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Common Trends and Common Cycles in Canada: Who Knew So Much Has Been Going On?

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Abstract: It is generally accepted that convergence is well established for Canadian regional per capita outputs. Another prevalent belief is that the Canadian regions respond symmetrically to the same aggregate shocks. We present a common trends–common cycles decomposition of Canadian regional outputs that casts doubt on the convergence hypothesis and reveals that trend shocks dominate fluctuations in Ontario, Quebec, and the Maritimes in the short run and long run but not in British Columbia and the Prairies. Thus, Canadian regional output fluctuations are driven by a rich, asymmetric, and economically important set of disaggregate propagation and growth mechanisms. The paper also reports that the Canadian regional trends and cycles are most related to the economic primitives of preferences and technology. Our results point to a new Canadian macroeconomic research agenda.

JEL classification: C32, E32, O47

Key words: common trends, common cycles, long-run convergence, disaggregate fluctuations

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1. Introduction

Canada is a fiscal and monetary union. The Government of Canada is responsible for monetary policy and operates a fiscal policy. Canadian provincial governments also run fiscal policies, which are unconstrained by the national government. This institutional design can be justified with three hypotheses: (i) aggregate shocks dominate Canadian trend and business cycle fluctuations; (ii) the regions of Canada are subject to the same aggregate shocks and respond symmetrically to those shocks in the short-, medium-, and long-run; and (iii) shocks specific to a region or regions are (approximately) idiosyncratic, serially uncorrelated, and have no impact on the rest of Canada.

Hypotheses $(i) - (iii)$ suggest disaggregate data contain no information about the aggregate Canadian trend and cycle. If disaggregate data lack information for Canadian long-run growth and short-run fluctuations, stylized facts of Canadian growth and business cycle facts can be constructed solely from aggregate data. Likewise, macroeconomic research on the sources and causes of Canadian trend and cycle can focus just on models of aggregate shocks, growth, and propagation mechanisms.

This paper analyzes Canadian regional outputs with a macro time series model developed by Vahid and Engle (1993). We use their approach to compute a common trends-common cycles decomposition based on British Columbia, Ontario, Quebec, Prairie, and Maritime per capita outputs from 1965 to 2002. The regional trends and cycles give another view of the sources and causes of Canadian fluctuations that points to a new Canadian macroeconomic research agenda.

Regional disparities are not a new phenomena in Canada. McInnis (1968), Blain, Paterson, and Rae (1974), Scott (2001), Wakerly (2002), and Barillas and Schliecher (2003) report differences in incomes and outputs across various Canadian economic and geographic subunits. However, this work contrasts with Coulombe and Lee (1995), Lee (1996), Helliwell (1996), and Coulombe (1999) who argue that convergence will inevitably occur for Canadian regional economies because there is a single source of long-run aggregate growth, which accords with hypotheses $(i) - (iii)$. These hypotheses are also an implicit part of the debate between Fortin (1996, 1999) and Freedman and Macklem (1998) about the role of fiscal, monetary, and technology shocks in the late 1980s and first half of the 1990s.

There are theoretical and empirical approaches to explain fluctuations with disaggregate objects. The multi-sector real business cycle model (RBC) of Long and Plosser (1983) and the stochastic growth model with non-convex technologies of Durlauf (1993) are theoretical examples. Durlauf and Johnson (1994), Bernard and Durlauf (1995, 1996), and Quah (1996a, b) show that concentrating only on aggregates ignores disaggregate factors important for tests of long-run growth models. Engle and Issler (1995) use the Long-Plosser RBC model to interpret trend-cycle estimates of U.S. regional outputs with methods Vahid and Engle (1993) develop. Barillas and Schliecher repeat Engle and Issler's analysis, but use Canadian sectoral outputs, which makes it a complement to our paper.[1] However, our paper most resembles the Carlino and Sill (2001) study of the trends and cycles of U.S. regional outputs.

We adapt the analysis of Engle and Issler (1995) to interpret a common trends-common cycles decomposition of Canadian regional outputs. They motivate their common trends-common cycles decomposition of U.S. sectoral outputs with the Long and Plosser (1983) multi-sector real business cycle (RBC) model. Common trends arise in this RBC model when there are more sectoral economies than productivity shocks (*i.e.*, productivity shocks cointegrate). Common cycles exist when there are more business cycle propagation mechanisms than sectoral economies (*i.e.*, the economies share common features). Thus, the Canadian regional trends and cycles can be interpreted with the Long and Plosser-RBC model and its economic primitives of preferences, market structure, and technology.

The empirical model of this paper is a vector autoregression (VAR) restricted by common trends and common cycles, as outlined by Vahid and Engle (1993). They graft common cycles onto the Stock and Watson (1988) common trends model, which is multivariate random walk version of the Beveridge and Nelson (1981) decomposition. The common trends map into cointegrating relations – linear combinations of the regional outputs – that share the same long-run comovement. Common cycles restrict the comovement of regional outputs to be stationary and persistent. Vahid and Engle show that a special and important case of the Beveridge, Nelson, Stock, and Watson (BNSW) decomposition arises when the number of common trends and common cycles equals the dimension of Canadian regional outputs.

[1] Engle and Issler uncover distinct trends among U.S. industrial sectors, but find similar cyclical behavior across these sectors. Barillas and Schliecher record similar results with corresponding Canadian data.

The results of this paper build on two common trends and three common cycles in the five Canadian regional outputs. Two common trends cast doubt on long-run convergence for Canadian regional outputs. Lack of convergence appears as regional trends that fail to catch up, notably Quebec and the Maritimes compared to Ontario. BC's trend fades to such an extent it lags all but the Maritimes' by 2002. The Prairie trend passes Ontario's during the sample, but Prairie trend growth is the most volatile. The common cycles reveal highly correlated transitory fluctuations in BC, Ontario, and Quebec. Prairie and Maritime cycles exhibit less comovement. Further asymmetries in error forecast variance decompositions of the Canadian regional outputs show Ontario, Quebec, and the Maritimes respond more to trend shocks than do BC and the Prairies. These results run counter to hypothesis (ii).

Hypothesis (ii) is also a necessary condition for an optimal currency area (OCA) to exist, in the sense of Mundell (1961).[2] Rather than argue about whether Canada is an OCA or about breaking up the Canadian monetary union, this paper explores reasons for disparities across the Canadian regional trends and cycles. The evidence lends support to the view that variation in the economic primitives of preferences and technology across the Canadian regions go a long way toward predicting disparities in Canadian regional trends and cycles.

The next section outlines the econometrics of decomposing Canadian regional outputs into common trends and common cycles. Section 3 presents empirical results. Evidence about the predictability of our estimates of Canadian regional trends and cycles appear in section 4. Section 5 concludes.

2. Econometric Methods

This section outlines the methods we employ to decompose Canadian regional outputs into common trends and common cycles. We draw on work by Beveridge and Nelson (1981), Engle and Granger (1987), Stock and Watson (1988), Johansen (1988, 1991), Vahid and Engle (1993), and Engle and Issler (1995). A reader comfortable with these techniques should skip ahead to section 3.

[2]Kouparitsas (2001) reviews conditions for an OCA. These are that all regional economies are subject to the same set of shocks, the response to and contribution of these shocks to regional economic fluctuations are symmetric, and regional shocks matter little for the volatility, persistence, and comovement of economic fluctuations at either the regional or aggregate level.

Stock and Watson develop a Beveridge and Nelson (BN) decomposition for a $n-$dimensional multivariate unit root time series, Z_t. Vahid and Engle consider the case in which Z_t possesses at least one cointegrating relation and between one and $n-1$ common feature relations. This implies at most $n-1$ common trends and at least one common cycle. When the number of common trends and common cycles equals the dimension of Z_t, Vahid and Engle show that the BNSW decomposition is computed using nonlinear transformations of the cointegrating and common feature vectors and the levels data, Z_t.

2.1 Common Trends Restrictions and the BNSW Decomposition

Engle and Granger (1987) introduce the concept of cointegration or common trends. Cointegration imposes cross-equation restrictions on the pth$-$order levels VAR

(1) $$Z_t \quad = \quad Z_t^* \;+\; B(\mathbf{L})Z_{t-1} \;+\; \xi_t,$$

where Z_t^* is the deterministic component (which can include non-stochastic trends) of the $n-$dimensional vector process Z_t, $\mathbf{L}x_t = x_{t-1}$, $B(\mathbf{L})$ is a pth$-$order lag matrix polynomial operator, and ξ_t is a vector of forecast innovations. When $\mathbf{I}_n - B(\mathbf{1})$ is less than full rank (*i.e.*, the common trends restriction), the pth$-$order levels VAR of (1) leads to a vector error correction model (VECM) of order $p-1$,

(2) $$\Delta Z_t \;=\; Z_t^* \;+\; \delta\alpha' Z_{t-1} \;+\; \mathcal{B}(\mathbf{L})\Delta Z_{t-1} \;+\; \xi_t, \;\; \Delta \equiv \mathbf{I}_n - \mathbf{L}, \;\; \mathcal{B}_j \;=\; -\sum_{i=j+1}^{p} B_i.$$

Johansen (1988, 1991) obtains tests of the number of cointegrating vectors, the rows of α', from the VECM's cross-equation restrictions, $\delta\alpha' = -[\mathbf{I}_n - B(\mathbf{1})]$, as well as estimates of these vectors and the matrix of error correction (EC) response parameters δ.

We maintain that Z_t is $I(1)$, its growth rates are $I(0)$, and jointly have a Wold representation

(3) $$\Delta Z_t \quad = \quad Z_t^* \;+\; A(\mathbf{L})\xi_t, \quad A(\mathbf{L}) \;=\; \sum_{j=0}^{\infty} A_j\mathbf{L}^j$$

where $A(\mathbf{L})$ is a lag matrix polynomial operator with absolutely summable elements. It is well known that the Wold representation (3) possesses a multivariate BN decomposition

(4) $$Z_t \quad = \quad A(\mathbf{1})\varepsilon_t \;+\; \mathcal{A}(\mathbf{L})\xi_t,$$

where $Z_t^* = 0$ for convenience (a constant in Z_t^* gives Z_t drift), $\varepsilon_t \equiv \sum_{j=0}^{\infty}\xi_{t-j}$, $\mathcal{A}_0 = \mathbf{I}_n - A(\mathbf{1})$, and $\mathcal{A}_i = -\sum_{j=i+1}^{\infty} A_j$. The BN trend component is the first term to the right of the equality of (4). It reflects the fact that the impact of past shocks never decays for $I(1)$ processes, rather it accumulates with time, $\varepsilon_t \equiv \sum_{j=0}^{\infty} \xi_{t-j}$. The BN cyclical component is $\mathcal{A}(\mathbf{L})\xi_t$.

Stock and Watson (1988) construct a BN decomposition given the rank of $A(\mathbf{1})$ is less than n. Assume Z_t has a BNSW *common trends* representation in which the rank of $A(\mathbf{1})$ is d, $1 \leq d < n$, which imposes d random walks on Z_t.[3] Engle and Granger (1987) call d the cointegrating rank and show $q = n - d$ linear combinations of the elements of Z_t are $I(0)$. Collect the q linearly independent vectors which create these combinations into the $q \times n$ matrix α' to compute the stationary BN component, $\alpha' Z_t = \alpha' \mathcal{A}(\mathbf{L})\xi_t$, of (4).[4] Since $\alpha' Z_t$ is constructed from linear combinations of the fundamental Wold innovations, Engle and Issler (1995) interpret cointegrating relations as "cycle generators".

2.2 *Common Cycles Restrictions and the BNSW-VE Decomposition*

Vahid and Engle (1993) provide conditions for restrictions that wipe out cycles in Z_t. This implies only $I(1)$ components remain. These restrictions also annihilate serial correlation in ΔZ_t, which leaves only white noise. Let ϑ' be the $f \times n$ matrix of linearly independent common feature vectors of Z_t that express these restrictions. Vahid and Engle show pre-multiplying the growth rates version of the BNSW decomposition, $\Delta Z_t = A(\mathbf{1})\xi_t + \Delta\mathcal{A}(\mathbf{L})\xi_t$, by ϑ yields the common feature relations

$$\vartheta' \Delta Z_t = \vartheta' \xi_t. \tag{5}$$

According to the restrictions ϑ' imposes on equation (5), a *common cycles* representation exists for Z_t when linear combinations of its growth rates are unpredictable.[5] The restrictions $\vartheta' A_j = 0$, $\forall\, j \geq 1$, follow from $A_0 \equiv I_n$ and $A_{j+1} = \mathcal{A}_{j+1} - \mathcal{A}_j$, $\forall\, j \geq 0$.[6]

The common feature vector ϑ leads to a prediction about the common trends of Z_t. When the BNSW decomposition (4) is pre-multiplied by ϑ', it yields $\vartheta' Z_t = \vartheta' \varepsilon_t$. Engle and Issler (1995) refer to

[3] If $d = n$, $A(\mathbf{1})$ is of full rank and Z_t consists of n independent random walk processes.

[4] The restrictions are $\alpha' A(\mathbf{1}) = 0$ (or $B(\mathbf{1})A(\mathbf{1}) = 0$), which follow from the cointegrating vectors being a basis of the null space of the sum of the vector moving-average (VMA) of the Wold innovations of (4), under $d < n$.

[5] Engle and Kozicki (1993) develop and popularize the idea of a serial correlation common feature in which a linear combination of stationary variables is orthogonal to the relevant past.

[6] The common feature vectors impose restrictions on the VECM (2) in the form $\vartheta' \mathcal{B}_i = 0$, $\vartheta' B(\mathbf{1}) = 0$, and $\vartheta' \delta = 0$. An implication is that $\mathcal{B}_i$, $i = 1, \ldots, p-1$, lacks full rank.

$\vartheta' Z_t$ as a "trends generator" because its linear combinations are driven only by scalar multiples of the accumulated Wold innovations, $\varepsilon_t \equiv \sum_{j=0}^{\infty} \xi_{t-j}$.

Vahid and Engle (1993) develop a simple way to compute a common trends-common cycles decomposition of Z_t, given $n = q + f$. It begins with the $n \times n$ matrix

$$[\Psi_{\cdot,n-q} \quad \Psi_{\cdot,q}] \quad = \quad \begin{bmatrix} \vartheta' \\ \alpha' \end{bmatrix}^{-1},$$

which exists because ϑ' and α' are linearly independent, where $\Psi_{\cdot,q}$ contains the q right most columns. The Vahid-Engle special case of the BNSW decomposition is recovered from

(6) $$Z_t \quad = \quad [\Psi_{\cdot,n-q} \quad \Psi_{\cdot,q}][\Psi_{\cdot,n-q} \quad \Psi_{\cdot,q}]^{-1} Z_t \quad = \quad [\Psi_{\cdot,n-q}\vartheta' \ + \ \Psi_{\cdot,q}\alpha'] Z_t.$$

Since $\vartheta' Z_t$ is the trend generator and $\alpha' Z_t$ is the cycle generator, the common trends and common cycles are $\mu_t = \Psi_{\cdot,n-q}\vartheta' Z_t$ and $\tau_t = \Psi_{\cdot,q}\alpha' Z_t$, respectively.[7]

2.3 A Structural Interpretation of the Common Cycles Restrictions

The f common features of ϑ' impose testable cross-equation restrictions on the VECM of (2). Vahid and Engle (1993) show that the common features give rise to a "structural" VECM, which stacks the f common feature equations of (5) on top of the remaining $n - f$ "reduced form" VECM regressions. These restrictions represent a test for common features because there is a reduction in VECM parameters, which yields the simultaneous equations system

(7) $$\begin{bmatrix} \mathbf{I}_f & \tilde{\vartheta}' \\ \mathbf{0}_0 & \mathbf{I}_{n-f} \end{bmatrix} \Delta Z_t \quad = \quad \begin{bmatrix} \mathbf{0}_Z & \mathbf{0}_{\Delta Z} \\ \tilde{\delta}\alpha' & \tilde{\mathcal{B}}(\mathbf{L}) \end{bmatrix} \begin{bmatrix} Z_{t-1} \\ \Delta Z_{t-1} \end{bmatrix} \ + \ \xi_t,$$

where the common feature vectors are normalized as $\vartheta' = [\mathbf{I}_f \quad \tilde{\vartheta}']$, $\tilde{\vartheta}'$ is $f \times (n - f)$, and the zero matrices $\mathbf{0}_0$, $\mathbf{0}_Z$, $\mathbf{0}_{\Delta Z}$ are $(n - f) \times f$, $f \times (n - q)$, and $(n - f) \times np$, respectively. Since a common features test is equivalent to a test of the structural model (7) against the unrestricted VECM of (2), this test has a likelihood ratio (LR) test interpretation. The next section presents cointegration tests, common feature tests, and the Canadian regional common trends-common cycles decomposition.

[7] Proietti (1997) develops methods to calculate a BNSW decomposition when $n > q + f$.

3. Canadian Regional Trends and Cycles

This section presents tests for cointegration and common features in Canadian regional per capita outputs. Also reported are cointegrating and common feature relations estimates, summary statistics of the common trends and common cycles, and forecast error decompositions (FEVDs) of the regional outputs with respect to innovations in their trends and cycles.

Cointegration and common feature tests use logged real per capita GDPs of five Canadian regions ($n = 5$) on a 1965 – 2002 annual sample.[8] Third-order VECM estimates are conditioned on data from 1961 – 1964. The provinces of British Columbia (BC), Ontario (O), and Quebec (Q) stand on their own. Alberta, Manitoba, and Saskatchewan comprise the Prairies (P) region. Newfoundland, New Brunswick, Nova Scotia, and Prince Edward Island form the Maritime (M) region.[9]

Figure 1 presents the log levels and growth rates of Canadian regional per capita GDPs in constant 1997 dollars for the 1961 – 2002 sample. The top window contains plots of the log levels of real per capita GDP for BC, Ontario, Quebec, the Prairies, and the Maritimes. Plots of their growth rates appear in the bottom panel of figure 1. The regional outputs all trend up and are persistent, but the Prairies and Maritimes exhibit larger wiggles than seen for BC, Ontario, and Quebec. The top window of figure 1 also shows that output in Quebec has caught up to BC by the end of the sample.[10] An ocular metric suggests that BC, Ontario, Quebec, and the Prairie region share a common trend in their outputs. Maritime output has a similar path, but at a lower level throughout the sample period.[11]

BC, Ontario, Quebec, and Maritime growth rates appear to move together in the lower window of figure 1, with the exception that Maritime growth equals -11.63 percent in 1980. Smaller spikes occur

[8] The appendix describes the data in detail and is available on request.

[9] There are constraints on the way Canadian regional outputs are grouped. According to Abadir, Hadri, and Tzavalis (1999) and Gonzalo and Pitirakis (2000), greater disaggregation distorts test size and power, while too much aggregation makes it difficult to uncover the regional heterogeneity in the data. Thus, we settle on the five regional outputs.

[10] Augmented Dickey-Fuller regressions of the outputs fail to reject the unit root null at a ten percent significance level. Stock (1991) 95 percent asymptotic confidence intervals of the largest AR root include one for all series.

[11] The regional outputs are persistent. An unrestricted VAR(4) fit to log levels yields (normalized) modulo of 1.00, 0.94, 0.88, 0.87, and 0.83. The half-lives of the four smallest are about 11, six, five, and four years, respectively.

in BC, Ontario, and Quebec growth rates two years later. Prairie growth rates appear to move inversely with growth rates in the other regions. We explore the observed behavior of Canadian regional outputs with cointegration and common feature tests in the next section.

3.1 Cointegration Tests

Table 1 reports results of Johansen (1988, 1991) cointegration tests on Canadian regional outputs. The tests depend on a VECM(3) restricted according to Case 1 of Osterwald-Lenum (1992), which allows for deterministic trends in Z_t. The data supports the Case 1-VECM(3) because a LR test of the null of no deterministic trends – a Case 1* model – against the alternative of the Case 1 model yields a $\chi^2(2)$ statistic of 7.28 with a $p-$value of 0.0263.

Johansen (1988, 1991) develops two LR tests for cointegration, the $\lambda-$max and trace statistics. Table 1 lists the test statistics and associated MacKinnon, Haug, and Michelis (1999) five and ten percent (asymptotic) critical values, conditional on the Case 1-VECM(3).[12] The $\lambda-$max and trace statistics are unable to reject $q = 3$ cointegrating relations at the five percent level.

Three cointegrating vectors indicate Canadian regional outputs are driven by more than one trend, which is evidence against the convergence hypothesis. The rejection of long-run convergence is consistent with Wakerly (2002). Her measures of disaggregated Canadian provincial and industry income dynamics indicate a lack of convergence.

Contrast these results to Coulombe and Lee (1995), Lee (1996), Helliwell (1996) and Coulombe (1999). They argue convergence has occurred for Canadian regional outputs. For example, Coulombe (1999) states that, “convergence across the provinces is a fundamental economic phenomenon.”[13] It is standard to use the Barro and Sala-i-Martin (1991) $\beta-$convergence cross-section regression to make these arguments.[14]

[12] Critical values for the Case 1-VECM are generated using `lrcdist.exe`, which James MacKinnon provides at *http://www.econ.queensu.ca/pub/faculty/mackinnon/johtest/*.

[13] Coulombe contends that regional convergence in Canada was resolved by about 50 percent by the late 1980s.

[14] The $\beta-$convergence regression runs annual per capita output growth of region j on this region's initial log level of per capita output and a constant.

Serious issues about using cross-sectional regressions to study long-run convergence are raised by Bernard and Durlauf (1995, 1996) and den Haan (1995). Bernard and Durlauf (1995, 1996) show that tests of convergence, which focus on long-run forecasts of outputs such as the Johansen (1988, 1991) cointegration tests, are best suited for a set of economies close to their steady states (*i.e.*, developed economies). Cross-section regressions are more appropriate for tests of convergence for economies in transition, far away from their steady states. Canadian regional outputs fit the Bernard and Durlauf rubric because it has been developed economy since, at least, World War I. den Haan (1995) finds that cross-section regression-based convergence tests are biased toward the convergence null for DSGE economies subject to more than one shock. Canada fits into this class of economies because it is subject to open economy and regional shocks, besides fiscal and monetary disturbances.

3.2 Tests for Common Features

Three cointegrating relations among the five Canadian regional outputs is evidence against convergence. It also suggests the presence of common features among Canadian regional economies. We use tests for common features found in Vahid and Engle (1993) and Engle and Issler (1995) to examine this hypothesis. These tests for common cycles rely on the cross-equation restrictions embedded in equation (5) and have a LR interpretation, according to the simultaneous equations model (7).

Common feature tests employ canonical correlations, ρ, of BC, Ontario, Quebec, Prairies, and Maritime output growth, conditional on the unrestricted VECM(3) information set. The null is growth rates share a common feature, represented by $\rho = 0$. The tests are $-(T-4)\sum_{i=1}^{f} ln(1-\rho_i^2)$ which is asymptotically distributed $\chi^2(f^2+5f)$, where f runs from the smallest to largest ρ_i, and an $F-$test due to Rao (1973). The latter test has better small sample properties, according to Engle and Issler (1995).

Table 2 presents estimates of the squared ρs and two tests for common features, a χ^2 test and Rao's $F-$test. The left most column contains the squared canonical correlations, ρ_i^2, from largest to smallest. The next two columns are the $p-$values of the χ^2 and $F-$tests, given the null hypothesis listed at the top of the right most column. The common feature null is the f smallest squared ρs equal zero, which imply a common feature relation is associated with $\{\rho_i\}_{i=1}^{f} = 0,\ f = 5, \ldots, 1$.

The common features tests of table 2 indicate the three largest squared ρs of Canadian regional growth rates are nonzero. The two smallest are not statistically different than zero. This imposes two serially correlated common features on Canadian regional outputs, which implies two common cycles from the business cycle through growth frequencies. Within the framework of a DSGE model, Long and Plosser (1983) and Engle and Issler (1995) show these restrictions can arise from the economic primitives of preferences, market structure, and technology shocks.

3.3 Summary Statistics of the Canadian Regional Common Trends-Common Cycles

Two common features and three cointegrating relations exist in the five Canadian regional outputs, according to the last two sections. Since $f = 2$ plus $q = 3$ equals the number of Canadian regions, $n = 5$, a result of Vahid and Engle (1993) allows us to compute the Canadian regional common trends and common cycles using the non-singular five-by-five matrix $[\Psi_{\cdot,2} \quad \Psi_{\cdot,3}]$ and the common features matrix ϑ' and cointegrating matrix α'.

The bases of the cointegrating and common feature relations appear in table 3. The three cointegrating relations and two common features give us the five-by-five matrix $[\Psi_{\cdot,2} \quad \Psi_{\cdot,3}]$. Although normalization of the cointegrating and common feature relations is arbitrary, their bases reveal trend and cycle relationships among the regional outputs. For example, the second common feature relation shows that Ontario output net of 80 percent of Quebec output, minus a quarter of BC output, and only tiny amounts of Prairie and Maritime outputs yields a common trend. Likewise, the third cointegrating relation generates a cycle by emphasizing the relationship Maritime output has with BC and Ontario outputs.

Summary statistics of the Canadian regional output growth rates and their trends and cycles are found in table 4. Its first two rows are the means and standard deviations of regional output growth. The Prairies experience the fastest average growth rate for the 1965 – 2002 sample, followed by Quebec and the Maritimes. Average BC and Ontario output growth is less than two percent. An implication is that the Prairie region requires less than 30 years to double its level of per capita output, but BC needs another 15 years. Higher average output growth is associated with greater volatility, except for BC which has the third largest standard deviation of output growth, and Quebec which has the smallest.

The next four rows of table 4 decompose the volatility of regional outputs into the standard deviation of trend growth, $Std(\Delta y_j^{\mu})$, the cyclical component, $Std(y_j^{\tau})$, and their relative volatilities. A striking aspect of table 4 is that Prairie trend growth and cycle are more volatile than the other four regions in several dimensions. For example, the standard deviation of its cycle (trend growth) is nearly three times (1.5) greater then the next largest, BC's (the Maritime's). The Prairies also produce the largest ratio of trend growth (or cycle) to output growth.

The Prairie cycle is the most persistent. Its AR1 coefficient is 0.82, which implies the half-life of a shock to the cyclical component is about 3.5 years. The cycles of the other regions exhibit much less persistence because their half-lives to a transitory shock are little more than one year.

The bottom row of table 4 reports the correlations of the regional trend growths and cycles, $Cor(\Delta y_j^{\mu}, y_j^{\tau})$. The correlations are all negative, ranging from -0.10 to -0.58. The negative correlations suggest trends will be smoother than the actual level of outputs, except for the Prairies (because of the relative volatility of actual output to trend).

Not reported on table 4 are the correlations of Δy_O^{μ}, Δy_Q^{μ}, and Δy_M^{μ}. These correlations are greater than 0.95. Trend growth of these regions are negatively correlated (-0.34, -0.07, and -0.23, respectively) with Δy_P^{μ}. For BC, the correlations with Ontario, Quebec, and the Maritimes are 0.24, 0.50, and 0.36. Thus, it is not a surprise the correlation of Δy_{BC}^{μ} and Δy_P^{μ} is positive and large at 0.83.

Likewise, the correlation structure of Canadian regional cycles is not included in table 4. There is strong contemporaneous co-movement among the BC, Ontario, and Quebec cycles. Their smallest contemporaneous correlation is 0.82. The Maritime cycle shows weaker co-movement with these regions, as its correlations with $y_{t,M}^{\tau}$ with $y_{t,BC}^{\tau}$, $y_{t,O}^{\tau}$, and $y_{t,Q}^{\tau}$ are 0.66, 0.44, and 0.26, respectively. On the other hand, the Prairies cycle is nearly uncorrelated with $y_{t,BC}^{\tau}$ and $y_{t,O}^{\tau}$ and negatively correlated (-0.43) with $y_{t,Q}^{\tau}$. The asymmetric correlation pattern of Canadian regional cycles differs from the U.S. regional cycle correlation structure that Carlino and Sill (2001) find averages 0.76.

3.4 Canadian Regional Trend and Cycle Decompositions

Equation (6) uses the common feature and cointegrating relations of Canadian region j applied to its output level to compute the trend-cycle decomposition, up to a scalar. The common trends, $y^{\mu}_{t,j}$, and common cycles, $y^{\tau}_{t,j}$, are plotted in figures 2 and 3, respectively.

There are several striking aspects to $y^{\mu}_{t,O}$, $y^{\mu}_{t,Q}$, and $y^{\mu}_{t,M}$ that appear in the top window of figure 2. These trends are similar, albeit with different initial levels of per capita output in 1965. The top window of figure 2 also shows a downturn in the trends around the time of the second oil price shock and a peak in 1988. The trough that follows occurs in 1993.

The volatility of $y^{\mu}_{t,P}$ and the lack thereof in $y^{\mu}_{t,BC}$ are the features that stand out in the bottom window of figure 2. The Prairies trend also shows a peak around 1980 – 1981, followed by a deep trough that persists for the rest of the 1980s. The BC trend is flat throughout the 1980s, rather than falling steeply. The BC and Prairie trends show renewed upward movement in the first half of the 1990s, which levels off by the middle of the decade. By the end of the sample, these trends are moving upward.

We present plots of the Canadian regional common cycles in figure 3.[15] The top window contains $y^{\tau}_{t,BC}$, $y^{\tau}_{t,O}$, and $y^{\tau}_{t,Q}$. These cycles display a high degree of comovement. Their smallest contemporaneous correlation is 0.82. A steep *transitory* contraction is also observed during the first half of the 1980s. There is a cyclical peak in 1989, a trough in 1991, and the recovery from this contraction peaks in the mid-1990s. This is followed by a contraction, common to BC, Ontario, and Quebec that begins in 1997 and has not run its course by the end of the sample in 2002.

The Prairie and the Maritime cycles appear in the bottom window of figure 3. These cycles are close to being uncorrelated, $Cor(y^{\tau}_{t,P}, y^{\tau}_{t,M}) = -0.16$. The persistence and volatility of $y^{\tau}_{t,P}$ dominates the lower window of figure 3. For example, $y^{\tau}_{t,P}$ shows two peak to peak cycles that run from 1974 to 1985 and 1985 to 2000. The peak to trough movements of $y^{\tau}_{t,P}$ sum to about 30 percent in both cases. Maritime cycles only range between six and negative six percent. The most striking movements in the Maritime cycle is a peak in 1973, a trough in 1980, and a long slow recovery from this trough to a peak in 1993, followed by a steady decline for the rest of the sample.

The common trends-common cycles decomposition can be used to resolve questions about their

[15]The means of the Canadian regional cycles are forced to zero.

relative importance for Canadian regional output fluctuations. Recall that figure 1 shows a trough in Maritime output growth of -11.63 percent in 1980. The common trends-common cycles decomposition reveals that $\Delta y^{\mu}_{1980,M} = -4.90$ percent and $y^{\tau}_{1980,M} = -5.61$ percent. This shows the 1980 collapse in Maritime real economic activity was split about 40 – 60 between its permanent and transitory components. This compares to the decline in real economic activity in Ontario and Quebec two years later in which the contributions of a falling trend and cycle are about equal.

Trend and business cycle dating histories can also be gleaned from the common trends-common cycles decomposition. For example, the 1988 peak and 1993 trough in the Ontario, Quebec, and Maritimes trends that appear in the top window of figure 2 are not the dates on which Fortin (1996, 1999) focuses his arguments about the 'Great Canadian Slump' of 1990 – 1996. Much the same holds for the 1989 peak, 1991 trough, and subsequent recovery in the BC, Ontario, and Quebec cycles. Thus, regional output trends and cycles add useful information to the history of real economic activity in Canada.

3.5 The Canadian Regional "Aggregate Trend and Cycle"

Figure 4 presents the "aggregate Canadian trend and cycle". We calculate the aggregate trend and aggregate cycle as weighted averages of the five Canadian regional trends and cycles. The weights are the regional GDP shares (in total regional GDP).[16]

The top window of figure 4 contains the aggregate weighted average trend and (log level of the) aggregate per capita output (real GDP). Aggregate output is below the weighted average trend from 1975 to 1985. This relationship is reversed from 1985 to 1991. A 'slump' in Canadian trend output occurs during 1988 – 1989, but not during the early 1990s as Fortin (1996, 1999) claims. By 2002, aggregate real output and the weighted average trend are nearly equal, but actual output was above the weighted average trend in the second half of the 1990s.

The aggregate weighted average cycle and the difference between actual Canadian output and its aggregate weighted-average trend appear in the bottom window of figure 3. The former (latter) cycle is

[16]Since the data used to construct the regional cycles is in log levels, the "aggregate Canadian cycle" does not precisely match BNSW cycle that would be extracted from aggregate Canadian data.

plotted as a solid line (dotted line). These cycles move together (the correlation is 0.85), but the aggregate weighted-average cycle shows little persistence. Its AR1 coefficient is 0.54. The dotted line-aggregate cycle has a AR1 coefficient of 0.76 or a half-life of 2.5 years in response to a transitory shock. Both cycles have a peak around the oil price shock of 1973, which is not matched until 1989. The next peak is in 1997, followed by a transitory downturn that has not reached a bottom by 2002.

There are aggregate cyclical troughs in Canada in 1977, 1982, and 1992, according to the bottom window of figure 4. The 1977 and 1982 cyclical troughs are deeper than the one experienced in 1992. However, the aggregate cycle of the late 1980s and early 1990s is three years long from peak to trough (or trough to peak). Table 8.1 of Abel, Bernanke, and Smith (1999) shows this to be the average length of a recession cycle in post-World War II Canada. Thus, the decline in the aggregate cycle from 1989 to 1995 was not of the order magnitude of the Great Depression, as Fortin (1996, 1999) suggests.

3.6 Canadian Regional Forecast Error Variance Decompositions

The last bit of information we extract from the common trends-common cycles decomposition of Canadian regional outputs are forecast error variance decompositions (FEVDs). The FEVDs are found in table 5.[17] The FEVDs show that the responses of Ontario, Quebec, and Maritime outputs to permanent shocks are similar. Trend shocks account for between 57 and 73 percent of the variation in output fluctuations in these regions at a one-year forecast horizon. By three years, 93 to 95 percent of these fluctuations are explained by trend shocks.

The behavior of the Ontario, Quebec, and Maritime FEVDs differ in an economically meaningful way from the BC and Prairie FEVDs. It takes four years or more for trend shocks to contribute 90 percent or more to fluctuations in BC and Prairie outputs. Thus, trend shocks dominate regional fluctuations

[17] Engle and Issler (1995) and Issler and Vahid (2001) outline methods to calculate the FEVD. The trend innovation is set equal to the first difference of the common trend at the one-year ahead forecast horizon. At forecast horizon j, j consecutive first differences of the common trend are summed to obtain the j-step-ahead trend innovation. Cyclical innovations are identified with the residuals of the cyclical component regressed on the information set of the VECM(3) lagged j times. Issler and Vahid orthogonalize the trend and cyclical innovations by ‘regressing’ the cyclical innovation on the trend innovation. This asserts the trend innovation is prior to the cyclical innovation. Footnote 11 and Appendix C of Issler and Vahid contain details.

in Canada in the medium- to long-run, but BC and the Prairies exhibit different responses to trend disturbances than Ontario, Quebec, and the Maritimes.

The lack of symmetry of the FEVDs with respect to the trend shock provides evidence against hypothesis (ii) for Canada. Although the cycles are common, we find the shocks to the common cycles have asymmetric effects. This suggests disparities in the underlying primitives of preferences, market structure, monetary and fiscal shocks, and technology in the Canadian regions. The next section presents reduced-form evidence that explores the connections between economic primitives and the common trends and common cycles of the Canadian regions.

4. Reduced-Form Evidence on the Sources and Causes of Canadian Regional Trends and Cycles

This section reports reduced-form evidence about the predictability of the estimates of Canadian regional trends and cycles. Our choice of predictors is directed by claims made to explain the disparity of Canadian regional economic activity. One group of predictors includes equalization entitlement payments, regional immigration flows, and hosting an Olympics. We also study the relationship between Canadian regional trends and cycles with observables that proxy for the economic primitives of preferences, technology, market structure, and fiscal and monetary shocks.

4.1 Granger Causality Tests

Hypothesis testing is conducted using the Granger causality null.[18] The null is that lags of a predictor, X, are unable to predict the future path of either $\Delta y^{\mu}_{j,t}$ or $y^{\tau}_{j,t}$. These tests have no structural interpretation because there are no cross-equation restrictions, which gives Granger causality its reduced-form interpretation. Rejection of the Granger causality null is the minimum *necessary* condition that should be satisfied to justify future research to explain the impact, say, of identified money supply shocks on Canadian regional trends and cycles.

We generate evidence about the linear predictability of Canadian regional trend growth and cycle

[18] Pesaran, Pierse, and Lee (1993) test similar propositions with cross-equation restrictions in structural time series models.

with the regression

$$W_t \quad = \quad \theta_0 \ + \ \sum_{i=1}^{\ell} \theta_{\tau,i} \ y_{j,t-i}^{\tau} \ + \ \sum_{i=1}^{\ell} \theta_{X,i} \ X_{t-i} \ + \ \psi_t, \tag{8}$$

where W_t is either $\Delta y_{j,t}^{\mu}$ or $y_{j,t}^{\tau}$, j = BC, Ontario, Quebec, Prairies, and Maritimes, X contains the variable identified with the associated hypothesis, and ψ_t is a mean zero, homoskedastic error. The regressions condition on two lags of $y_{j,t}^{\tau}$ to eliminate (potential) serial dependence in W_t. We compute $F-$statistics that $\theta_{X,1} = \theta_{X,2} = 0$ to test the null. The sample period is 1965 – 2002, except if otherwise noted.

4.2 Canadian Regional Development, Regional Trends, and Regional Cycles

This section studies the impact of immigration, equalization entitlement program, and hosting an Olympics on Canadian regional trends and cycles. The regional immigration-total immigration ratio is unable to predict future movements in Canadian regional trend growth or cycle. The relevant Granger causality tests yield $p-$values of 0.76 or more. It is also argued by Helliwell (1996) that immigration across Canada is driven by regional economic disparities. Tests for this reverse Granger causality yield $p-$values of 0.57 or more, which shows immigration is not predicted by Canadian regional cycles.[19]

Another element of Canadian economic development policy is the equalization entitlement program that aims to smooth out regional economic disparities. We explore the efficacy of this program by estimating 30 versions of regression (8) in which X is either the ratio of Quebec, Prairie, or Maritime equalization payments to total payments. These regressions yield Granger causality tests with $p-$values no smaller than 0.12. Thus, the equalization program cannot systematically predict future movements in Canadian regional trend growth or cycle. These results question Coulombe's (1999) claim, among others, that the equalization program has promoted convergence among the regions of Canada.

This section also studies claims that the Olympics are a boon to regional economic activity. The statement of the BC Minister of State for the 2010 Olympic Bid (2002) is typical,

> … hosting the 2010 Olympic and Paralympic Winter Games will provide major economic benefits to British Columbia … the Games will mean up to \$10 billion in total economic activity, more than 200,000 total jobs and \$2.5 billion in tax revenues.

[19] Not surprisingly, lags of regional trend growth forecast future immigration flows across all five Canadian regions.

Note that in 2002, BC current dollar GDP (employment) is about $135 billion (1.97 million).

We examine the conjecture Olympics promote real economic activity with two observations: the 1976 Montreal Summer Olympics and 1988 Calgary Winter Olympics. The impact on $\Delta y^{\mu}_{Q,t}$ or $\Delta y^{\mu}_{P,t}$ is evaluated using a $t-$test that the intercept, θ_0, of regression (8) shifts in the six years prior to and including the Olympic games. A test of the impact of hosting an Olympics on the persistence of the Quebec or Prairies cycle interacts the same dummy variable with lags of $y^{\tau}_{Q,t}$ or $y^{\tau}_{P,t}$ in regression (8).

The $t-$ and $F-$tests do not support claims that hosting an Olympics affects Canadian regional trends and cycles. The 1976 Montreal Summer Olympics appears to have had no effec on $\Delta y^{\mu}_{Q,t}$ or $y^{\tau}_{Q,t}$. The $p-$values of the relevant tests are all greater than 0.31. The same is true for $F-$tests of changes in the persistence of $y^{\tau}_{P,t}$ tied to the 1988 Calgary Winter Olympics, given $p-$value of 0.32 or more. On the other hand, the $p-$values of four of the six $t-$tests for shifts in the mean of $\Delta y^{\mu}_{P,t}$ are less than 0.03, but the changes are negative and larger than the sample mean of Δy^{μ}_{P}. Thus, there may be good reasons to host an Olympics, but promoting trend growth or a cyclical expansion is most likely not one.

4.3 Economic Primitives I: Preferences and Technology

The connection between Canadian regional trends and cycles and the economic primitives of preferences and technology is explored in this section. We use the permanent income hypothesis (PIH) to identify preferences with an observed variable. The PIH is the canonical macro-theory of household optimizing consumption behavior. The small open economy version of the PIH is the present-value model (PVM) of the current account. Kano (2003) develops a PVM that shows the current account-output ratio responds to transitory consumption tilting and long-run income smoothing factors. An implication of the PVM is that lags of the current account-output ratio Granger cause these factors. The PIH suggests common trends (common cycles) can proxy for income smoothing (consumption tilting).

There is strong evidence that the Canadian current account-output ratio Granger causes regional trend growth and cycle. When X is the current account-output ratio, the $p-$values are below 0.086 for Ontario, Quebec, and the Maritime trend growth and cycle. For BC and the Prairies, only $y^{\tau}_{BC,t}$ and $y^{\tau}_{P,t}$ is predicted by lags of the current account-output ratio. Thus, there is broad support for the conjecture that the economic primitive of preferences matters for Canadian regional trends and cycles.[20]

Our measure of the economic primitive of technology is total factor productivity (TFP). It equals the log of aggregate real GDP minus the sum of the logs of capital's and labor's share. We obtain no evidence that lags of aggregate TFP growth predict future movements in Canadian regional trend growth or cycle. However, lags of $y^{\tau}_{BC,t}$, $y^{\tau}_{O,t}$, and $y^{\tau}_{Q,t}$ predict the future path of aggregate TFP growth.[21] The $p-$values of these $F-$tests are 0.038 or smaller. These results are consistent with Wakerly (2002) who reports that her measures of disaggregated Canadian provincial and industry income dynamics predict aggregate Canadian business cycle fluctuations. The correlation of the BC, Ontario, and Quebec cycles and that these regions account for 65 percent or more of aggregate Canadian output suggest the technology of these regions are tied together in the way Long and Plosser (1983) and Engle and Issler (1995) describe. This raises a question about the need for models of regional technology to measure better Canadian TFP.

4.4 Economic Primitives II: Industrial and Labor Market Structure

The composition of Canadian regional employment and regional industry structure proxies for the economic primitive of market structure. We define industrial structure with the outputs of seven sectors, where i = *agriculture, logging, and fishing; mining, oil and gas extraction; construction; manufacturing; educational services; health and social services;* and *provincial and local public administration*. When disparities in Canadian regional industrial structure arise, Granger causality from regional industrial sectors to regional trend growth or cycle will vary across those sectors and regions.

[20]We also tested for Granger causality of Canadian regional trends and cycles by Canadian aggregate wealth data supplied by Macklem (1997). None of the aggregate wealth measures Granger cause regional trend growth or cycle, except for non-human capital wealth (excluding equity), which predicts future BC trend growth.

[21]The endogeneity of aggregate Canadian TFP is consistent with Cozier and Gupta (1993). Since the AR1 coefficient of our notion of TFP growth is 0.33, this version of technology is also measured incorrectly. Nonetheless, our TFP measure reflects changes in aggregate Canadian technology. Paquet and Robidoux (2001) propose another way to construct Canadian TFP to make it exogenous with respect to many Canadian aggregates, but it is conditional on a Statistics Canada measure of capacity utilization. Statistics Canada applies interpolation and linear moving average filtering methods to construct this series. This renders any econometric work suspect because of the impact of filtering on the estimators and test statistics.

We ask if sectoral industrial output helps to explain the path of Canadian regional trend growth and cycle. Regression (8) implements tests of this hypothesis with X set to the ratio of sectoral industrial output i of region j either to aggregate output of sector i or total industrial output of region j. The estimation sample is reduced to 1973 – 2002 for these regressions.

Granger causality tests provide mixed results about the impact of industrial structure on regional trend growth and cycle. For example, the five regional cycles are Granger caused by all seven sectorial outputs no matter the definition of X. However, only the ratio of output of the *mining, oil and gas extraction* sector in BC, Ontario, Quebec, and the Prairies to aggregate output in this sector consistently predicts trend growth of these regions. This predictability could be an artifact of the relationship between oil and the U.S. macroeconomy debated, for example, by Hamilton (1983, 1996) and Hooker (1996a, b). For the Maritimes, its trend growth is Granger caused by the ratio of its *agriculture, logging, and fishing* output to this sector's aggregate output. Thus, there is limited support for disparities in the industrial structure of Canadian regions driving fluctuations in regional trends and cycles. These results stand in contrast to Carlino and Sill (2001) who find that the cycles of the U.S. regions respond to their share of manufacturing output in aggregate manufacturing output.

Differences in the responses of Canadian regional trends and cycles to the composition of regional labor markets reflect the impact of underlying labor supply and demand shocks. We glean preliminary evidence about the impact these shocks have on Canadian regional trends and cycles with X set to the ratio of regional to aggregate employment in regression (8). The Granger causality tests offer limited support for common labor supply and demand shocks, given just a 1978 – 2002 sample. Only BC employment flows predict future Ontario, Quebec, and Maritime trend growth. It is interesting to note that since the 1970s about two-thirds of the increase in university educated workers in BC were absorbed from the rest of Canada, as reported by Allen (1997). This may reflect either labor supply or productivity shocks in eastern Canada that raise BC's employment of the highly skilled and then appear as movements in $\Delta y^{\mu}_{O,t}$, $\Delta y^{\mu}_{Q,t}$, and $\Delta y^{\mu}_{M,t}$.

These results suggest limited labor market integration across the Canadian regions, which is in line with Coe and Emery (2004). They find Canadian regional labor markets are less integrated since the 1970s. They argue that information about Canadian labor market integration can be found in the response of regional labor market i to a shock in region j. Reversing the previous Granger causality tests yields reduced-form evidence about this conjecture. The results are that lags of $y^{\tau}_{Q,t}$ Granger causes BC, Ontario, its own, and Prairie employment, lags of $y^{\tau}_{O,t}$ predicts its own and Quebec employment, lags of $y^{\tau}_{BC,t}$ forecasts Quebec employment, and lags of $y^{\tau}_{M,t}$ Granger causes Prairie employment. The BC, Ontario and Quebec labor markets appear the most integrated, which mirrors the cyclical comovement of these regions. This reduced-form evidence points to the need for more work on the sources and causes of Canadian regional labor market integration, as Coe and Emery argue.

4.5 Economic Primitives III: Fiscal Policy, Money Supply, and Money Demand

We report the responses of Canadian regional trend growth and cycle to fiscal policy and identified money supply and money demand shocks in this section. We measure fiscal policy with government spending (at all levels), which is standard in RBC theory. Given X is government spending growth, the smallest and second smallest $p-$values are 0.091 for $y^{\tau}_{M,t}$ and 0.28 for $y^{\tau}_{BC,t}$. This is more evidence that fiscal policy has few implications for Canadian regional trends and cycles.

Our identification of money demand and supply shocks follows standard practice. An unrestricted VAR(1) is fit to real GDP, the $90-$day Canadian T-Bill rate, and the currency-GDP deflator ratio to extract the orthogonalized money demand shock series. These variables reflect the information set of a typical money demand function. It is also standard for monetary models to tie money demand to the economic primitive of preferences, for example, by Walsh (2003). We extract the money supply shock from an unrestricted VAR(1) of the consumption-output ratio, inflation (GDP deflator), the US-Canadian dollar exchange rate, and the bank rate.[22] Given the consumption-output ratio proxies for transitory aggregate demand, these variables cover the information set Côté, Lam, Liu, and St-Amant (2002) use to construct monetary policy rules.

[22]The money demand (supply) VAR includes a constant and (but not) a linear time trend as regressors. Our shock ordering places nominal factors subsequent to real-side and financial-side shocks.

We obtain almost no evidence that identified money demand and supply shocks matter for Canadian regional trends. Lags of the identified shocks fail to predict $\Delta y^{\mu}_{BC,t}$, $\Delta y^{\mu}_{O,t}$, and $\Delta y^{\mu}_{Q,t}$. The former (latter) shock possesses information about the future path of $\Delta y^{\mu}_{P,t}$ ($\Delta y^{\mu}_{M,t}$), but the evidence is not strong because the $p-$value of the $F-$test is 0.10 (0.11). Since the null of only two of the ten exclusion tests are rejected when $\Delta y^{\mu}_{j,t}$ is the dependent variable, there is no *systematic* evidence that the identified money demand and money supply shocks contain information about regional trend growth during our sample period. There is also no evidence that the identified money supply shock predicts Canadian regional cycles. These $F-$tests have $p-$values in excess of 0.36. Since Carlino and Defina (1998) find that disparities in U.S. regional response to monetary policy shocks, it suggests the U.S. and Canadian regions respond differently to monetary policy.

The null that identified money demand shocks do not predict future movements in $y^{\tau}_{BC,t}$, $y^{\tau}_{O,t}$, $y^{\tau}_{Q,t}$, and $y^{\tau}_{M,t}$ is rejected. The $p-$values of the $F-$tests are 0.01, 0.02, 0.10, and 0.05, respectively. For the Prairie cycle, the $F-$test has a $p-$value 0.67. The ability of identified money demand shocks to predict Canadian regional trends and cycles is consistent with Scott (2001) and Ambler, Dib, and Rebei (2003). Scott finds that the transitory component of Canadian regional outputs respond asymmetrically to money demand shocks. Ambler, Dib, and Rebei report that money demand shocks account for more than half of the variation of aggregate Canadian output. The upshot money demand shocks have asymmetric affects on Canadian regional trends and cycles, which is more evidence for the importance of variation in the economic primitive of preferences.

The key role of economic primitives for Canadian regional trends and cycles also provides insights into the debate between Fortin (1996, 1999) and Freedman and Macklem (1998) about the impact of Bank of Canada policy on economic activity in Canada. Fortin claims that monetary policy created a severe recession during the late 1980s and early 1990s in Canada that was the deepest in more than 50 years. Freedman and Macklem point to technology and fiscal factors to explain aggregate fluctuations in Canada during the 1990s. Fortin's position requires that money supply shocks predict the future path of Canadian output. There is scant evidence that our identified money supply shocks do this for our regional measures of the Canadian economy. Thus, the contention that monetary policy can be held directly responsible for the recession of the late 1980s and early 1990s is not supported by the evidence this paper presents.

5. Conclusions

This paper studies Canadian regional trends and cycles. Estimates employ BC, Ontario, Quebec, Prairie, and Maritime constant dollar per capita outputs from 1965 – 2002. The empirical model relies on the Vahid and Engle (1993) approach to common cycles in a model of cointegrating relations, which builds on the Stock and Watson (1988) common trends model generalization of the Beveridge and Nelson (1981) decomposition. Cointegration tests use the maximum likelihood estimator of Johansen (1988, 1991). Vahid and Engle (1993) and Engle and Issler (1995) outline common feature tests. Engle and Issler also show that the multi-sector real business cycle model of Long and Plosser (1983) restricts the sources and causes of common trends and common cycles.

The paper reports that the five Canadian regional outputs share two common trends and three common cycles. This casts doubt on the convergence hypothesis for the regions of Canada because two permanent shocks are the sources of Canadian long-run growth. Canadian regional outputs trend paths show Quebec and the Maritimes fail to catch up to Ontario, the Prairies surpass the other regions, while BC lags all but the Maritimes by 2002. This pattern of regional trend is consistent with Prairie trend growth being the most volatile, and BC trend growth the least.

The three common cycles imply there are three business cycle propagation mechanisms across the five regions of Canada. Of the three common cycles, one groups BC, Ontario, and Quebec together. The others are found in the Prairie and Maritime cycles. This structure is associated with asymmetries in the volatility, correlation structure, and persistence of the Canadian regional cycles. These asymmetries are further reflected in the forecast error variance decompositions of the Canadian regional outputs that show Ontario, Quebec, and the Maritimes respond much less to cyclical shocks than do BC and the Prairies. Thus, the paper reveals the richness and diversity of Canadian regional fluctuations.

Asymmetric Canadian regional output fluctuations does not imply there is neither a need for a unitary currency in Canada nor a prime role for the Bank of Canada. For example, Ravikumar and Wallace (2002) show that a uniform currency pushes production and trade toward optimal levels. Given monetary policy involves management of the value of currency, a central bank occupies a central position in an economy in which common cycles matter for aggregate fluctuations. Thus, our evidence suggests that Canadian monetary policymakers may want to attend to potential trade-offs between aggregate price stability and the welfare implications of persistent common cycles in Canadian regional outputs.

The paper also examines several claims made about the sources and causes of Canadian regional trends and cycles. The evidence lends support to the view that economic primitives are at the heart of these disparities. Rather than fiscal, economic development, or monetary policies, our results point to the importance of the economic primitives of preferences and technology for regional economic fluctuations in Canada. An upshot is that claims for monetary policy to have driven the recession of the late 1980s and early 1990s in Canada are not sustained, conditional on our common trends-common cycles decomposition of BC, Ontario, Quebec, Prairie, and Maritime outputs.

Our results lay out a new macroeconomic approach to study regional and aggregate fluctuations in Canada. Since the econometric methods we employ provide a view of Canadian regional trends and cycles in which economic primitives dominate, greater emphasis on building dynamic stochastic general equilibrium models to study regional fluctuations and the welfare effects of fiscal, economic development, and monetary policies seems to us a fruitful approach. We judge this to be a vital part of future macroeconomic research in Canada.

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Table 1. Johansen Tests of Canadian Regional Common Trends

VECM(3) and Case 1 of Osterwald-Lenum (1992)

Sample Period: 1965 – 2002, $T = 38$

λ_{max} Statistic	Critical Values λ_{max} Statistic*	Trace Statistic	Critical Values Trace Statistic*	Null Hypothesis
0.35	3.84 2.70	0.35	3.84 2.71	∃ at most 4 cointegrating relations
9.91	14.26 12.30	10.26	15.49 13.43	∃ at most 3 cointegrating relations
21.25†	21.13 18.89	31.52†	29.80 27.07	∃ at most 2 cointegrating relations
26.22‡	27.58 25.12	57.73†	47.86 44.49	∃ at most 1 cointegrating relations
53.29†	33.88 31.24	111.02†	69.82 65.82	∃ at most 0 cointegrating relations

* The five (ten) percent critical value is the first (second) value in each stack. Critical values are generated using `lrcdist.exe`, which James MacKinnon, Queen's University (Kingston, Ontario) provides at *http://www.econ.queensu.ca/pub/faculty/mackinnon/johtest/*.

† (‡) Denotes significance at the five (ten) percent level.

Table 2. Tests of Canadian Regional Common Cycles

Sq. Canonical Correlations, ρ_i^2	$p-$value of χ^2 Test	$p-$value of Rao's $F-$test	Null Hypothesis
0.8874	0.0000	0.0000	$\rho_5^2, \ldots, \rho_1^2$ are zero
0.7168	0.0000	0.0002	$\rho_4^2, \ldots, \rho_1^2$ are zero
0.7045	0.0001	0.0057	$\rho_3^2, \ldots, \rho_1^2$ are zero
0.4559	0.1821	0.2019	ρ_2^2, and, ρ_1^2 are zero
0.3780	0.3048	0.3185	ρ_1^2 is zero

Tests are based on Case 1-VECM(3) specification that has three cointegrating relations. The common feature null is the f smallest ρ^2s equal zero. The sample period is: 1965 – 2002, $T = 38$.

Table 3. Bases for Common Feature and Cointegration Spaces

	BC	Ontario	Quebec	Prairies	Maritimes
Comfeat. 1	1.0000	0.9910	-2.5413	-0.2642	-0.9167
Comfeat. 2	-0.2469	1.0000	-0.8294	-0.0941	-0.0779
Coint. 1	-1.0530	0.4553	1.0000	0.2724	-0.9259
Coint. 2	-0.5665	8.4466	-6.8739	1.0000	-1.3865
Coint. 3	-1.0548	-0.8683	0.2971	0.2492	1.0000

The sample period is 1965 – 2002, $T = 38$.

Table 4. Summary Statistics of Canadian Regional Common Trend-Common Cycles

Sample Period: 1965 – 2002, $T = 38$

	BC	Ontario	Quebec	Prairies	Maritimes
$Mean(\Delta y_j)$	1.5579	1.8313	2.0775	2.5270	2.0031
$Std(\Delta y_j)$	0.0306	0.0263	0.0212	0.0468	0.0319
$Std(\Delta y_j^{\mu})$	0.0175	0.0235	0.0217	0.0570	0.0237
$Std(y_j^{\tau})$	0.0315	0.0224	0.0195	0.0851	0.0231
$\frac{Std(\Delta y_j^{\mu})}{Std(\Delta y_j)}$	0.5716	0.8937	1.0227	1.2182	0.7430
$\frac{Std(y_j^{\tau})}{Std(\Delta y_j)}$	1.0290	0.8537	0.9179	1.8170	0.7230
$AR1(y_j^{\tau})$	0.5328	0.5032	0.6096	0.8195	0.5226
$Cor(\Delta y_j^{\mu}, y_j^{\tau})$	-0.1003	-0.4929	-0.5760	-0.2344	-0.2815

The first and second rows are the mean and standard deviation (Std) of Canadian region j's output growth. The next two rows are the standard deviations of the growth rate of the permanent component, Δy_j^{μ}, and the transitory component y_j^{τ} of Canadian region j's output. The next two rows are the relative volatility of Canadian region j's trend growth and cyclical volatility, respectively. The penultimate row is the AR1 coefficient of the transitory component of Canadian region j's output growth labelled $AR1(y_j^{\tau})$. The last row is the contemporaneous correlation of the permanent and transitory components of Canadian region j's output growth, $Cor(\Delta y_j^{\mu}, y_j^{\tau})$.

Table 5. FEVDs of Canadian Regional Common Trends-Common Cycles

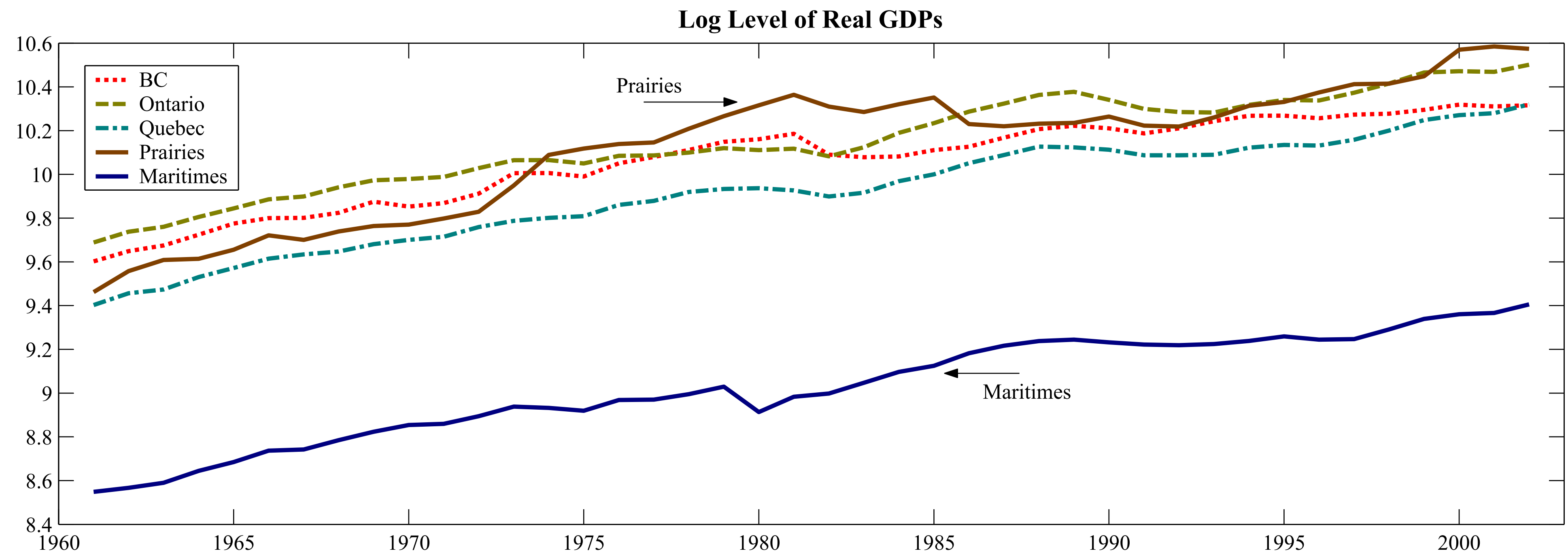
Sample Period: 1965 – 2002, $T = 38$

w/r/t the Permanent Shock

Forecast Horizon	BC	Ontario	Quebec	Prairies	Maritimes
1	37.34	57.41	72.72	45.48	73.14
2	69.78	84.85	88.90	61.40	91.18
3	84.58	93.72	94.92	74.57	93.21
4	89.97	95.94	96.88	83.73	95.98
5	92.54	97.30	98.19	89.65	96.86
10	97.26	98.34	98.93	96.12	99.05

The trend innovation equals the first difference of the common trend at the one-year forecast horizon. At forecast horizon j, j consecutive first differences of the common trend are summed to obtain the j-step-ahead trend innovation. Innovations to the cyclical component are the residuals of the cyclical component regressed on the information set of our VECM(3) lagged appropriately (the information set lagged j times); see Engle and Issler (1995) and Issler and Vahid (2001) for details.

Figure 1: Canadian Regional Real GDPs



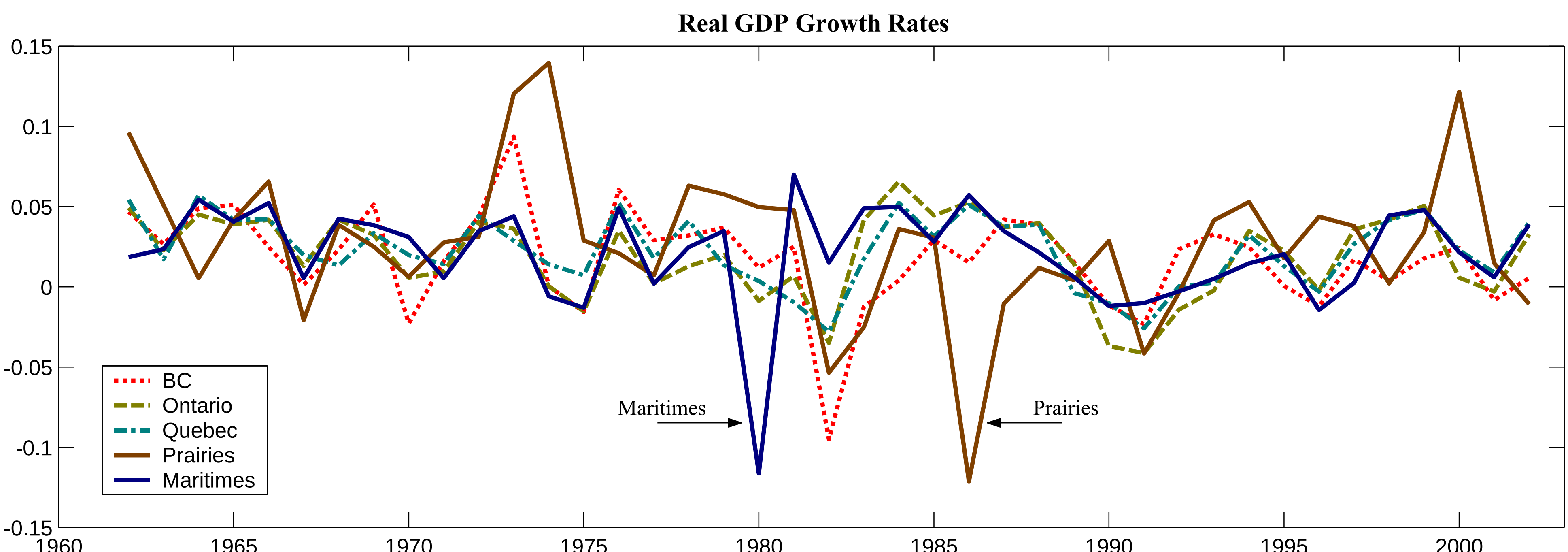
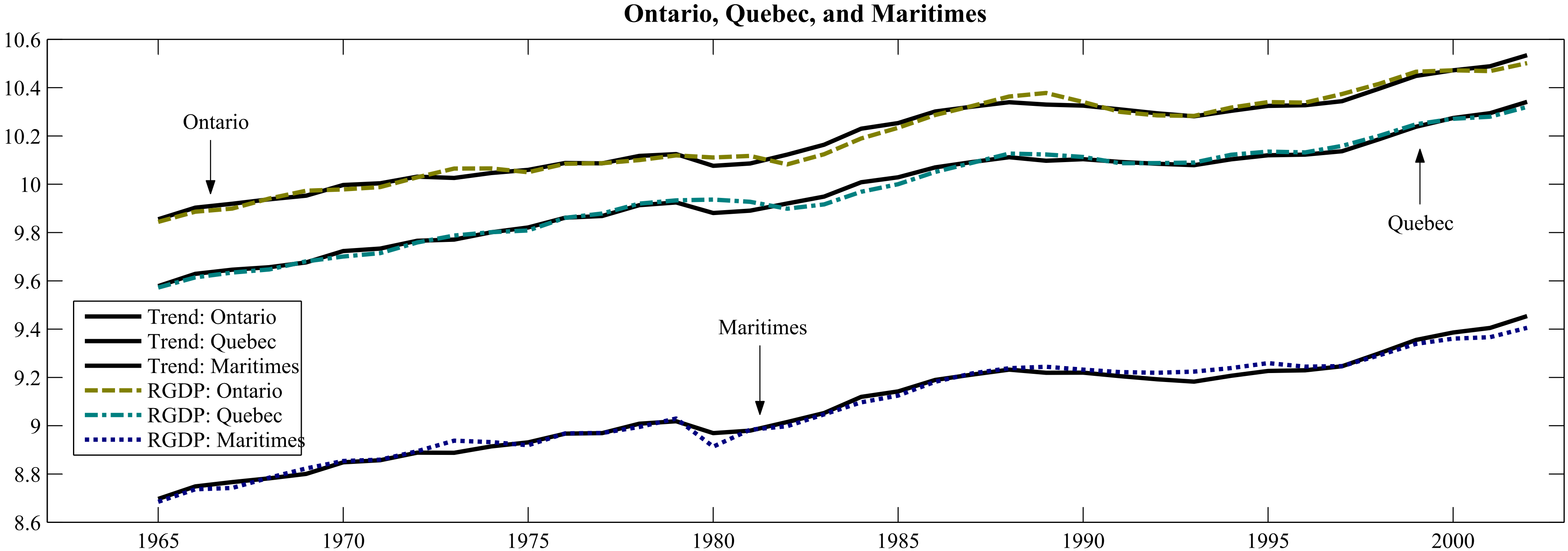


Figure 2: Canadian Regional Trends



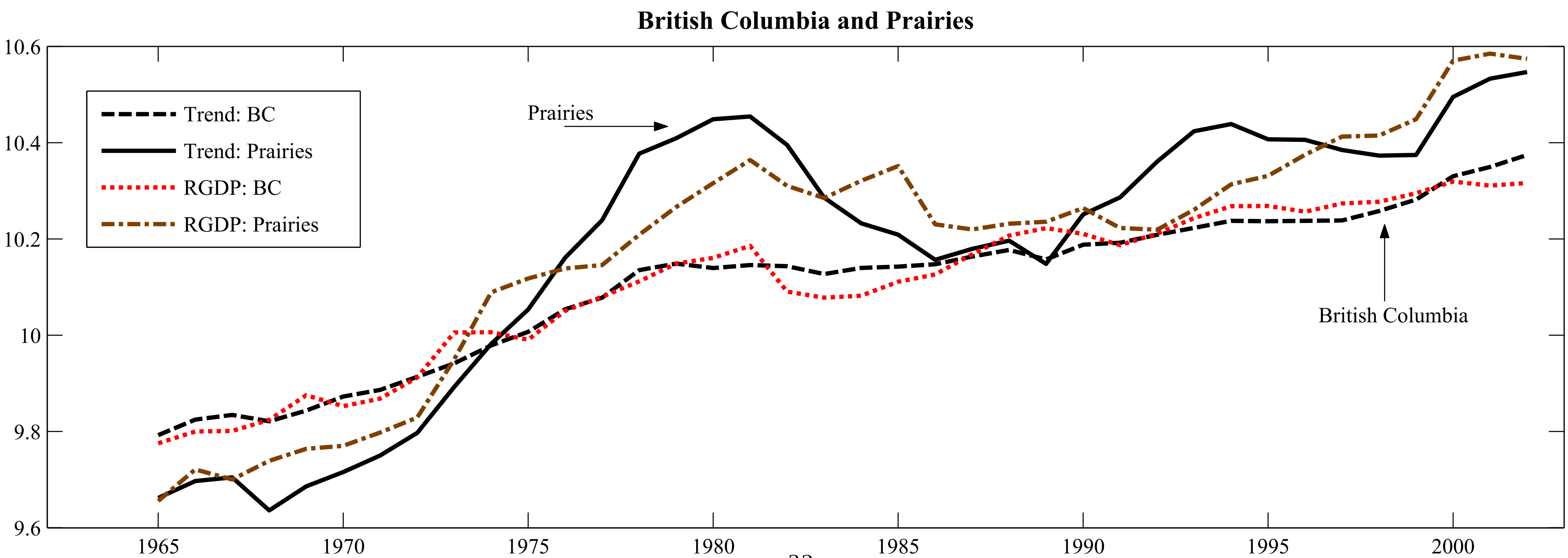


Figure 3: Canadian Regional Cycles

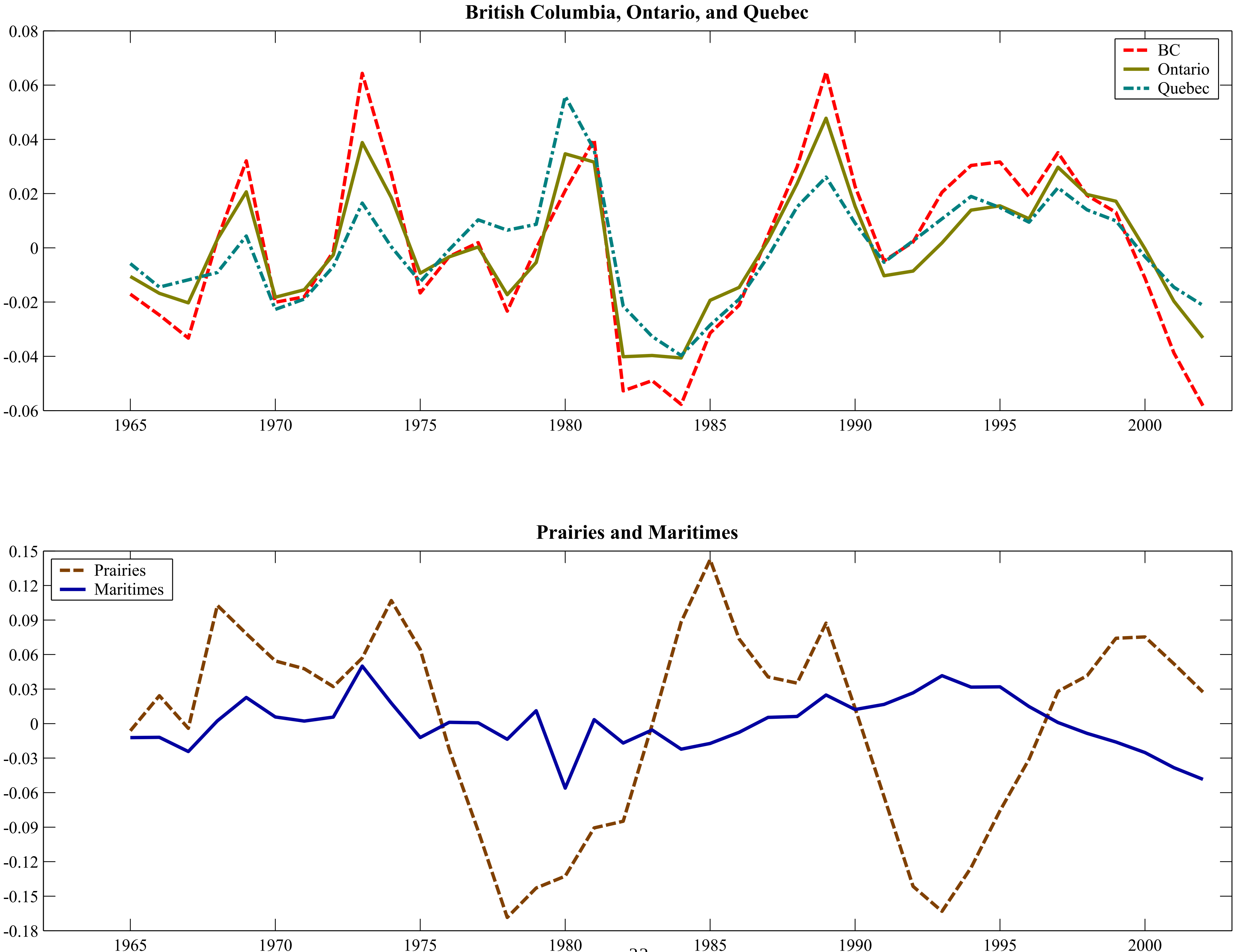


Figure 4: Canadian Trend and Cycle