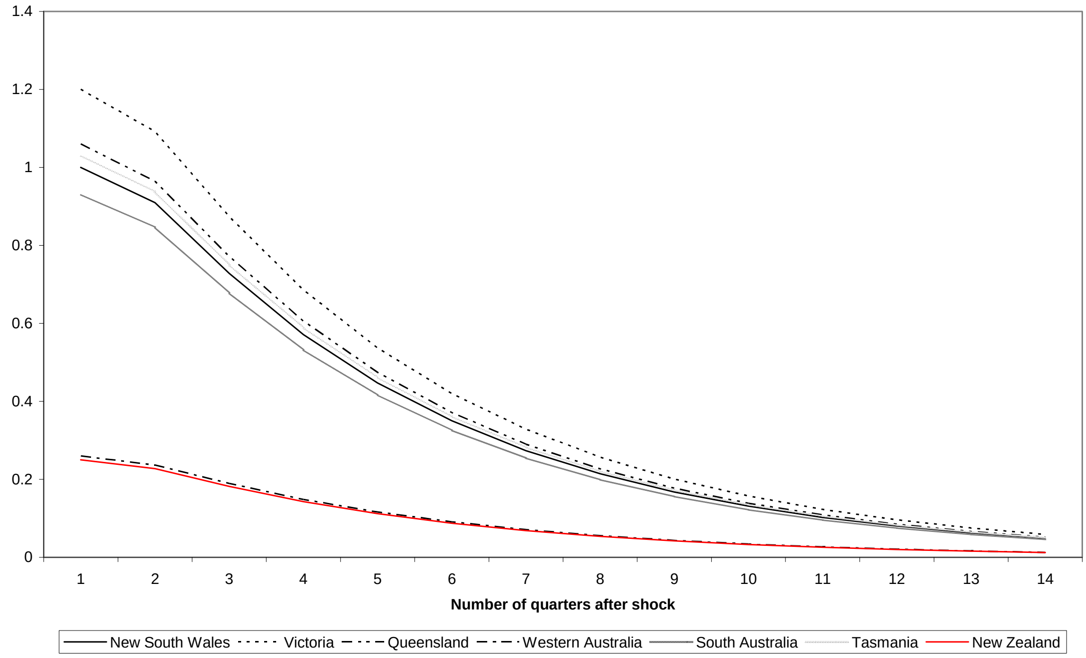
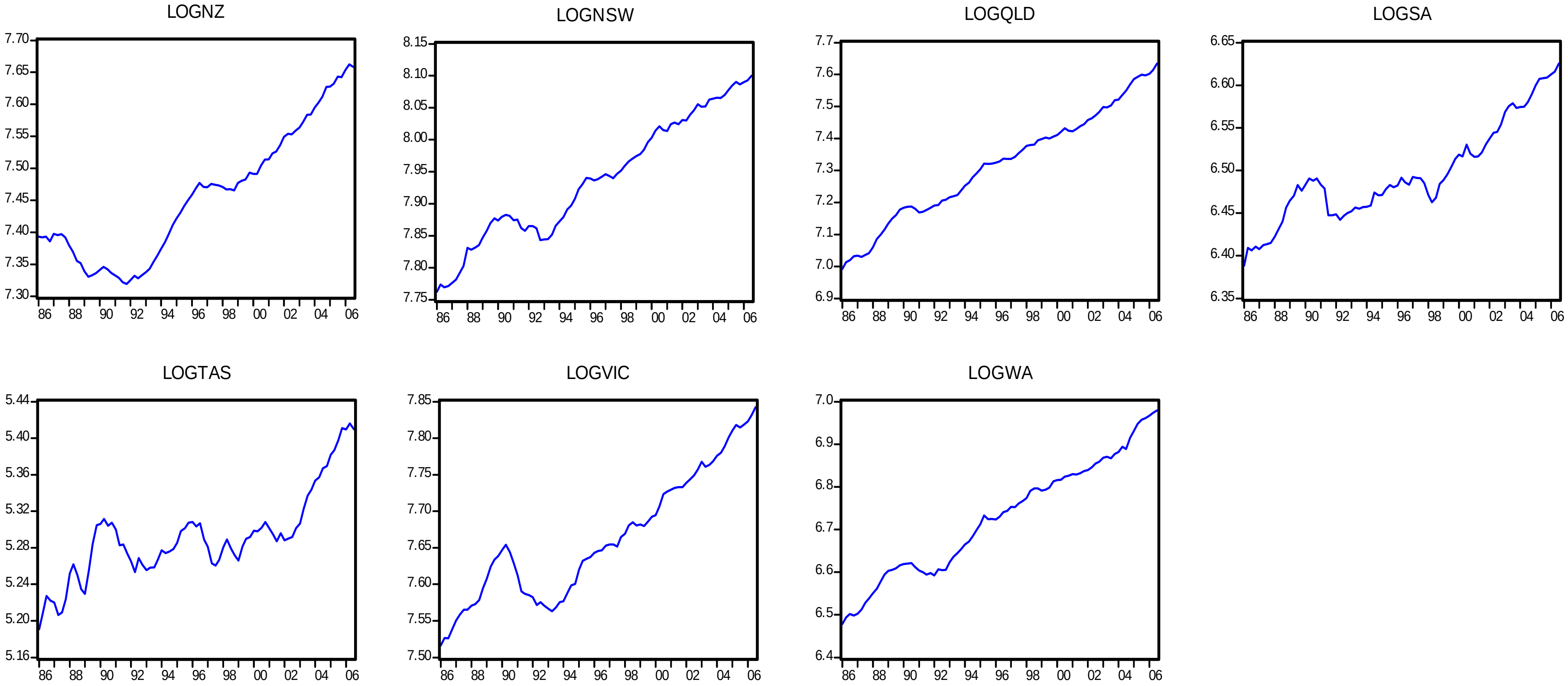


**Figure 3: Australasian Employment Growth, 1986q1 – 2006q3**



## Figure 4:

### Australian 6 States plus New Zealand Total Employment
### Hodrick-Prescott, Band Pass, and Unobserved Components Common Cycles

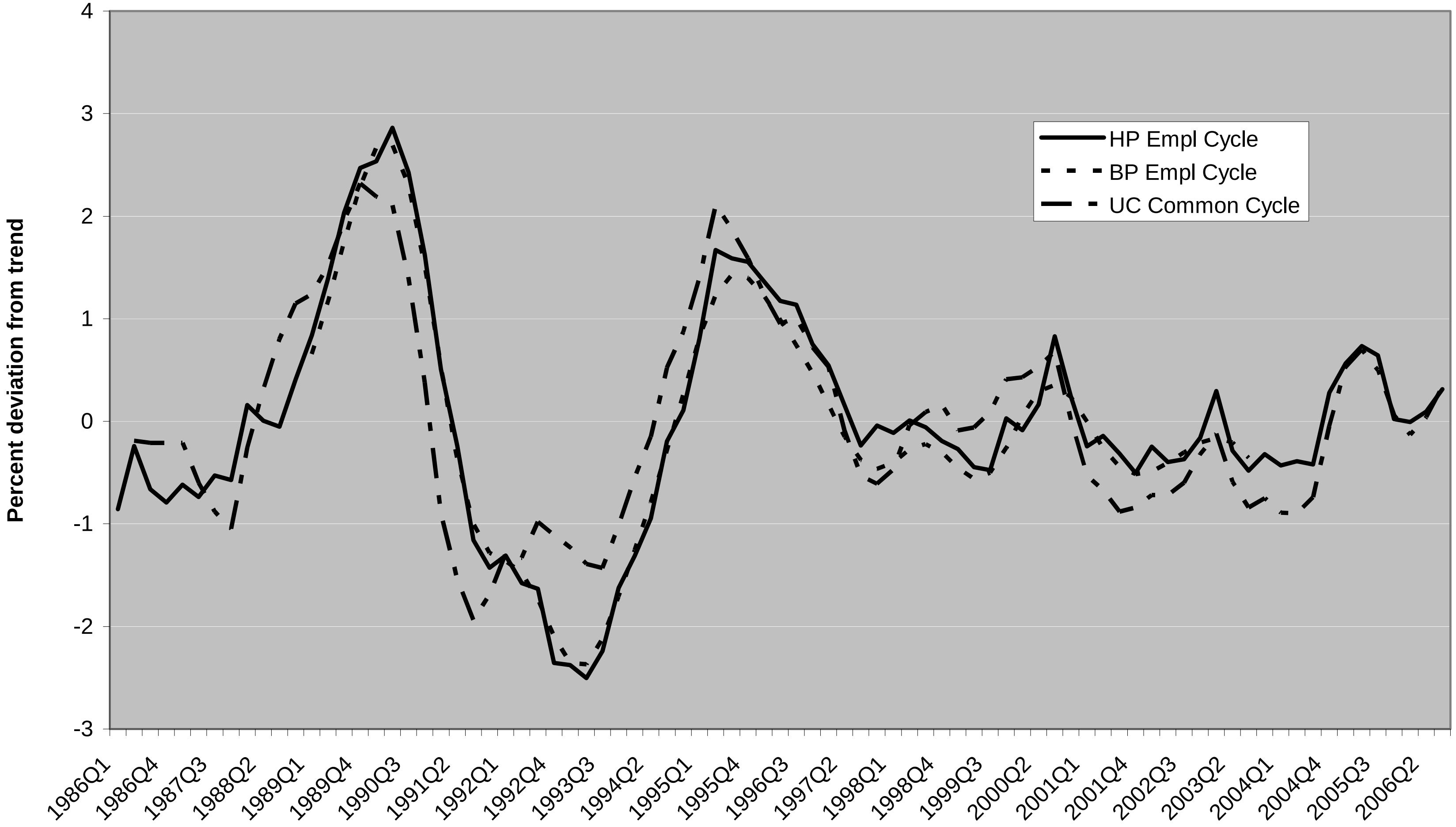


**Figure 5:**

**Australasian Unobserved Components Common Cycles**
**Australian SFD and NZ GDP Output, and Total Employment**

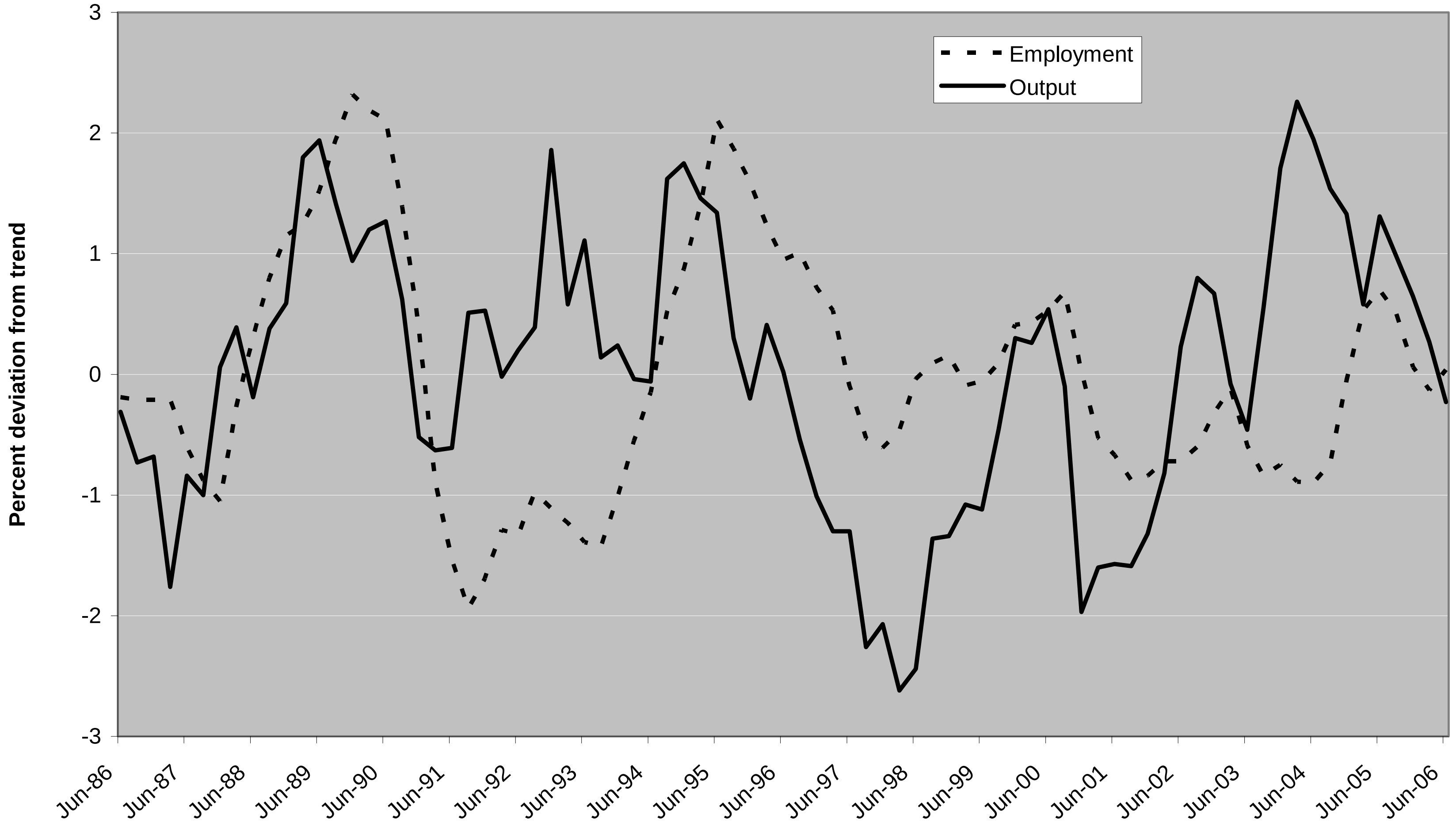
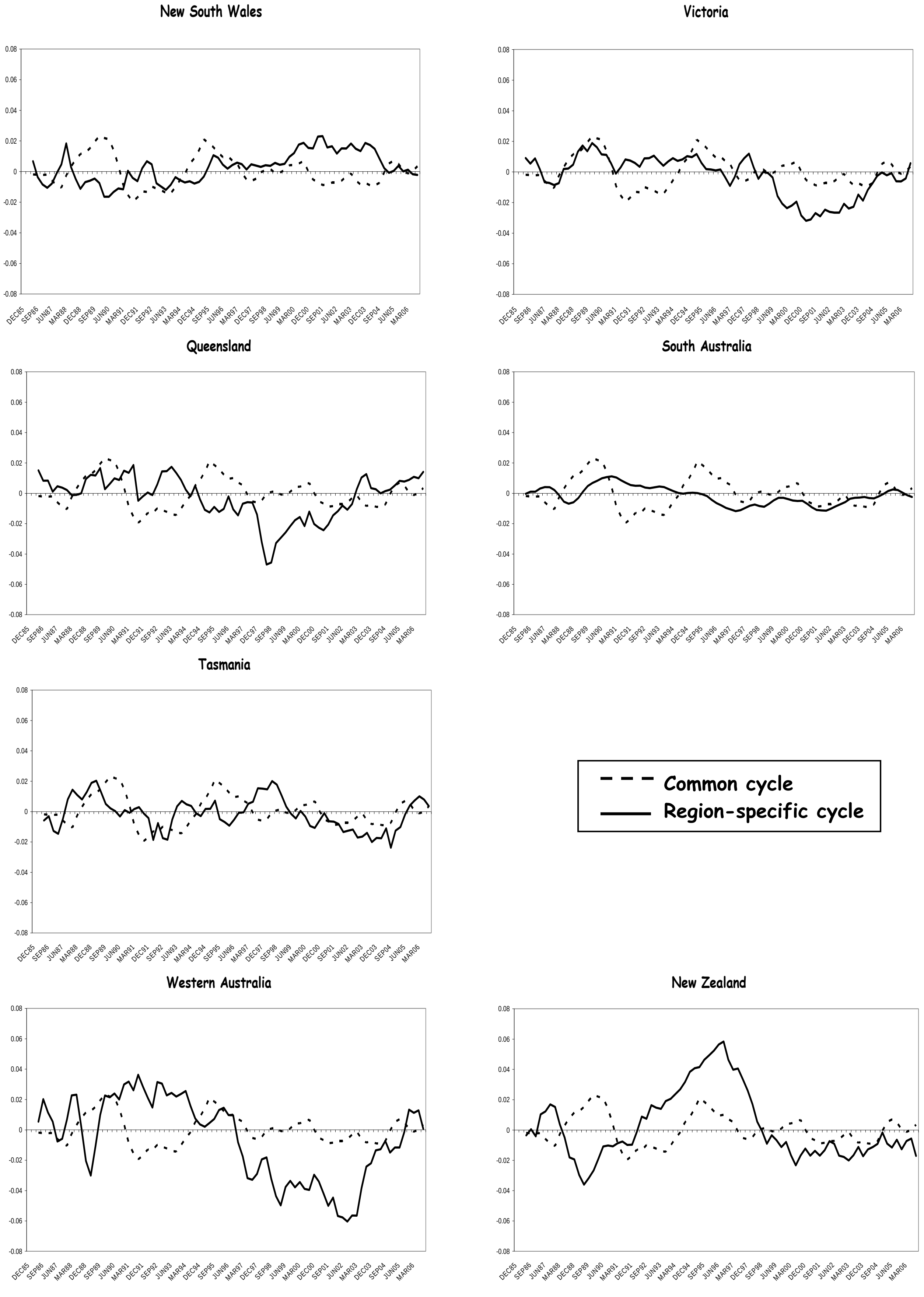


**Figure 6: The Australasian Common and Region-specific Employment Cycles**



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