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UNOBSERVED COMPONENTS BUSINESS CYCLES FOR NEW ZEALAND. WHAT ARE THEY, AND WHAT MIGHT DRIVE THEM? *

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Abstract

We use unobserved components methodology to establish a New Zealand common cycle from economic activity data for 14 regions, and to assess the extent to which the region-specific cycles are additionally important. We then aggregate the 14 regions to 5 regions, and estimate a similar common cycle. At this level of aggregation we can assess the statistical significance and relative strengths of influence on the common cycle of monetary and fiscal policy variables and several external shock variables.

Our results show that structural breaks associated with New Zealand's major economic policy reforms of the mid-1980s through to the early 1990s play an important role, and that New Zealand's region-specific growth cycles have exhibited considerable diversity. The variance contributions of region-specific cycles dominate common-cycle contributions, a result consistent with multivariate findings for Australasia, but contrary to evidence for the U.S. and for Australian States.

We also establish that during key periods, terms of trade and net immigration variables have had distinctive procyclical influences on the common cycle, that real government expenditure has had a modest crowding-out role, and that monetary policy has had no additional significant influence.

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1. Introduction

Bivariate, classical business cycle work for New Zealand has established that regional cycles exist, relative to an aggregate cycle (Hall and McDermott, 2007). Significant bivariate drivers of key regional cycles were also discovered. These include movements in New Zealand's terms of trade and real milk solids prices, and unusually dry climatic conditions, but not net migration movements. But despite the apparent robustness of these bivariate drivers, the work of Baxter and Kouparitsas (2005) suggests that bivariate relationships are not always maintained when multivariate methods are used.

Multivariate methods are more advanced for examining growth cycles than are classical cycle methods, despite the well-known deficiencies associated with trend removal. For example, using unobserved components (UC) methodology, Kouparitsas (2002) finds that the 8 U.S. BEA regions are largely subject to common sources of disturbance, and 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 Norman and Walker's variance analysis 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. In contrast, recent UC work for Australasia by Hall and McDermott (2008) has provided striking findings on the importance of region-specific cycles dominating an Australasian common cycle. This has been especially so for Western Australia and New Zealand. Our finding such a distinctive role for the New Zealand cycle, especially for the years prior to the late 1990s, emphasises that it is important to understand the relative importance of New Zealand's common and region-specific cycles, and which variables might drive them.

In this paper therefore, we use UC methodology on regional economic activity data, to establish benchmark common cycles for New Zealand which are consistent with well-accepted regional growth rate trends. We also assess the extent to which idiosyncratic/region-specific cycles are additionally important, and the relative strengths of influence on the common cycle of monetary and fiscal policy variables, and several external shock variables[1].

The specific questions we address are: (i) is there a credible common cycle for New Zealand, consistent with well-accepted trend regional growth rates?; (ii) if so, what are the corresponding idiosyncratic cycles?; (iii) how sensitive are the idiosyncratic cycles to the common cycle?; (iv) what are the relative contributions of the common and idiosyncratic cycles to each region's total cycle? (v) what role if any do spillover effects from one region to another play?; (vi) what are the relative strengths of influence on the common cycle of monetary policy, fiscal policy, terms of trade, net immigration and world demand variables?; and (vii) are our model-related findings materially different from related New Zealand and Australasian studies (Buckle, Kim and McLellan, 2003; Claus, Gill, Lee and McLellan, 2006; Dungey and Fry (2009); Grimes, 2005, 2006, 2007; Hall and McDermott, 2007; 2008)?

[1] Our analysis does not include explicit roles for industry structure effects, but Grimes (2005, 2006) evaluates the relative roles of industry cycle and structure effects for Australasian regions. Using cycles in employment gap data, 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.

The answers to these and related questions have important implications for the relative strengths of influence of monetary, fiscal and regional policies; as well as for the impacts of and responses to external shocks.

Description of the economic activity data used, and evidence on bivariate comovements are presented in section 2. Section 3 provides the specification of our UC Model. Empirical results and their implications are reported and assessed in section 4. Section 5 concludes.

2. Regional Business Cycle Fluctuations – a bivariate perspective

In Hall and McDermott (2007), it was established that there have been significant contemporaneous associations between the *classical* NZ business cycle and 11 of the corresponding 14 regional cycles. But they also found that over half the bi-regional comovements were not significant, findings which contrast with the much higher proportion of regional cycle comovements for the U.S. (Kouparitsas, 2002), and which perhaps imply that idiosyncratic cycles may have had a relatively more substantial role in New Zealand than for the U.S.

So, to provide a comparable bivariate perspective on fluctuations in New Zealand's regional *growth* cycles, we assess cycles from the band-pass filter method made popular by Baxter and King (1999)[2]. This well-known filter uses spectral analysis theory to remove all but a band of frequencies from a time series associated with the business cycle, typically taken to be between 6 and 32 quarters.

The economic activity data we use for aggregate New Zealand and its 14 regions are compiled by the National Bank of New Zealand (NBNZ) and published as their *Regional Trends* series[3]. The quarterly data sample period used is 1975q1 to 2006q4. Twenty-three series, which include leading and coincident indicators, are used to calculate the composite indices of regional economic activity. These include: business confidence; consumer confidence; retail sales; new motor vehicle registrations; regional exports; registered unemployment; building permits approved; real estate turnover; household labour force data; job ads; and accommodation survey data. All quarterly rates of change are calculated on seasonally adjusted and inflation adjusted data. The composite index for each region is essentially constructed by cumulating the mean rates of quarterly change, and the procedures to combine the components into an index are designed to prevent the more volatile series from dominating the index. The series are standardised to equalise their average absolute changes. Further detail can be found in Edwards (1994).

The national measure of activity is formed by constructing a (fixed) weighted average of the 14 regional activity indices. The weights are based on NBNZ estimates of relative gross regional product as of 1998. These NBNZ weights are consistent with those estimated by the NZIER for the March 2004 year (*NZIER Quarterly Predictions*, March 2005, p 67).

Panel A of Table 1 reports band-pass filter correlation coefficient measures, for contemporaneous regional cycle comovements over the full sample period. The strongest comovements with the New Zealand cycle involve the larger regions of Auckland, Canterbury, Waikato and Bay of Plenty (93 to 88 per cent); while the weakest associations

[2] Similar results are obtained from using the HP filter, so are not additionally reported.
[3] In Hall and McDermott (2007), it was illustrated that there is a close relationship between this aggregate/national economic activity series and official real GDP series.

are for the smaller regions of Gisborne, Nelson-Marlborough, Southland, and Taranaki (64 to 58 per cent). Wellington's contemporaneous cross-correlation is 78 per cent. The bi-regional co-movements shown in the off-diagonal cells of Panel A on the whole suggest relatively weaker associations, with 69 per cent of them being less than 75 per cent. Wellington provides the dominant number of these weaker associations (9 of its 13 being 50 per cent or less), but its associations with Auckland (81 per cent) and Canterbury (60 per cent) are noticeably stronger.

A perspective on bivariate persistence and lead/lag relations can be obtained from the correlation coefficients presented in panels B and C, for one-period and four-period lead/lags respectively. The coefficients on the diagonal in Panel B show strong short-term persistence for all regional cycle fluctuations (all co-movements being between 94 and 88 per cent), but minimal persistence over the four-quarter horizon (all except one being between 6 and 28 per cent).

The coefficient estimates in the off-diagonal elements in Panel C suggest little in the way of material lead/lag relationships.

The overall impression from these bivariate correlations is therefore that the three largest regions, Auckland, Canterbury and Wellington have moved together relatively strongly, and that together with the dominant rural region of Waikato being strongly associated with the New Zealand cycle, would be strong candidates to be core regions of a New Zealand common cycle. A number of the smaller regions, such as Gisborne, Nelson-Marlborough, Southland, and Taranaki seem potentially peripheral in their association with any common cycle.

However, while this bivariate data analysis is suggestive, it should not be used on its own to assess 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.

3. Specification of Unobserved Components Model

To estimate the common business cycle of New Zealand we use an unobserved components model[4]. 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 in each of the regions in New Zealand, as well as a common or national business cycle, we employ a multivariate version of the unobserved components model. The particular model we use is the dynamic multiple indicator multiple causes (DYMIMIC) model. This model was used by Kouparitsas (2001 and 2002) to study regional business cycles in the United States, by Norman and Walker (2007) to study state business cycles in Australia, and by Hall and McDermott (2008) to

[4] Alternative multiple equation approaches were considered, including some form of VAR approach (Grimes (2007), a dynamic factor model (Kose et al., 2003), and a common trends/common cycles approach (Carlino and Sill, 2001; Vahid and Engle, 2003). The modest size of our data set ruled out the use of dynamic factor methodology. A common trends/common cycles approach could be considered in subsequent research, and may well provide additional insights.

assess implications for an Australasian common currency by determining whether there are asymmetric shocks across regions of Australasia.

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 τ_{it} and c_{it} be region-specific trend and cycle components, so that

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

Assume that the trend component τ_{it} can be represented as a process with a unit root and deterministic drift[5]

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

The drift term, δ_{it}, captures the trend growth rate of economic activity in region *i* at time *t*; μ_{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, μ_{it}, are assumed to be orthogonal for all *t*. Note that if $\sigma^2_{\mu i} = 0$ then τ_{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 be typically be estimated in a univariate setting, such as when a Hodrick-Prescott (HP) filter is used.

That said, some additional flexibility is required in the estimation of the trend component to deal with the changing structure of the economy, following the major economic reforms implemented in the mid-1980s and early-1990s. As explained below, we introduce this flexibility by adopting two break points in the trend component at 1986q3/1986q4 and 1991q2/1991q3. The time subscript on the parameter δ is to allow for different growth rates across these sub-periods.

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 γ_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 assumed to be captured by an AR2 model[6]

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

[5] The Augmented Dickey-Fuller test (with a constant and a time trend) indicates that the log-levels of regional economic activity for all regions contain a unit root. The unit root tests are rejected for the first difference of the log-level of economic activity.
[6] This is consistent with Kouparitsas (2002) common cycle specification.

The common cycle, which is unobserved, evolves according to an autoregressive process of order two with autoregressive coefficients ρ_1 and ρ_2, as well as responding to a $k\times1$ vector Z_t of predetermined variables. The innovation to the common cyclical component, ε_{nt}, is assumed to be an independent normal random variable with mean zero and variance σ_n^2.

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 $X_t = [x_{1t}, x_{2t}, ..., x_{mt}]'$, Φ is an m by m matrix of coefficients and $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}, ..., \varepsilon_{mt}]'$ is the vector of innovations to the regional cycles, which is assumed to an independent normal random vector with a zero mean and diagonal covariance matrix Λ. In principle, predetermined drivers could be appended to equation (5) but the limited length of the available times series prohibits us from doing this at present[7]. For example, estimating equation (5) with three additional predetermined variables would use up 42 degrees of freedom.

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 μ_{it} and c_{it} are uncorrelated at all leads and lags. When we convert the model into its state space form we impose the restrictions that all innovations are assumed to be orthogonal. At first glance this assumption may seem overly restrictive. While regional shocks are not allowed to spillover to other regions contemporaneously (that is, the variance-covariance of the regional innovations is assumed to be diagonal), the shocks are allowed to spillover after a lag of one quarter. That is, the extent of any spillovers can be identified by examining the off-diagonal elements of the Φ matrix. An added benefit of thinking about regional spillovers in this way is that it allows us to conduct a likelihood ratio test for the null hypothesis of no spillovers in a very simple way. The final identifying restriction we make is that the vector measuring the sensitivity to the common cycle, γ, is normalized by setting one of its elements to unity. In all cases we set Auckland's sensitivity to unity.

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

$$\Delta Y_t = \begin{bmatrix} \delta_{75q2,86q3} & \delta_{86q4,91q2} & \delta_{91q3,06q4} \end{bmatrix} \begin{bmatrix} D_{75q2,86q3} \\ D_{86q4,91q2} \\ D_{91q3,06q4} \end{bmatrix} + \begin{bmatrix} \gamma & I_{m\times m} \end{bmatrix} \begin{bmatrix} \Delta x_{nt} \\ \Delta X_t \end{bmatrix} + \mu_t \tag{6}$$

and the transition equation is

$$\begin{bmatrix} x_{nt} \\ X_t \end{bmatrix} = \begin{bmatrix} \rho_1 & 0 \\ 0 & \Phi \end{bmatrix} \begin{bmatrix} x_{nt-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \rho_2 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_{nt-2} \\ X_{t-2} \end{bmatrix} + \begin{bmatrix} \beta' & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} Z_t \\ 0 \end{bmatrix} + \begin{bmatrix} \varepsilon_{nt} \\ \varepsilon_t \end{bmatrix} \tag{7}$$

[7] Similarly, the limited length of the available series for predetermined variables prevents us from allowing for an AR2 process in equation (5).

where $Y_t = [y_{1t}, y_{2t}, ..., y_{mt}]'$, $\delta_{t1,t2} = [\delta_{1t1,t2}, \delta_{2t1.t2}, ..., \delta_{mt1,t2}]'$, $D_{t1,t2}$ is one for $t1 \leq t \leq t2$ and zero for all other *t*, since we have two break points in this application we consider three sets of *t1* and *t2* (specifically 1975q2 to 1986q3, 1986q4 to 1991q2, and 1991q3 to 2006q4) $\gamma = [\gamma_1, \gamma_2, ..., \gamma_m]'$, $\mu_t = [\mu_{1t}, \mu_{2t}, ..., \mu_{mt}]'$, and I_{mxm} is a *m* by *m* 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. In particular, we use the recursive Expectation Maximization (EM) algorithm for our estimation, details of which are presented in Watson and Engle (1983).[8]

4. Empirical Results

Two key factors condition the empirical results which follow: the necessity to allow for structural breaks in the trend regional growth rates; and the predetermined variables which can potentially affect the common cycle.

In work establishing a common Australasian cycle (Hall and McDermott, 2008), and in Kouparitsas (2002), it was found important to ensure both that the trend rates of growth were consistent with well-accepted regional growth rates, and that the resulting common cycle was stationary. The break points stated in section 3 above as at 1986q3/1986q4 and 1991q2/1991q3 are consistent with the mode breaks from univariate Andrews-Ploberger tests[9]. These breaks are also consistent with New Zealand's period of major economic reforms from the mid-1980s through to the early 1990s, and its subsequent lengthy business cycle expansion phase.

Consistent with the bivariate findings in Hall and McDermott (2007), with the potential shocks summarised in Hall and McDermott (2009, pp 1059-1060), and with the structural VAR results reported in Buckle, Kim and McLellan (2003), in Claus, Gill, Lee and McLellan (2006), and in Dungey and Fry (2009), we assembled data to enable testing the relative strengths of influence on the common cycle of monetary and fiscal policy variables, and of three external shock variables reflecting movements in New Zealand's terms of trade, net immigration, and "world" economic activity. The monetary policy variable is included to capture the idea that if the economy is overheating, that is the common cycle is strongly positive, the monetary authorities will intervene to moderate the cycle to stop any inflation pressures from building up. Empirically, our various macroeconomic fiscal policy variables might be pro-cyclical, a-cyclical or counter-cyclical in nature[10]. The terms of trade variable is

[8] For the results which follow, we set the convergence criterion on the log likelihood function at a relatively severe level of 1×10^{-5}. The EM algorithm then took 6,598 iterations to converge when we estimated our 14-region model with three exogenous variables, and 2,019 iterations to converge when we estimated the model for the 5 aggregated regions with three exogenous variables. Extensive investigation of alternative starting values for the region-specific variances confirmed that our results are robust to alternative starting values.

[9] See Andrews (1993), Andrews and Ploberger (1994). If no break is assumed then the estimated common cycle from the model is not stationary. The imposition of one or more breaks is therefore material to the results. We experimented with the possibility of imposing just one break, and with different break dates in the neighbourhood of our imposed two breaks, and found either that the estimated common cycle was not stationary or the resulting second sub-sample period had too few observations to be meaningful.

[10] Work reflecting the influence of fiscal policy variables uses the government spending, tax revenue and transfer payment variables successfully examined in Claus et al. (2006), and in Dungey and Fry (2009). We are

included to capture the influence of international prices on overall New Zealand economic activity. The net immigration variable is included to capture the idea that a large net inflow of people will put pressure on resources, especially housing, and thus accelerate domestic demand in excess of the supply capacity of the domestic economy. A "world" economic activity variable influence is consistent with the work of Selover and Round (2005, p 239), who established from VAR analysis that Australian GDP was not significant in explaining NZ GDP, and that both Japan and the U.S. had statistically significant effects on Australian GDP and on NZ GDP.

The empirical results reported in section 4.1 are obtained from both 14-region and 5-region data sets, compiled from the maximum number of observations available for our economic activity variables, i.e. from 1975q1 to 2006q4. Using a sample period of this length has, however, conditioned both the number of predetermined variables able to be tested, and the form of our monetary policy variable. The empirical work testing for the influence of fiscal and world demand variables has had to be based on the smaller sample period from 1983q1, and those results are presented in section 4.2.

4.1 Common and idiosyncratic cycles, 1975q1 to 2006q4

4.1.1 Fourteen-region analysis

The 14 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.

The trend regional growth rates

Table 2 contains estimates of the (annualized) trend growth rates, δ_{it}. It provides evidence that for the relatively short second period associated with New Zealand's major economic reforms, almost all the trend economic growth rates are materially lower than those for both the preceding and following periods. Canterbury is the key exception, with successive trend growth rates of 2.9, 2.9 and 3.4 per cent. It is also evident that for seven of the 14 regions, trend growth was higher post-reforms than pre-reforms, the seven being Waikato, Wellington, and all the South Island regions. This confirms that it is important to control for structural breaks 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?

Figure 1 shows the common cycle and region-specific cycles, expressed as percentage point deviations from each region's trend growth rate. The common cycle reproduced in Figure 2 is 72 per cent correlated with a benchmark HP growth cycle for New Zealand aggregate economic activity[11].

Examination of the time paths and amplitudes of the idiosyncratic cycles in Figure 1 shows there is considerable diversity of cycles across regions. Taranaki has the strongest region-

grateful to Bob Buckle and Nathan McLellan for providing us with these New Zealand Treasury series updated to 2006q4.

[11] This result is consistent with the findings of Gerlach and Yiu (2004) for eight small open Asian economies, that the UC, HP and BK output gap measures were similar. They also emphasised that advantages from using the UC approach were to allow simultaneous estimation of trend growth rates and construction of confidence bands for the output gap paths.

specific cycle, suggesting that its cyclical behaviour is not well explained by fluctuations in the common cycle, and only the Waikato, Hawkes Bay and Canterbury region-specific cycles seem to show reasonable overall consistency with the common cycle.

The regional sensitivities of the response of activity in region *i* to the common cycle are reported in Table 2. The sensitivity is normalized to unity for Auckland. The point estimates show that Northland and Manawatu-Wanganui (and Canterbury and Otago) are somewhat more sensitive, and that five of the 14 regions display approximately the same sensitivity as Auckland. However, Gisborne, West Coast, Nelson-Marlborough and Taranaki are considerably less sensitive to the common cycle than are the other New Zealand regions.

The autoregressive parameters from equation (4), which describe the response of the common cycle to a common cyclical shock, have point estimates of 1.07 for ρ_1 and -0.282 for ρ_2. Using a likelihood ratio test, the AR2 specification for the dynamics of the common cycle cannot be rejected in favour of an AR1 specification. These estimated parameters inform us that the half-life of shocks to the common cycle is nearly 3 quarters. The shape of each region's response is forced to be identical and is one of steady decay. The amplitude of each region's response to a common shock depends additionally, however, on the sensitivity of the parameter values reported in Table 2. Hence the response of the Gisborne region to the common cyclical shock is considerably more muted than those for 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 the cyclical components, reported in Table 3. The key result is that for every region except Waikato and Canterbury, the variance of the idiosyncratic cycle component dominates that of the common cycle. Within this overall result, the region-specific cycle variance for Taranaki is particularly dominant, and for Gisborne, Southland, Manawatu-Wanganui, Auckland, Wellington, West Coast and Nelson-Marlborough, their region-specific variance contributions are also very strong relative to that from the common cycle.

Results in this area therefore complement the visual impressions gained from Figure 1 and reinforce the importance of region-specific cycle influences relative to those of the common cycle.

Key findings and limitations of the 14-region analysis

We have established from the 14-region data set a credible UC common cycle and considerably diverse region-specific cycles. Contributions from the variances of the latter cycles dominate those from the common cycle. However, these potentially valuable results come from point estimates, and the fact that we have too many parameters to be estimated relative to the number of observations has meant that to this point, we had not been able to assess the robustness of our parameter estimates nor of regional spillover effects[12].

[12] 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.

To achieve the latter aims, we investigated the possibility of using a suitably aggregated data set, with the assistance of two statistical methods[13]. From log-eigenvalue plots, it was established that much of the variance is explained by the first principal component (interpreted to be the common cycle), and from the cumulated percentage of variance explained it could be deduced that the common cycle plus five regions would capture over 80 percent of the variation.

Accordingly, we aggregated economic activity in the 14 regions to five economically and geographically sensible regions, using weights based on NBNZ estimates of relative gross regional product of 1998[14]. The five regions, with percentage weights in parentheses, are: Auckland (31.0), Wellington (13.2), Rest of the North Island (RNI) (31.9), Canterbury (12.3) and the Rest of the South Island (RSI) (11.6). The RNI and RSI groupings, which incorporate key rural-based regions, should enable any potential terms of trade and commodity price influences to be tested for.

4.1.2 Five-region common and idiosyncratic cycles, and their potential drivers

The five-region common cycle, 1975q1 to 2006q4

As illustrated in Figure 2, the five-region common cycle is 89 per cent correlated with the corresponding 14-region cycle and 78 per cent correlated with an HP 1600 growth cycle.

Monetary policy, terms of trade, and net migration influences on the 5-region common cycle?

Coefficient values and standard errors for the monetary policy, terms of trade, and net immigration variables are reported in Table 4. Monetary policy is reflected through the RBNZ's real first mortgage housing rate, historical series, in de-meaned form; movements in the terms of trade variable are represented by a Hodrick-Prescott filtered series of the natural log of SNZ's Terms of Trade Index (Merchandise), base June 2006 = 1000; and net immigration movements, also in de-meaned form, come from SNZ's seasonally adjusted Net Permanent and Long Term Arrivals series. The coefficients on all three variables are of correct sign, but are not statistically significant at the 5 per cent level. However, net immigration is significant at the 10 per cent level. The likelihood ratios for the null hypotheses that the three drivers jointly and net immigration singly are zero, are consistent with rejecting the null hypothesis at 5 per cent and 1 per cent levels respectively. The joint and single significance of these three variables therefore provide initial insights into candidate macroeconomic drivers of the common cycle for this sample period of over three decades. Net migration is potentially the most important of the three factors.

What role if any do spillover effects from one region to another play?

The estimated VAR coefficients, Φ, for equation (5) are reported in the top panel of Table 5. Estimates along the diagonal show that autoregressive behaviour varies across region-specific cycles: relatively strong autoregression for Canterbury, Auckland and the RNI, and relatively weak persistence for Wellington. The off-diagonal estimates suggest limited spillover of

[13] See Martinez and Martinez (2008)
[14] These weights are consistent with those estimated by the NZIER for the March 2004 year (NZIER 2005, Table A27, p 67). The reformulated 5 regions correspond with those for which Statistics New Zealand publishes regional CPI series (see *CPI Review – outcome of review* at http://www.stats.govt.nz/developments/price-index-developments/review-cpi-regions.htm).

region-specific shocks into other regions, with the possibility of spillovers to Wellington from Canterbury and RSI (from coefficients of 0.35 and -0.47), and from Wellington to RNI (-0.22). To formally test the hypothesis of no spillovers we again use a likelihood ratio test, the LR value of which is 103.2. The 5 per cent critical value taken from the asymptotic Chi-squared distribution with 20 degrees of freedom is 31.4. The likelihood ratio test of the null of no spillover effects is clearly rejected[15], a rejection which seems due essentially to three of the spillovers involving Wellington.

4.2 Testing additionally for world economic activity and fiscal variable influences, 1983q1 to 2006q4

Testing additionally for world economic activity and fiscal influences on the common cycle required us to restrict the number of time series observations to the period 1983q1 to 2006q4, and to continue to work at the 5-region level of aggregation. A likelihood ratio test for this shorter sample period led to an AR2 specification for the dynamics of the common cycle being rejected in favour of an AR1 specification with $\rho_1 = 0.69$.

The trend regional growth rates

The key results are preserved for the shorter period, despite the trend growth rates for the first sub-period having to be computed from only 16 observations (Top panel of Table 6). In particular, all second sub-period growth rates are lower than those in the other two periods. The Wellington, RNI and RSI regions have trend annualised growth rates, of 0.82, 1.03, and 0.36 per cent respectively, which are credibly low and not statistically significant at the 10 per cent level. This is consistent with two break points still having to be imposed.

The common and region-specific cycles, the degree of sensitivity of regional cycles to the common cycle, and the relative contributions of the common and idiosyncratic cycles to each region's total cycle

The common cycle and region-specific cycles, expressed as deviations from each region's trend growth rate, are displayed in Figure 3. The five-region common cycle is very highly correlated (97 per cent) with the five-region growth cycle observations computed from the longer sample.

Examination of the time paths and amplitudes of the idiosyncratic cycles in Figure 3 confirms there is considerable distinctiveness in the regional cycles relative to the common cycle, and noticeable diversity of cycles across regions. The Auckland and Canterbury region-specific cycles have moved quite similarly, though with some timing and amplitude differences in the late 1980s/early 1990s and during 2005-06. Wellington's movements were similar to those of Auckland and Canterbury up until the 1990s, but displayed somewhat different patterns during the 1990s and the current decade. From the 1990s onwards, the RNI region-specific cycle has significant periods in common with Canterbury, whilst the RSI idiosyncratic cycle has periods which are distinctively different from those of the other four regions.

The regional sensitivities of the response of activity in region *i* to the common cycle, reported in Table 6 (second panel), are all statistically significant. With Auckland's sensitivity

[15] The same result is obtained from the 14-region data set. The LR value is 505.2, and as the 5 percent critical value taken from the asymptotic Chi-squared distribution with 182 degrees of freedom is 214.5, the null of no spillover effects is clearly rejected.

coefficient again normalized to unity, the Canterbury region now displays approximately the same sensitivity as Auckland. The Wellington and RSI regions are somewhat less sensitive, and the RNI more so..

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

When 14 regions are aggregated to five-regions, it is not surprising that the magnitudes of the overall cycle variances and idiosyncratic variances are smaller (Table 6, third panel). The overall cycle variances now lie between 6.8 and 2.9 per cent, and the idiosyncratic variances between 4.6 and 2.2 per cent. Nevertheless, the key result from the longer-period 14-region work is preserved, i.e. for each of the five regions, the variance of the idiosyncratic cycle component dominates that of the common cycle. This is especially so for Wellington and Auckland (contributing 102 and 78 per cent of the overall cycle variance), is markedly so for Canterbury and RNI (63 and 61 per cent), and is material for RSI (57 per cent)

Potential predetermined variable influences on the common cycle

Testing additionally for world economic activity and fiscal influences required us to restrict the number of our time series observations for our regional activity variables to the period 1983q1 to 2006q4, and to continue to work at the 5-region level of aggregation. Our world variable reflects movements in the real GDP of New Zealand's 12 major trading partners, i.e. the GDP-12 measure described in Smith (2004). The fiscal variables reflect movements in real government (consumption plus investment) expenditure, real taxation revenues and real transfer payments[16].

As is conventional, we first examined bivariate cross correlations between each of the nine potential common-cycle driver variables and New Zealand's common cycle. The results presented in Table 7 for the 1983q2 to 2006q4 period show that the following additional variables could have been candidates to influence the common cycle: monetary policy (negative nine quarter lead), terms of trade (two quarter lead), net immigration (one quarter lead and two quarter lag), world demand (contemporaneous), government expenditure (negative five quarter lead and five quarter lag), taxation (one quarter lag), transfers (negative contemporaneous), and negative net government expenditure (one quarter lead and lag)[17].

However, while these bivariate results seem relatively robust, it is important to recognise again the key finding of Baxter and Kouparitsas (2005) that bivariate growth cycle relationships are not always maintained when multivariate methods are used. We therefore proceeded to assess, within our more demanding unobserved components framework, which of our predetermined variables could continue to provide explanatory power over and above that coming from the previous quarter's common cycle movements (i.e via ρ_1).

[16] The fiscal variable results we report are for seasonally adjusted, Hodrick-Prescott filtered series, as utilised in Claus *et al* (2006). Results are not reported for real net taxation (i.e. taxation less transfers), and real net government expenditure (i.e. expenditure less net taxation) as a percentage of GDP; nor for the 4 quarter moving average linearly detrended variables used by Dungey and Fry (2009). From likelihood ratio tests, the former failed to provide additionally significant results. The latter provided similar, but less significant outcomes than those we report in Table 8 for our government expenditure, taxation and transfer variables.

[17] These variables are significant for intervals of two standard errors. Results for this sample period are not dissimilar to those obtained for the monetary policy, terms of trade and net immigration variables over the longer 1975q2 to 2006q4 sample.

Within a "general to specific" framework, we tested equations in which our remaining predetermined variables can be seen as a reduced form representation of a modern open economy New Keynesian IS equation[18].

From the LR test results presented in Table 8[19], the collective additional influence from six[20] predetermined variables is not significant at the 10 per cent level, relative to the null of no driver, and only the real government expenditure, terms of trade and net immigration variables seem to have the potential to be significant as individual influences. Successive testing of equations which include four through to one influence then showed that three of the six variables (monetary policy, taxation and transfers) provide no significant explanation, over and above that provided by the three-driver combination of terms of trade, net immigration, and government expenditure. Moreover, it can be concluded from the LR test on the three-driver equation relative to two drivers, and from the LR test on the three drivers against the null, that net migration provides explanatory power additional to that from the terms of trade and government expenditure variables.

The three-driver specification is therefore preferred. The relatively modest additional explanation provided by the three exogenous drivers, and the minimal further explanation from incorporating six drivers can be seen from Figure 4.

It is not surprising that the terms of trade and net immigration variables contribute additionally to explaining New Zealand's common cycle during this sample period. For example, their influence further amplified the above-trend common growth cycle activity during the mid-1990s and 2002-05 periods, and the below-trend growth cycle movements during the mid- to late-1980s major reforms period and the shorter 1997-98 Asian financial crisis/two-successive-droughts period[21].

It is also not surprising that monetary policy has had no additionally significant effect on the common cycle, and that this effect has been dominated by an additional cycle effect from fiscal policy.

Perhaps initially surprising and controversial, though, is that the government expenditure variable has a negative sign. This is consistent with increased government expenditure having crowded out other real economic activity during above-average cyclical growth periods and

[18] For example, private consumption and investment could be influenced by movements in our monetary policy interest rate variable, and by net immigration, taxation and transfers variables affecting household disposable income and business sector expected sales. Demand side government expenditure influence obviously comes through that expenditure variable, and net exports can be materially influenced by our terms of trade variable. These interpretations are essentially from a demand side perspective, but it is also possible that the net immigration, terms of trade, and taxation variables could reflect certain supply side influences. These, and other region-specific supply side influences (such as dairy milk solids prices and unusually dry climatic conditions) might, of course, be reflected either within or additional to the region-specific cycles derived from our full unobserved components model.

[19] To economise on our relatively small number of time series observations, we specified and tested all variables in the vector Z_t in one-period lag form. None of the longer lagged or leading variables, significant in bivariate cross correlations, was statistically significant when tested individually in our unobserved components equations.

[20] The world economic activity influence was not able to be tested in predetermined variable form, as data observations are available only from 1983q1. It was not significant as a (probably weakly exogenous) contemporaneous variable, and its influence in this research is perhaps dominated by the terms of trade variable.

[21] Net immigration possibly had a stronger influence than the terms of trade over the longer 1975 to 2006 period, but the relative influence of the two seems to have been reversed for the 1983 to 2006 period (Tables 4 and 8).

with a decreased rate of increase of government expenditure having enhanced cyclical growth during periods of below-trend growth. The result is also consistent with Alesina *et al*. (2002), who found sizeable robustly negative effects of public spending on business investment, for a 35-year panel of data for 18 OECD countries. Alesina *et al.*'s supporting argument is that it is primarily business investment, and hence real GDP, which is crowded out from the supply side by increased public spending (especially so from public sector wage bill increases), leading to higher labor costs, reduced profits and lower investment. They further argue (section I.B) that this so-called "labor-market channel" is consistent with a wide range of competitive and non-competitive theoretical macro models. Our finding a negative coefficient is also consistent with the dynamics of the results presented in Hall and Rae (1998), and in Dungey and Fry (2008), in which a real government expenditure shock can lead to positive effects on cyclical real GDP in the short run but which are then more than outweighed by the negative effects which cumulate over the medium term.

The extent of regional spillover effects

The estimated VAR coefficients, Φ, for equation (5) estimated over the period 1983q1 to 2006q4, are reported in the bottom panel of Table 5. As was the case for the longer sample period, the autoregressive behaviour varies across region-specific cycles: quite pronounced autoregression for the Auckland and RNI, moderate persistence for Canterbury and the RSI, and very much weaker persistence for Wellington. The off-diagonal estimates suggest there remains the possibility of negative spillovers. Testing for this formally, the null hypothesis of no spillovers has to be rejected, essentially due to the possibility of the two negative spillover effects involving Wellington[22].

4.3 Results, relative to previous New Zealand and Australasian studies

Key findings from the *bivariate comovements* reported in section 2 for our BK growth cycles, are consistent with those from the classical cycle analysis presented in Hall and McDermott (2007). In particular: the regions most highly synchronised with the New Zealand cycle are Auckland and Canterbury, and those least synchronised include Gisborne, Taranaki and Southland; bi-regional synchronisations are essentially contemporaneous; and while there is strong short-term persistence for all regional cycle fluctuations, there is minimal persistence over a four-quarter horizon.

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. Here, we provide evidence in a New Zealand context that UC estimation can be used to derive credible common growth cycles. We report 14-region and five-region common cycles, which are very similar to each other and closely match movements in a benchmark Hodrick-Prescott growth cycle.

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

[22] The LR value of 83.0 is greater than the 5 per cent critical value for 20 degrees of freedom of 31.4.

States that the major source of fluctuations in states' economic activity is shocks which are common to all states. But Norman and Walker's (2007, p 371) variance analysis 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.

In major contrast, the Hall and McDermott (2008) results for Australasia show a substantially more distinctive role for *region-specific cycles*, especially for Western Australia and New Zealand. Results from their variance contributions analysis differ markedly from those of Kouparitsas, and Norman and Walker, as for the five major Australian states and for New Zealand, the *region-specific variance contributions* dominate those from the common cycle. This is especially the case for Western Australia and New Zealand. The results presented in sections 4.1 and 4.2 above are in the same vein. For both the 14-region and five-region groupings, and despite our additionally allowing for three potentially important exogenous variable influences on the respective common cycles, every region-specific cycle variance contributes more to its overall cycle variance than does the common cycle variance.

With respect to previous findings on *additional drivers of the common cycle*, Kouparitsas (2001) placed considerable emphasis on whether the relative price of oil and the U.S. federal funds rate might have been significant. He concluded (2001, pp 2-3, 19-20, Table 5) that the largest share of regional fluctuations is due to common shocks rather than region-specific shocks; that the common income component explains on average 70 per cent of the variation attributable to all three common shocks; and that there is considerable variation across regions associated with oil shocks but quite uniform variation for monetary policy shocks.

From Buckle, Kim and McLellan's (2003, p 14) 13-variable SVAR model of the New Zealand business cycle, international shocks, domestic climate shocks and non-financial domestic shocks were shown to have been pro-cyclically important, while domestic (90-day interest rate) financial shocks were generally moderately counter-cyclical. Specific fiscal variables were not included in that SVAR, but work reported in Claus, Gill, Lee and McLellan (2006) focussed on potential fiscal policy impulses. They established that government spending increases have led to GDP increases in the short term, and that net tax increases have led to GDP reductions. It was also the case that when net tax shocks are decomposed, tax revenue increases lead to (small) reductions in GDP, and increases in government transfers result in short-term increases in GDP but subsequent declines.

More recent SVAR work, combining the identification methods using sign restrictions, cointegration, and traditional exclusion restrictions has been reported in Dungey and Fry (2009). Prominent in their findings, from impulse response and historical decomposition analysis, have been that: the terms of trade influence on New Zealand's growth cycles have been more dominant than either fiscal or monetary policy variables; the effects of fiscal policy shocks have been greater and more variable than those from monetary policy; and the effects from taxation movements have had considerably greater amplitude than the generally negative effects from government expenditure (during the late 1980s, the mid-1990s and the 2000s to date).

The issue of whether New Zealand cycles have been driven by or associated with Australian regional cycles, Grimes (2005, p 395, Tables 3, 5) found no strong evidence of the New Zealand cycle having been "caused" by the cycles in other Australasian regions or industries[23]. This finding is consistent with that in Hall and McDermott (2008). Their analysis could find no material evidence of New Zealand's economic activity cycle having responded to the region-specific shocks of the five largest Australian states, nor of those states responding to a New Zealand-specific shock. The two studies are therefore consistent in suggesting that an Australian cycle need not be a strong candidate to be an exogenous driver for New Zealand cycles.

The issue of *spillovers* of region-specific shocks to other regions is also potentially important. Kouparitsas (2001, p 30) concluded that spillovers do not contribute a statistically significant share of regional-cycle variation, and Norman and Walker (2007, pp 360, 373) conclude similarly that spillovers from one Australian 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, was assessed in Hall and McDermott (2008, section 4.1), there also seemed minimal evidence of material spillover effects.

In summary, for New Zealand, and as for Hall and McDermott's (2008) Australasian analysis, region-specific cycles have had a considerably more important role, than has been the case for the Australia's five largest States and the eight BEA regions of the U.S. The specific roles in this of New Zealand's four biggest regions (i.e. Auckland, RNI, Canterbury, and Wellington), and each of which has a particularly dominant idiosyncratic cycle, is particularly interesting and is the subject of ongoing investigation.

5. Conclusion

We have established from regional economic activity data, three closely related *common cycles* for New Zealand, consistent with well-accepted regional growth rate trends. These common cycles have been derived from data for 14 regions, and from data aggregated over two different sample periods for five regions. The common cycles closely match movements in corresponding benchmark Hodrick-Prescott growth cycles. They are conditional on allowing for two breaks in trend growth rates, consistent with New Zealand's major economic policy reforms of the mid-1980s through to the early 1990s.

The corresponding *region-specific cycles exhibit considerable diversity*, relative to the common cycle. When 14 regions are considered, the idiosyncratic cycle of Taranaki is particularly distinctive, and those of Southland, Manawatu-Wanganui, Gisborne, Wellington, Northland, Auckland, and Otago are notable. This diversity result is sustained for the five-region analyses.

Variance analysis of the common and idiosyncratic cycle components establishes that for both the 14-region and five-region data sets, region-specific cycle variance contributions dominate those of the common cycle. This finding of *dominance of the idiosyncratic cycle contribution* is consistent with the findings for Australasia in Hall and McDermott (2008), but in direct contrast to those of Kouparitsas (2002) for U.S. BEA regions, and Norman and Walker (2007) for the six Australian states.

[23] This was despite the fact that since 1991, the New Zealand employment cycle has generally been closely correlated with the Australasian and larger Australian regional employment cycles.

Our key findings in relation to potential *additional drivers* relate primarily to the period from 1983q1. It is not surprising that terms of trade and net immigration influences are additionally important during key periods, and that a monetary policy influence has not only been dominated by the influence from a key fiscal expenditure variable but also has had no significant additional influence on New Zealand's common growth cycle. The real government expenditure variable has had the effect of acting in a modestly countercyclical fashion by crowding out other economic activity during key periods.

Table 1

Regional business cycle comovement and persistence, 1975q1 – 2006q4

A. Contemporaneous correlation

Economic activity at time t

Activity at time t	Nthld	Auck	Waik	BOP	Gisb	HB	Tar	M-W	Well	NM	WC	Cant	Otago	Sthld
New Zealand	0.77	0.94	0.88	0.88	0.62	0.80	0.58	0.84	0.78	0.64	0.75	0.91	0.70	0.63
Northland	1.00													
Auckland	0.59	1.00												
Waikato	0.88	0.75	1.00											
Bay of Plenty	0.75	0.80	0.82	1.00										
Gisborne	0.71	0.49	0.58	0.68	1.00									
Hawkes Bay	0.81	0.61	0.79	0.78	0.76	1.00								
Taranaki	0.68	0.39	0.68	0.43	0.46	0.61	1.00							
Manawatu-Wanganui	0.77	0.68	0.78	0.78	0.66	0.85	0.64	1.00						
Wellington	0.50	0.81	0.58	0.65	0.30	0.48	0.21	0.48	1.00					
Nelson-Marlb.	0.45	0.48	0.49	0.55	0.57	0.76	0.54	0.73	0.28	1.00				
West Coast	0.83	0.58	0.74	0.69	0.69	0.84	0.61	0.87	0.39	0.58	1.00			
Canterbury	0.69	0.79	0.81	0.78	0.56	0.79	0.66	0.84	0.60	0.80	0.73	1.00		
Otago	0.58	0.53	0.60	0.62	0.68	0.82	0.57	0.77	0.30	0.86	0.75	0.78	1.00	
Southland	0.51	0.54	0.63	0.52	0.50	0.58	0.49	0.67	0.21	0.50	0.63	0.63	0.67	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)

Table 1 (continued)

Regional business cycle comovement and persistence, 1975q1 – 2006q4

B. Lead/lag correlation for t + 1

Economic activity at time t + 1

Activity at time t	Nthld	Auck	Waik	BOP	Gisb	HB	Tar	M-W	Well	NM	WC	Cant	Otago	Sthld	NZ
New Zealand	0.72	0.89	0.81	0.79	0.55	0.67	0.49	0.70	0.73	0.48	0.70	0.77	0.57	0.47	0.90
Northland	0.93	0.55	0.82	0.65	0.63	0.72	0.61	0.63	0.47	0.34	0.74	0.56	0.47	0.36	0.69
Auckland	0.53	0.92	0.67	0.70	0.41	0.47	0.30	0.52	0.75	0.32	0.51	0.66	0.39	0.39	0.84
Waikato	0.80	0.67	0.90	0.73	0.49	0.66	0.59	0.64	0.51	0.36	0.68	0.66	0.46	0.43	0.76
Bay of Plenty	0.73	0.75	0.75	0.89	0.59	0.69	0.31	0.67	0.66	0.40	0.67	0.65	0.48	0.36	0.80
Gisborne	0.72	0.53	0.59	0.67	0.93	0.73	0.39	0.63	0.36	0.45	0.71	0.48	0.60	0.41	0.62
Hawkes Bay	0.78	0.63	0.76	0.71	0.69	0.90	0.57	0.77	0.50	0.62	0.82	0.70	0.74	0.47	0.77
Taranaki	0.69	0.39	0.66	0.46	0.48	0.57	0.94	0.60	0.20	0.53	0.61	0.62	0.56	0.38	0.57
Manawatu-Wanganui	0.78	0.68	0.76	0.72	0.62	0.77	0.56	0.88	0.46	0.60	0.83	0.73	0.65	0.55	0.79
Wellington	0.41	0.71	0.47	0.47	0.19	0.30	0.13	0.32	0.88	0.12	0.30	0.44	0.18	0.11	0.64
Nelson-Marlb.	0.48	0.52	0.51	0.56	0.62	0.75	0.48	0.70	0.30	0.91	0.65	0.74	0.84	0.47	0.65
West Coast	0.81	0.56	0.69	0.58	0.60	0.73	0.56	0.75	0.37	0.43	0.92	0.59	0.59	0.48	0.68
Canterbury	0.70	0.77	0.78	0.74	0.59	0.73	0.59	0.76	0.59	0.69	0.75	0.89	0.70	0.52	0.86
Otago	0.61	0.56	0.60	0.62	0.68	0.75	0.52	0.75	0.30	0.74	0.80	0.71	0.91	0.60	0.69
Southland	0.56	0.57	0.70	0.56	0.52	0.57	0.51	0.67	0.20	0.43	0.68	0.59	0.60	0.91	0.64

Note: Regional and aggregate economic activity data, natural logged and filtered using quarterly business cycle band-pass filter described in Baxter King (1999)

Table 1 (continued)

Regional business cycle comovement and persistence, 1975q1 – 2006q4

C. Lead/lag correlation for t + 4

Economic activity at time t + 4

Activity at time t	Nthld	Auck	Waik	BOP	Gisb	HB	Tar	M-W	Well	NM	WC	Cant	Otago	Sthld	NZ
New Zealand	0.19	0.27	0.13	0.12	0.11	0.03	0.03	-0.12	0.20	-0.11	0.13	0.05	-0.06	-0.15	0.17
Northland	0.28	0.20	0.23	0.11	0.13	0.16	0.23	0.03	0.18	0.02	0.16	0.06	0.02	-0.18	0.18
Auckland	0.08	0.28	0.08	0.11	0.00	-0.10	-0.12	-0.21	0.28	-0.21	0.02	0.01	-0.16	-0.15	0.14
Waikato	0.17	0.09	0.10	0.05	0.06	0.04	0.09	-0.09	0.05	-0.04	0.07	0.00	-0.11	-0.28	0.05
Bay of Plenty	0.18	0.24	0.15	0.06	0.10	0.10	-0.04	-0.11	0.25	-0.17	0.11	0.00	-0.12	-0.13	0.15
Gisborne	0.43	0.45	0.34	0.33	0.27	0.33	0.16	0.27	0.38	0.01	0.41	0.15	0.15	0.04	0.39
Hawkes Bay	0.26	0.27	0.18	0.10	0.19	0.19	0.24	0.08	0.12	0.07	0.26	0.12	0.16	-0.04	0.22
Taranaki	0.50	0.19	0.33	0.29	0.42	0.41	0.47	0.27	0.09	0.41	0.41	0.35	0.36	-0.04	0.31
Manawatu-Wanganui	0.33	0.30	0.30	0.24	0.25	0.30	0.24	0.09	0.13	0.12	0.26	0.20	0.18	0.02	0.28
Wellington	-0.18	0.02	-0.23	-0.25	-0.19	-0.38	-0.23	-0.46	0.08	-0.45	-0.24	-0.27	-0.37	-0.31	-0.15
Nelson-Marlb.	0.27	0.30	0.21	0.25	0.37	0.35	0.16	0.18	0.06	0.24	0.41	0.22	0.36	0.09	0.28
West Coast	0.37	0.29	0.33	0.18	0.16	0.20	0.35	0.10	0.15	0.04	0.23	0.14	0.07	0.01	0.27
Canterbury	0.29	0.26	0.20	0.18	0.28	0.22	0.17	0.02	0.11	0.08	0.31	0.15	0.13	-0.07	0.22
Otago	0.39	0.36	0.30	0.31	0.39	0.32	0.24	0.26	0.10	0.18	0.46	0.23	0.28	0.20	0.34
Southland	0.37	0.25	0.40	0.27	0.23	0.19	0.30	0.23	-0.04	0.07	0.33	0.21	0.09	0.20	0.25

Note: Regional and aggregate economic activity data, natural logged and filtered using quarterly business cycle band-pass filter described in Baxter King (1999)

Table 2. Trend Regional Growth Rates (Average annualised percentages), and Sensitivity of Economic Activity in Region *i* to the Common Cycle (Normalised to unity for Auckland), 14 regions, 1975q2 – 2006q4

14-regions	Trend Growth Rate, δ_{it}				14-regions	Sensitivity Coefficient, γ_i
	1975q2 - 1986q3	1986q4 - 1991q2	1991q3 - 2006q4	$\sigma_{\mu i}$		1975q2 – 2006q4
Northland	4.82	0.81	3.60	4.0E-05	Northland	1.230
Auckland	3.70	2.28	3.07	3.1E-05	Auckland	1.000
Waikato	3.13	2.15	3.64	2.1E-05	Waikato	1.086
Bay of Plenty	3.88	1.48	3.45	2.7E-05	Bay of Plenty	1.068
Gisborne	2.77	-2.82	2.67	4.1E-05	Gisborne	0.703
Hawke's Bay	3.05	0.52	2.95	2.0E-05	Hawke's Bay	0.990
Taranaki	3.52	-0.33	3.09	6.8E-05	Taranaki	0.881
Manawatu-Wanaganui	4.02	-0.81	2.60	3.0E-05	Manawatu-Wanganui	1.229
Wellington	2.94	0.63	3.00	6.0E-05	Wellington	1.028
Nelson-Marlborough	3.29	2.78	3.39	3.4E-05	Nelson-Marlborough	0.868
West Coast	2.38	0.56	2.94	3.3E-05	West Coast	0.854
Canterbury	2.93	2.87	3.39	1.7E-05	Canterbury	1.183
Otago	2.34	0.28	2.99	2.7E-05	Otago	1.127
Southland	2.32	-0.08	2.73	4.5E-05	Southland	0.994

Notes: $\sigma_{\mu i}$ is the standard deviation of the innovation to the regional trend.

.**Table 3. Variances of Cyclical Components (Percentage points), 1975q2 – 2006q4**

14-regions	**Common Cycle**	**Idiosyncratic cycle**	**Covariance of cycles**	**Overall Cycle**	**5-regions**	**Common Cycle**	**Idiosyncratic cycle**	**Covariance of cycles**	**Overall Cycle**
Northland	3.89	4.84	1.44	10.17	Auckland	1.65	5.32	0.35	7.32
Auckland	2.57	4.65	2.19	9.41	Wellington	1.57	4.99	-0.41	6.15
Waikato	3.03	1.80	-0.53	4.31	Rest of North Island	2.00	4.01	-0.59	5.42
Bay of Plenty	2.93	3.98	-1.57	5.34	Canterbury	2.70	5.43	-0.07	8.07
Gisborne	1.27	4.92	-0.68	5.51	Rest of South Island	1.69	2.56	0.56	4.82
Hawke's Bay	2.52	2.56	-0.85	4.23					
Taranaki	2.00	11.99	2.16	16.14					
Manawatu	3.88	7.59	-2.12	9.35					
Wellington	2.72	4.91	0.56	8.19					
Nelson	1.94	3.30	0.27	5.50					
West Coast	1.88	3.23	1.20	6.31					
Canterbury	3.60	2.50	1.50	7.60					
Otago	3.27	4.34	-0.57	7.04					
Southland	2.54	9.50	-2.41	9.62					

Table 4. Common cycle parameter values, 5 regions, 1975q2 – 2006q4

	Parameter Value	
ρ_1	0.989 (9.23)	1.002 (9.75)
ρ_2	-0.291 (2.95)	-0.292 (2.89)
Monetary policy	-0.021 (0.50)	
Terms of Trade	0.016 (0.39)	
Net immigration	0.051 (1.66)	0.046 (1.50)
σ_n	0.0065	0.0065
Likelihood†	2305.1	2304.8
LR	8.8*	8.2**

Notes: ρ_1 and ρ_2 are the autoregressive coefficients; σ_n is the standard deviation of the common cycle; z-statistics are in parentheses;
LR denotes the likelihood ratio test for the test that three or one predetermined variable drivers of the common cycle are jointly and significantly different from zero.
*(**) influence of driver(s) additionally significant at 1 (5) per cent level, relative to no driver variable
The 5 % (1%) critical values taken from the asymptotic Chi-squared distribution with three degrees of freedom (df) are 7.81 (11.35), and for 1 df are 3.84 (6.64).
† *Likelihood* for no drivers is 2300.7

Table 5. Regional cycle parameters, 5-regions

region	Φ Matrix, **1975q2 – 2006q4**				
	AKL	WLG	RNI	CA	RSI
AKL	**0.924**	-0.018	0.055	0.074	0.078
WLG	0.009	**0.538**	-0.074	0.353	-0.471
RNI	-0.096	-0.218	**0.888**	0.195	-0.188
CA	-0.070	0.006	0.150	**0.931**	0.022
RSI	-0.164	-0.125	-0.060	0.178	**0.746**

region	Φ Matrix, **1983q1 – 2006q4**				
	AKL	WLG	RNI	CA	RSI
AKL	**0.902**	-0.028	-0.057	0.216	0.008
WLG	0.036	**0.299**	0.081	0.193	-0.611
RNI	-0.018	-0.291	**0.873**	0.083 (0.22)	-0.142
CA	0.064	-0.149	0.145	**0.700**	0.058
RSI	-0.147	-0.237	-0.037	0.109	**0.712**

Table 6. Regional cycle parameters, 5-regions, 1983q1 – 2006q4

	Trend Growth Rate, δ_{it}			
	1983q1 – 1986q4	**1987q1 – 1991q1**	**1991q2 – 2006q4**	$\sigma_{\mu i}$
Auckland	5.29	2.29	3.05	.0002
	(5.10)	(2.61)	(13.46)	
Wellington	3.49	0.82	3.01	.0001
	(3.63)	(1.33)	(20.80)	
Rest of North Island	2.63	1.03	3.21	.0001
	(2.39)	(1.57)	(17.56)	
Canterbury	3.68	2.95	3.36	.0001
	(4.29)	(5.21)	(20.31)	
Rest of South Island	3.24	0.36	3.07	.0061
	(2.58)	(0.51)	(18.06)	

Notes: $\sigma_{\mu i}$ is the standard deviation of the innovation to the regional trend; z-statistics in parentheses.

	Sensitivity coefficient, γ_i	
Auckland	1.000	
Wellington	0.925	(2.65)
Rest of North Island	1.050	(4.38)
Canterbury	1.017	(4.31)
Rest of South Island	0.960	(5.09)

Notes: z-statistics in parentheses.

	Variances of Cyclical Components (Percentage points)			
	Common Cycle	**Idiosyncratic cycle**	**Covariance of cycles**	**Overall Cycle**
Auckland	1.32	4.55	-0.05	5.81
Wellington	1.13	2.93	-1.19	2.87
Rest of North Island	1.45	2.24	-0.27	3.96
Canterbury	1.36	2.75	0.25	4.36
Rest of South Island	1.22	4.12	1.44	6.77

Table 7. Cross-correlations of 14-region and 5-region common cycles with potentially leading or lagging exogenous variables

	Common cycle lags the exogenous variable						Contemporaneous	Common cycle leads the exogenous variable					
Variables*	other	-5	-4	-3	-2	-1	0	1	2	3	4	5	other
1975q2-2006q4													
14-region common cycle**													
Monetary policy (HP)	-10 -0.25†	0.23	0.24	0.19	0.10	0.05	0.01	-0.09	-0.10	-0.07	-0.04	0.08	8 0.26†
Monetary policy		0.09	0.08	0.05	0.01	0.01	0.03	-0.01	-0.01	0.00	0.01	0.06	
Terms of trade		0.04	0.05	0.14	0.21	0.26	0.27†	0.20	0.12	-0.01	-0.12	-0.20	
Immigration (HP)	-7 0.20†	0.13	0.11	0.10	0.06	0.04	0.01	0.06	0.11	0.11	0.10	0.09	
Immigration	-7 0.21†	0.17	0.16	0.14	0.10	0.07	0.04	0.06	0.08	0.07	0.05	0.02	
5-region common cycle**													
Monetary policy (HP)	-9 -0.19†	0.12	0.11	0.05	-0.02	-0.04	-0.07	-0.15	-0.14	-0.08	-0.02	0.14	8 0.30†
Monetary policy		0.11	0.08	0.03	-0.02	-0.03	-0.02	-0.05	-0.04	-0.01	0.02	0.08	
Terms of trade		-0.11	-0.13	-0.05	0.02	0.08	0.10	0.05	-0.01	-0.10	-0.16	-0.17	
Immigration (HP)		0.21	0.24	0.27†	0.27	0.24	0.19	0.20	0.19	0.15	0.10	0.06	
Immigration		0.28	0.30	0.32†	0.30	0.28	0.23	0.24	0.23	0.19	0.14	0.09	
1983q2-2006q4													
5-region common cycle***													
Monetary policy (HP)	-9 -0.31†	0.25	0.22	0.08	-0.06	-0.08	-0.07	-0.15	-0.05	0.08	0.08	0.19	
Monetary policy	-9 -0.34†	0.12	0.11	0.00	-0.11	-0.12	-0.11	-0.18	-0.09	0.03	0.04	0.13	
Terms of trade		0.26	0.25	0.32	0.33†	0.29	0.19	0.07	-0.01	-0.08	-0.15	-0.17	
Immigration (HP)		-0.01	0.09	0.18	0.23	0.23†	0.20	0.27	0.28†	0.22	0.12	0.07	
Immigration		0.04	0.11	0.16	0.19	0.20	0.19	0.24	0.26†	0.23	0.16	0.13	
World GDP		-0.01	-0.01	0.02	0.13	0.25	0.36†	0.39†	0.31	0.20	0.15	0.04	
Govt expenditure		-0.27†	-0.24	-0.24	-0.13	-0.07	0.14	0.20	0.28	0.21	0.26	0.27†	
Net Taxation		0.04	0.03	-0.03	0.17	0.26	0.27	0.36†	0.34	0.21	0.16	0.14	
Taxation		0.03	0.00	-0.06	0.13	0.20	0.22	0.36†	0.33	0.20	0.18	0.17	
Transfers		-0.01	-0.01	-0.03	-0.07	-0.15	-0.16†	-0.01	-0.06	-0.03	0.04	0.04	
Net Govt expend/GDP 1		-0.14	-0.11	-0.06	-0.20	-0.27	-0.21	-0.27†	-0.22	-0.11	-0.06	-0.04	
Net Govt expend/GDP 2		-0.11	-0.11	-0.09	-0.25	-0.33†	-0.29	-0.32†	-0.25	-0.13	-0.06	-0.03	

Notes:
* Common cycles based on break points at 1986q4 and 1991q1; monetary policy and immigration variables de-meaned, all variables Hodrick-Prescott filtered
** contemporaneous cross correlation of 14-region and 5-region common cycles is 0.82
*** contemporaneous cross correlation of 14-region and 5-region common cycles is 0.85
† denotes significant at 2 standard errors

Table 8. Common cycle parameters, 5 regions, 1983q1 – 2006q4

Specification	Monetary policy	Terms of trade	Immigration	Government expenditure	Taxation	Transfers	Likelihood	LR
No exogenous driver							1744.0	
6 drivers	-0.006	0.069	0.061	-0.055	0.015	0.004	1748.8	9.6
4 drivers	-0.003	0.066	0.057	-0.057	-	-	1748.6	9.2***
3 drivers	-	0.066	0.057	-0.057	-	-	1748.6	9.2**
2 drivers	-	0.051	-	-0.040	-	-	1746.4	4.8***
Single drivers								
Monetary policy	-0.001						1743.8	-0.4
Terms of trade		0.051					1745.6	3.2***
Immigration			0.029				1744.4	0.8
Government expenditure.				-0.040			1744.7	1.4

Notes:
The 5-region common cycle is based on break points at 1986q4 and 1991q1.
* (**)*** predetermined variable(s) additionally significant at 1 (5) 10 per cent level, relative to no driver variable, based on LR test
1% (5%) 10% critical values for LR tests taken from asymptotic Chi-squared distribution with seven degrees of freedom (df) are 18.45(14.07)10.65, for four df are 13.28(9.48)7.78, for three df are 11.35(7.81)6.25, for two df are 9.21(5.99)4.61, and for one df are 6.64(3.84)2.71.

**Figure 1. New Zealand's 14-region Common and Region-specific Cycles
Deviations from trend, 1975q3 – 2006q4**

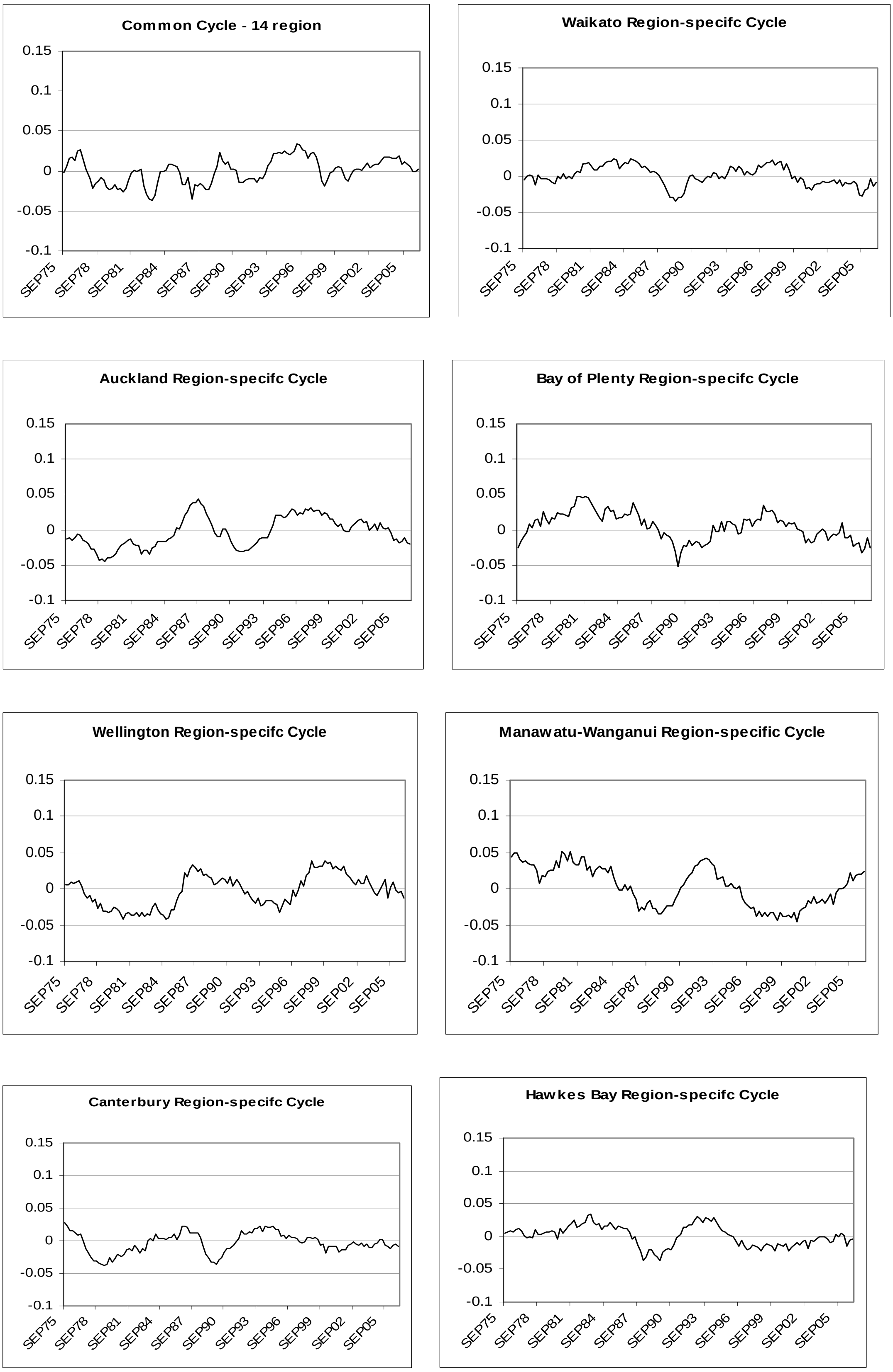


Figure 1. (continued)

New Zealand’s 14-region Common & Region-specific Cycles
Deviations from trend, 1975q3 – 2006q4

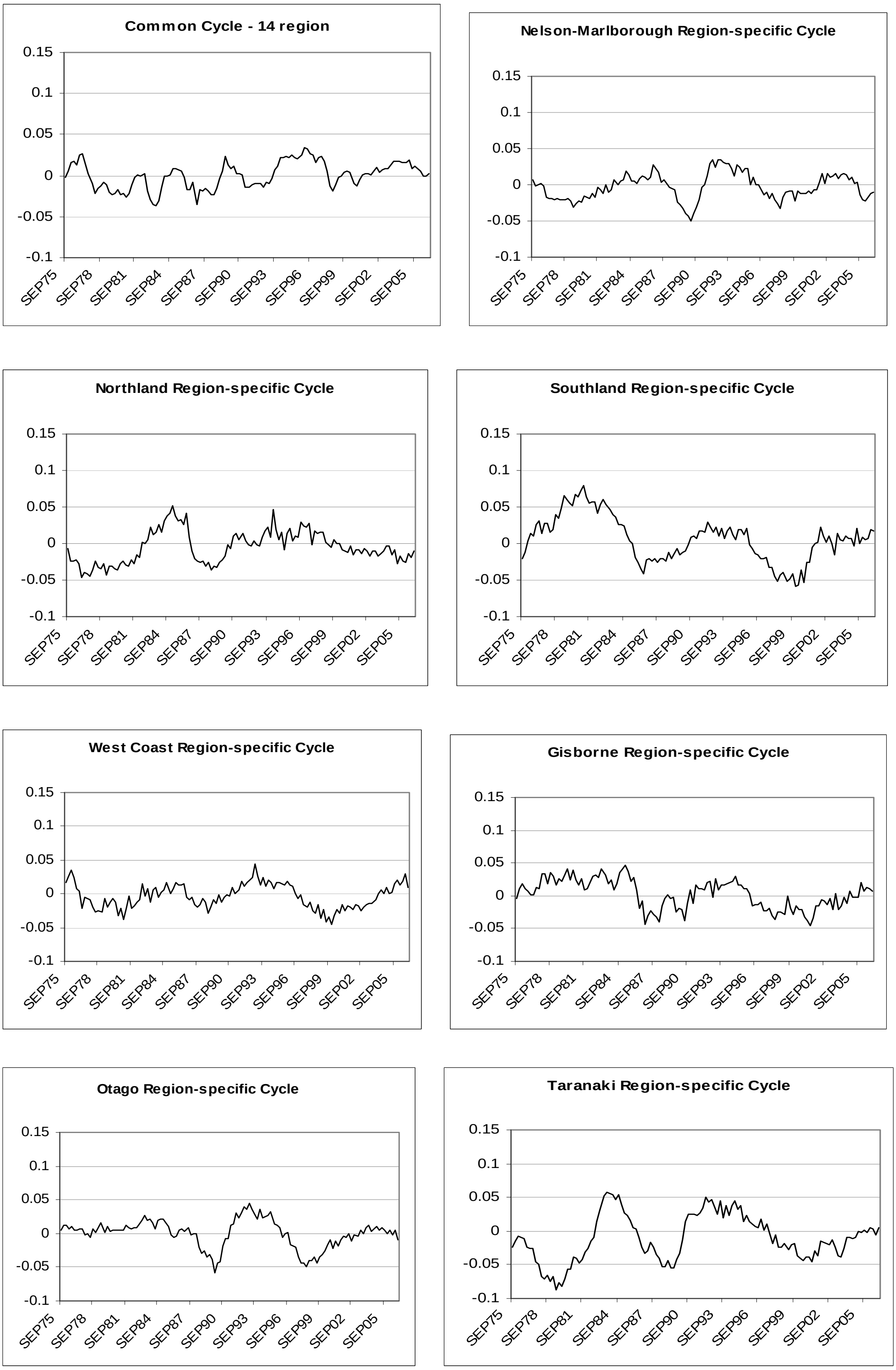


Figure 2. New Zealand's Common and HP Aggregate Activity Cycles, 1975q3 - 2006q4

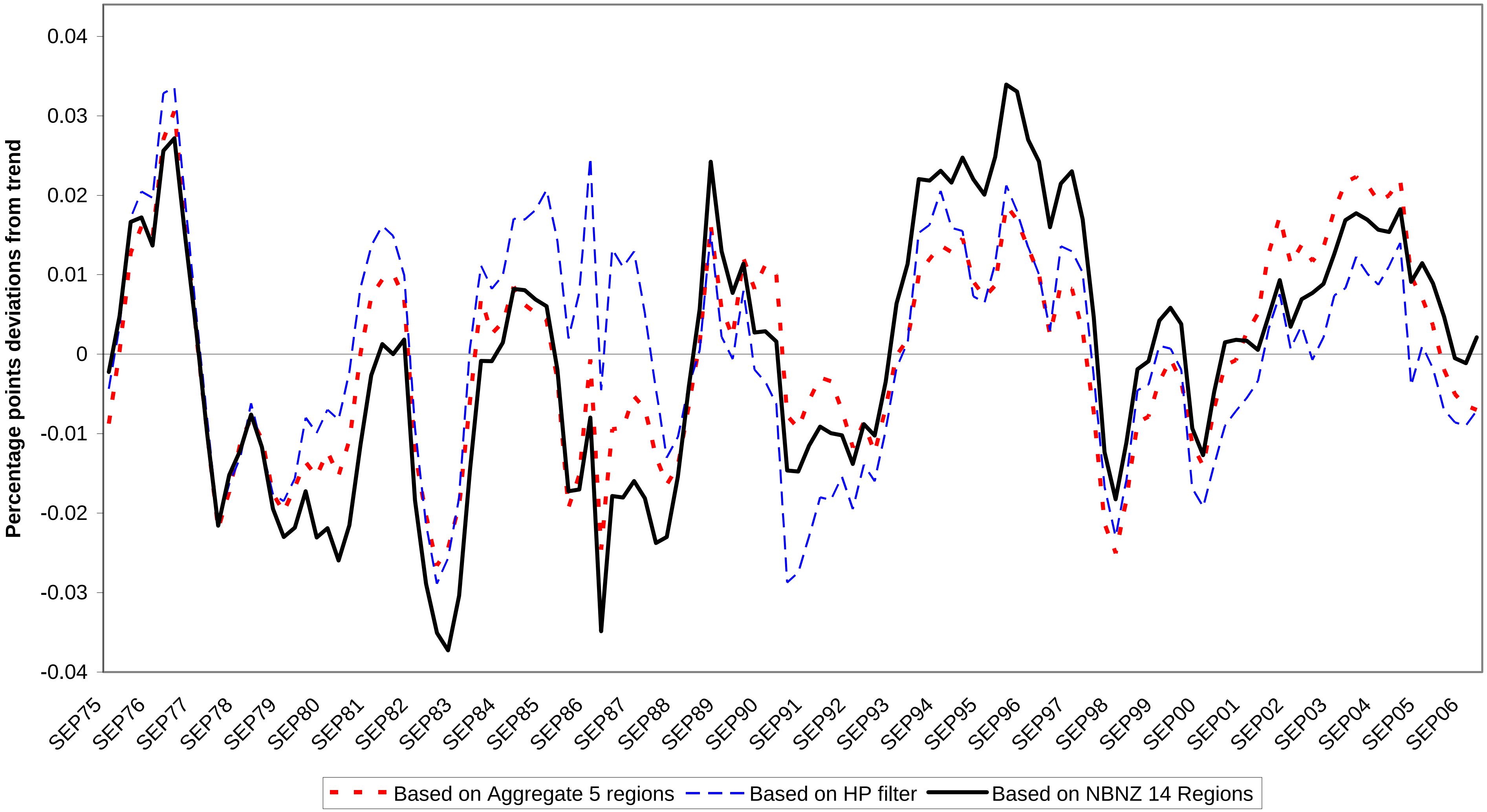


Figure 3. New Zealand's 5-region Common and Region-specific Cycles
Deviations from trend, 1983q2 – 2006q4

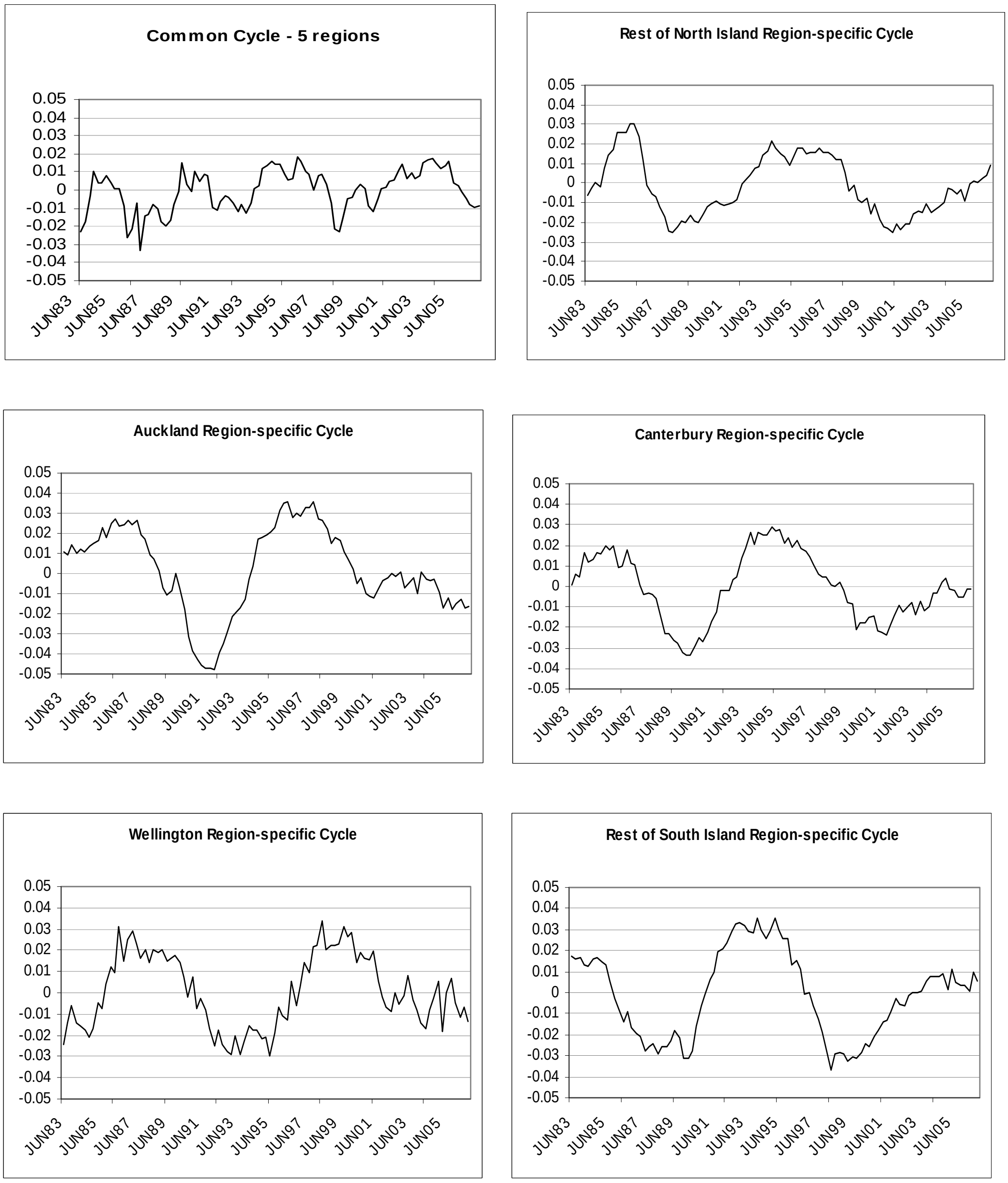


Figure 4. New Zealand's Common Cycle, Aggregate 5 regions, 1983q2 - 2006q4

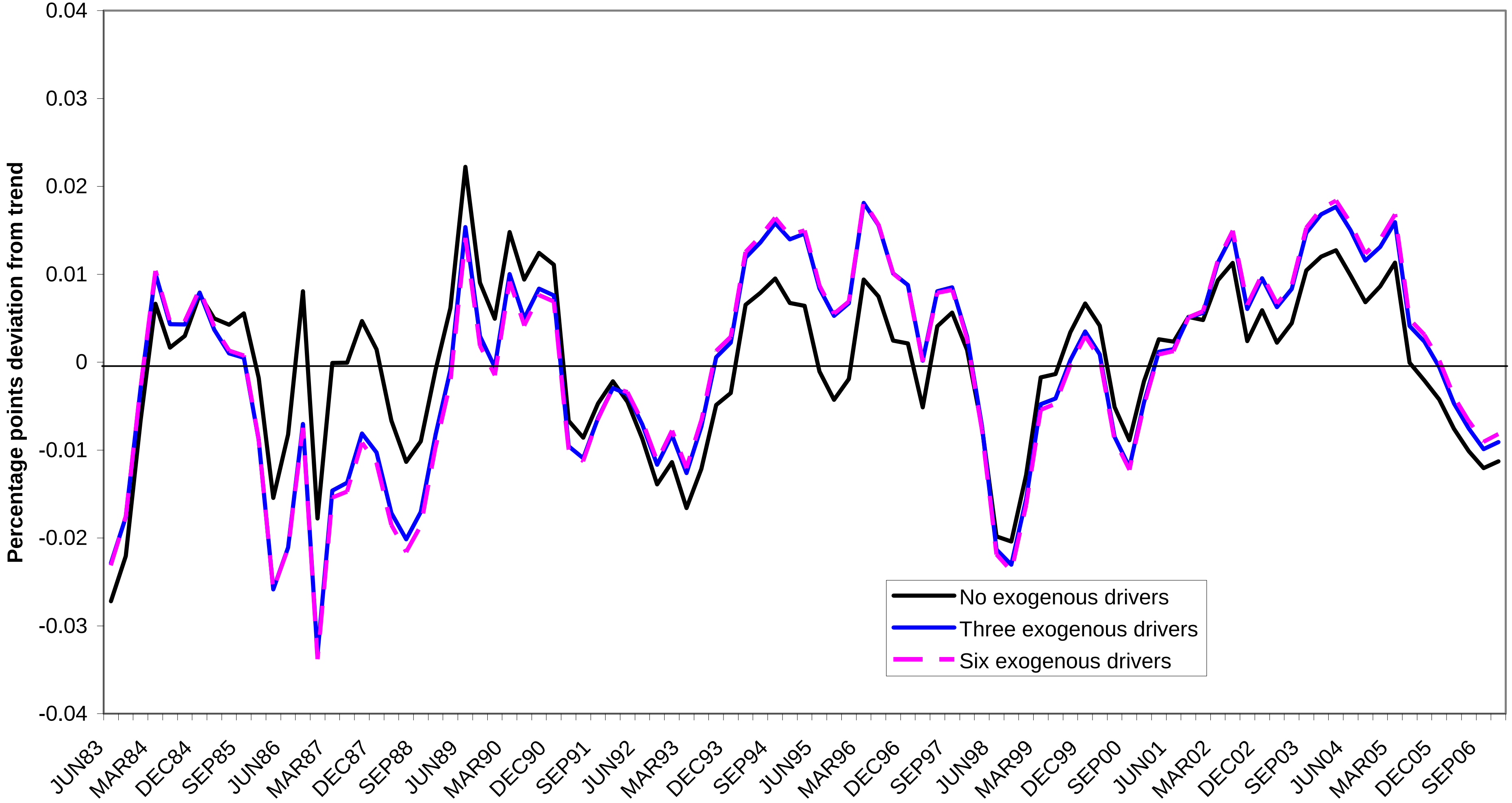
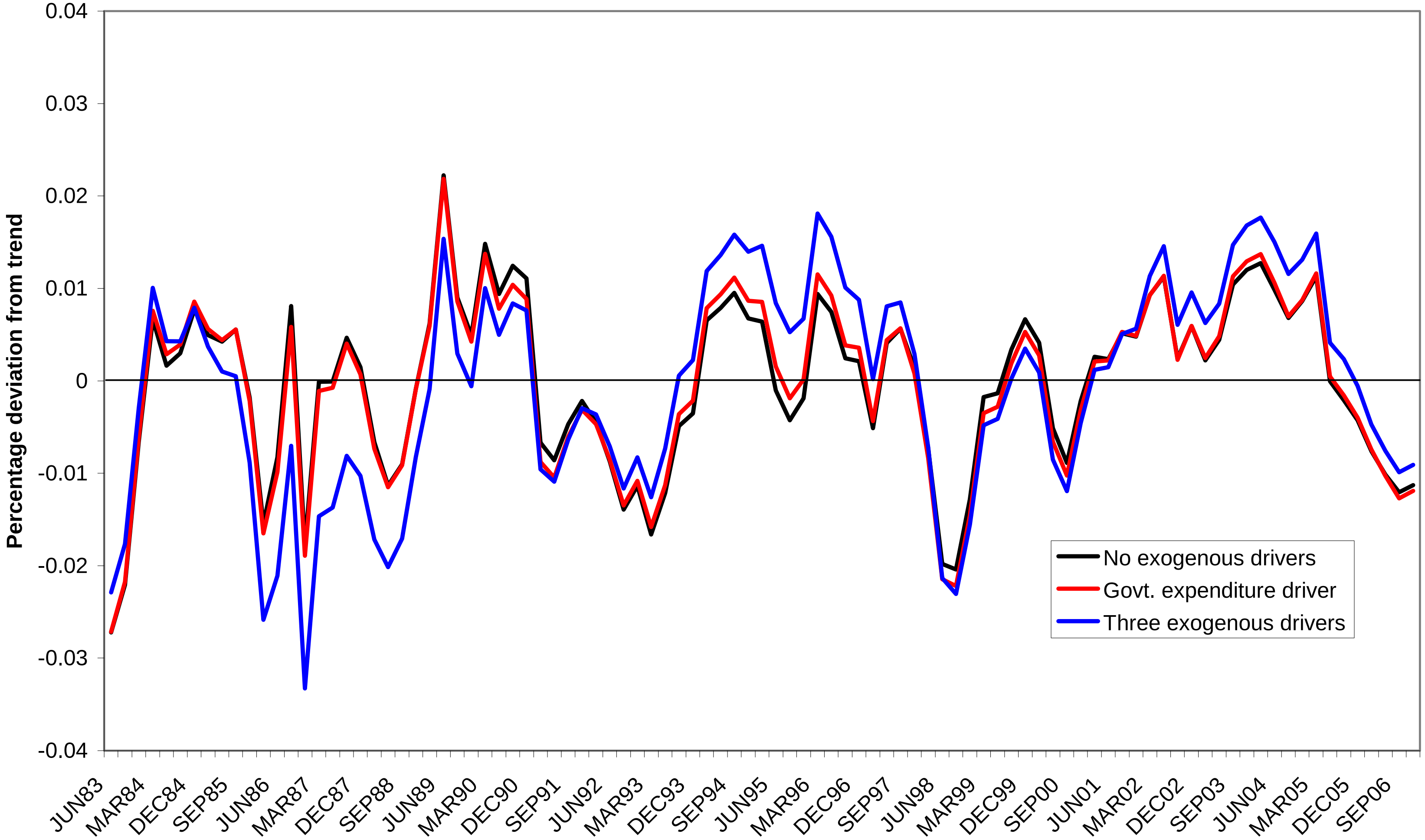


Figure 5. New Zealand's Common Cycle, Aggregate 5 regions, 1983q2 - 2006q4



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