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

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Working Paper 2004-5
February 2004

WORKING PAPER SERIES

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Abstract: It is generally accepted that convergence is well established for regional Canadian per capita outputs. The authors present evidence that long-run movements are driven by two stochastic common trends in this time series. This evidence casts doubt on the convergence hypothesis for Canada. Another prevalent belief is that Canada forms an optimal currency area (OCA). The authors uncover three serially correlated common cycles whose asymmetries suggest Canada is not an OCA. Their common trend–common cycle decomposition of regional outputs also 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 Prairie region. Thus, regional Canadian economic fluctuations are driven by a rich, diverse, and economically important set of propagation and growth mechanisms.

JEL classification: C32, E32, O47

Key words: Beveridge-Nelson-Stock-Watson-Vahid-Engle decomposition, common trends, serially correlated common cycles, long-run convergence, optimal currency area

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We thank Marco Del Negro for useful discussions and Jeremy Rudin for access to the equalization entitlement data. E.C. Wakerly acknowledges funding from the Faculty Research Program of the government of Canada. The views expressed here are the authors' and not necessarily those of the Federal Reserve Bank of Atlanta or the Federal Reserve System. Any remaining errors are the authors' responsibility.

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

1. Introduction

Canada is a fiscal and monetary union. The Government of Canada is responsible for monetary policy and operates a fiscal policy. Canadian regional governments run fiscal policies that are unconstrained by the national government. This institutional design is often justified by beliefs held about the sources and causes of economic fluctuations in Canada.

Assumptions about the dominance of aggregate shocks for Canadian business cycle and long-run fluctuations are key. One is that regional per capita incomes across Canada will converge in the long-run. Although the sources and causes of convergence of regional economies in Canada remains open to debate, Coulombe and Lee (1995), Lee (1996), Helliwell (1996), and Coulombe (1999), among others, argue that convergence will inevitably occur among the regions of Canada.[1]

This paper presents new evidence about the convergence of regional economies in Canada. We uncover two stochastic common trends in the (log level of) real per capita GDPs of British Columbia (BC), Ontario, Quebec, the Prairies, and the Maritimes in annual data that runs from 1961 to 2002. Since two trends produce common long-run movements in regional Canadian economies, there is neither a single source of long-run growth in Canada nor is long-run growth in one region of Canada independent of the others.[2] Thus, convergence is rejected as fundamental for Canadian regional output fluctuations.[3]

Implicit in discussions of the history of Canadian monetary policy is the belief that the regions of Canada form an optimal currency area (OCA) in the sense of Mundell (1961). Kouparitsas (2001) reviews the conditions to be met by an OCA. The conditions are that all geographic-economic units are subject

[1]Coulombe (1999) also adds that convergence will be impeded if regional-specific disparities in human capital are important.

[2]Carlino and Sill (2001) report similar results for U.S. regions using cointegration tests.

[3]Bernard and Durlauf (1995, 1996) give a working definition of convergence and provide conditions under which it can be identified in cross-section and time series models.

to a set of shocks common to all, 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.

We report on the claim that BC, Ontario, Quebec, the Prairies, and the Maritimes form an OCA. The outputs of these regions support three serially correlated common cycles. Thus, the first OCA condition is satisfied by our data and empirical model. However, the character of the common cycles is inconsistent with the third OCA condition. Further, our results indicate the serially correlated common cycles have asymmetric features.[4] First, transitory movements in BC, Ontario, and Quebec have one cycle in common. The Prairies region is related to another and the Maritimes to a third. Forecast error variance decompositions also reveal that transitory shocks to output in BC and the Prairies region remain economically important at forecast horizons of up to three years. At this horizon, trend shocks explain 93 percent or more of the variation in output in the other regions. These two results violate the second OCA condition.

Our focus on disaggregate fluctuations in Canada is motivated by Durlauf and Johnson (1994) and Quah (1996a, b). They argue that a focus on the macroeconomy ignores elements in the disaggregated economy that are important for aggregate fluctuations at the business cycle and growth horizons. Wakerly (2002) finds support for this view of Canadian trend and cycle. Her measures of disaggregated Canadian provincial and industry income dynamics indicate a lack of convergence and that these dynamics help to predict aggregate Canadian business cycle fluctuations. Scott (2001) provides similar evidence. He reports that the transitory component of Canadian regional outputs respond asymmetrically to money demand shocks. We follow their tack by using our estimates of the common trends and common cycles to test hypotheses about the fundamentals of regional and aggregate fluctuations in Canada. This allows us to analyze the extent of economically useful information in disaggregated Canadian outputs.

[4] U.S. regional data yields similar results, according to Kouparitsas (2001).

Our empirical model is the common trend-common cycle decomposition of Vahid and Engle (1993). They extend the Beveridge and Nelson (1981) decomposition and Stock and Watson (1988) common trends model to include common cycles. A special and important case of the Beveridge, Nelson, Stock, and Watson (BNSW) decomposition arises according to Vahid and Engle when the sum of common trends and common cycles equals the number of regional economies in Canada.

We construct and interpret our common trends-common cycles decomposition of Canadian regional outputs in light of the work of Vahid and Engle (1993), Engle and Issler (1995), and Issler and Vahid (2001). Their approach begin with tests for common trends based on the Johansen (1988, 1991) maximum likelihood methods. The next step employs canonical correlations to test for the common features that give rise to serially correlated common cycles, conditional on the cointegration restrictions. We find three cointegrating relations and two common features among the BC, Ontario, Quebec, Prairies, and Maritime outputs. This allows us to engage the BNSW-Vahid and Engle (BNSW-VE) decomposition.

The common trend-common cycle decomposition of Canadian regional outputs contains a few surprises. Innovations to the Ontario trend are nearly perfectly correlated with Maritime trend innovations. In the common cycle space, the BC and Ontario cycles are more highly correlated than any other regional pair, while the cycles of Ontario and the Prairie region are uncorrelated. Thus, our results reveal the richness of economic fluctuations across the Canadian regions. However, our results are at odds with consensus views about business cycle propagation and long-run growth mechanisms in Canada. A goal of this paper is to reconcile the consensus with our results.

The next section outlines our econometric approach to the decomposition of Canadian regional output fluctuations into trend and cycle. Section 3 presents empirical results. The connection between our decomposition of Canadian regional output fluctuations and monetary, economic development, and fiscal policy in Canada is discussed 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), Granger and Engle (1987), Stock and Watson (1988), Johansen (1988, 1991), Vahid and Engle (1993), and Engle and Issler (1995).

Stock and Watson (1988) develop a BN decomposition for an $n-$dimensional multivariate unit root time series, Z_t. Vahid and Engle (1993) consider the case in which Z_t possesses at least one cointegrating relation and between one and $n-1$ common feature relations. This implies there are at most $n-1$ common trends and at least one common cycle. When the sum of the common trends and common cycles equals the dimension of Z_t, Vahid and Engle (1993) show that the BNSW-VE decomposition is computed using nonlinear transformations of the cointegrating and common feature vectors and the levels data, Z_t.

Engle and Issler (1995) motivate their use of the BNSW-VE decomposition with the Long and Plosser (1983) multi-sector real business cycle (RBC) model.[5] Common trends arise when sectoral productivity shocks are cointegrated. Common cycles exist when the number of fundamental business cycle propagation mechanisms is less than the number of sectoral economies. This focuses the analysis on the impulse and propagation mechanisms of the disaggregate economy.

2.1 Common Trends Restrictions and the BNSW Decomposition

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

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

where Z_t^* is the deterministic component (which can include non-stochastic trends) of the $n-$dimensional

[5]Engle and Issler uncover distinct trends among U.S. industrial sectors, but they find similar cyclical behavior across these sectors. Barillas and Schliecher (2003) record similar results with the corresponding Canadian data.

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 (the common trends restriction), the pth$-$order levels VAR of (1) leads to a VECM of order $p-1$,

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

in the Granger and Engle framework. 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 EC response parameters δ.

We maintain that Z_t, (the log level of) Canadian regional per capita output $(n = 5)$, is $I(1)$. The growth rates of the elements of Z_t are $I(0)$ and jointly have a Wold representation

$$(3) \qquad \Delta Z_t = Z_t^* + A(\mathbf{L})\xi_t,$$

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

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

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 a well-known fact of $I(1)$ processes: the impact of a past shock never decays, 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 when 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, $1 \leq d < n$. This imposes d random walks on Z_t.[6] Granger and Engle (1987) call d the cointegrating rank, show

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

$q = n - d$ linear combinations of the elements of Z_t are $I(0)$, and collect the vectors that create the linear combinations into the $q \times n$ matrix α', whose rows are the cointegrating vectors. The cointegrating relations are stationary because α' and the BN decomposition (4) yield $\alpha' Z_t = \alpha' \mathcal{A}(\mathbf{L})\xi_t$, where the restrictions $\alpha' A(\mathbf{1}) = 0$ (or $B(\mathbf{1})A(\mathbf{1}) = 0$) follow from the cointegrating vectors being a basis of the null space of the (infinite) sum of the vector moving-average (VMA) of the Wold innovations of (4), under $d < n$. 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 a set of restrictions that wipe out cycles in Z_t. This implies only $I(1)$ components remain. At the same time, these restrictions 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, where the number of vectors restricts the common feature space. Pre-multiplying the growth rates version of the BNSW decomposition (4), $\Delta Z_t = A(\mathbf{1})\xi_t + \Delta\mathcal{A}(\mathbf{L})\xi_t$, by ϑ produces the common feature relations

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

A *common cycles* representation exists for Z_t when linear combinations of its growth rates are unpredictable, conditional on the appropriate history.[7] The restrictions $\vartheta' A_j = 0$, $\forall\, j \geq 1$, follow from $A_0 \equiv I_n$ and $A_{j+1} = \mathcal{A}_{j+1} - \mathcal{A}_j$, $\forall\, j \geq 0$.[8]

The common feature vector ϑ leads to a prediction about the common trends of Z_t. When the

[7] 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.

[8] 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.

BNSW decomposition (4) is pre-multiplied by ϑ', it yields

$$\vartheta' Z_t \quad = \quad \vartheta' \varepsilon_t. \tag{6}$$

Engle and Issler (1995) refer to equation (6) as a "trends generator" because linear combinations of $\vartheta' Z_t$ are driven only by scalar multiples of the accumulated Wold innovations, which are fundamental for Z_t.

A special case of the BNSW decomposition arises when $n = d + f$. Vahid and Engle (1993) show there is a simple way to compute a common cycle-common trend BNSW decomposition of Z_t in this case. Begin with the $n \times n$ matrix

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

where $\Psi_{\cdot,d}$ contains the d right most columns. The inverse exists because α' and ϑ' are linearly independent by construction. The BNSW-VE decomposition is recovered from

$$Z_t \quad = \quad [\Psi_{\cdot,n-d} \quad \Psi_{\cdot,d}][\Psi_{\cdot,n-d} \quad \Psi_{\cdot,d}]^{-1} Z_t \quad = \quad [\Psi_{\cdot,n-d}\vartheta' \ + \ \Psi_{\cdot,d}\alpha'] Z_t. \tag{7}$$

Since $\vartheta' Z_t$ is the trend generator and $\alpha' Z_t$ is the cycle generator, the BNSW-VE common trends and common cycles are $\mu_t = \Psi_{\cdot,n-d}\vartheta' Z_t$ and $\tau_t = \Psi_{\cdot,d}\alpha' Z_t$, respectively.[9]

2.3 A Structural Interpretation of the Common Cycles Restrictions

Common cycles impose testable cross-equation restrictions on the VECM of (2). An implication of common cycles is a reduction in VECM parameters. This follows from restrictions the common feature vectors ϑ' place on the first f equations of the VECM of (2), which can be used to test for common features.

Vahid and Engle (1993) exploit these restrictions to test for common features. Their approach creates a "structural" VECM by stacking these f simultaneous equations on top of the remaining $n - f$ "reduced form" VECM regressions. This yields

[9] Proietti (1997) develops methods to calculate BNSW decompositions when $n \neq d + f$.

$$
\text{(8)} \qquad \begin{bmatrix} \mathbf{I}_f & \widetilde{\vartheta} \\ \mathbf{0}_0 & \mathbf{I}_{n-f} \end{bmatrix} \Delta Z_t = \begin{bmatrix} \mathbf{0}_Z & \mathbf{0}_{\Delta Z} \\ \widetilde{\delta}\alpha' & \widetilde{\mathcal{B}}(\mathbf{L}) \end{bmatrix} \begin{bmatrix} Z_{t-1} \\ \Delta Z_{t-1} \end{bmatrix} + \xi_t,
$$

where the common feature vectors are normalized as $\vartheta = [\mathbf{I}_f \ \ \widetilde{\vartheta}]$, $\widetilde{\vartheta}$ is $(n - f) \times f$, and the zero matrices $\mathbf{0}_0$, $\mathbf{0}_Z$, $\mathbf{0}_{\Delta Z}$ are $(n - f) \times f$, $f \times (n - d)$, and $(n - f) \times np$, respectively. Since tests for common features are equivalent to a test of the structural model (8) against the unrestricted VECM (2), common features tests have a likelihood ratio (LR) test interpretation. We present these tests, cointegration tests, and the resulting BNSW-VE decomposition for Canadian regional outputs in the next section.

3. Regional Trends and Cycles in Canada

This section presents tests for common trend-common cycles in Canadian regional real per capita GDP. We also report estimates of the cointegrating and common feature relations, summary statistics of the BNSW-VE common trend-common cycle decomposition, and forecast error decompositions (FEVDs) of Canadian regional outputs with respect to innovations in their trends and cycle.

Our common trend and common cycle tests use the logs of five regional Canadian real per capita GDPs for the $1965 - 2002$ annual sample. Third-order VECM estimates are conditioned on data from $1961 - 1964$. The provinces of British Columbia (BC), Ontario, and Quebec stand on their own. Alberta, Manitoba, and Saskatchewan comprise the Prairies region. Newfoundland, New Brunswick, Nova Scotia, and Prince Edward Island form the Maritime region. The nominal provincial GDP (income-based) data of the five regions is divided by regional population series, and deflated into constant 1997 Canadian dollars. The appendix details our data sources and construction.

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 left window contains BC, Ontario, Quebec, and Prairie outputs. Maritime output is shown in the top right window. BC, Ontario, Quebec, and Maritime output growth rates appear in the bottom left window. The bottom right window plots Prairie growth rates.

The way we organize figure 1 anticipates the results of our tests for common trends and common cycles. The regional outputs all trend up, but the Prairies and the Maritimes show larger wiggles than BC, Ontario, and Quebec. The top left window of figure 1 also shows that output in Quebec has caught up to BC by the end of the sample. Nonetheless, all the series are persistent.[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 move together with the exception of a large negative spike in the Maritime growth rate in 1980. Similar spikes occur in BC, Ontario, and Quebec growth rates two years later. Prairie growth rates appear to move inversely with growth rates in the other Canadian regions. Our conjectures about the observed behavior of the Canadian regional real per capita GDP in levels and growth rates deserve more formal examination.

3.1 Common Trend Tests

Table 1 reports results of Johansen (1988, 1991) cointegration tests based on regional Canadian output data. The tests are conditional on a VECM(3) restricted according to Case 1 of Osterwald-Lenum (1992), which allows for deterministic trends in Z_t. A test of the null of no deterministic trends – a Case 1* model – against the alternative of the case 1 model yields a test statistic of 7.28 with a p-value of 0.0263 (on two degrees of freedom). These results reject the null at a three percent significance level.

Johansen (1988, 1991) develops two LR tests for cointegration based on $\lambda-$max and trace statistics.

[10]Augmented Dickey-Fuller regressions of the GDP series provide no evidence against the unit root null at the ten percent significance level. Stock (1991) 95 percent asymptotic confidence intervals of the largest AR root all include one.

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

Table 1 presents these test statistics and the associated MacKinnon, Haug, and Michelis (1999) five percent (asymptotic) critical values, conditional on the Case 1-VECM(3).[12] The $\lambda-$max and trace statistics are unable to reject three cointegrating relations at the five percent level. Three cointegrating vectors endow the Canadian regional outputs with two common trends. Thus, the hypothesis that the five Canadian regional outputs are driven by more than one common trend cannot be rejected at a conservative significance level.

Bernard and Durlauf (1995, 1996) show that time series tests of convergence, which focus on long-run forecasts of outputs, are appropriate for a set of economies close to their steady states (e.g., developed economies).[13] Since Canada can be counted as a developed economy during our sample, the regional economies of Canada fit the Bernard and Durlauf rubric. Thus, the cointegration tests we report for Canadian regional outputs represent evidence against the convergence hypothesis.

Coulombe and Lee (1995), Lee (1996), and Helliwell (1996) argue convergence has occurred in terms of regional outputs in Canada. These arguments are based on cross-section analysis and represent the consensus. For example, Coulombe (1999) claims that "convergence across the provinces is a fundamental economic phenomenon."[14] Besides the Bernard and Durlauf (1996) critique that cross-section analysis applies best to developing economies in transition, den Haan (1995) shows that this class of convergence

[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]The cross-section regression of Barro and Sala-i-Martin (1991) has been applied to tests for convergence in the Canadian context. Typically, this is the $\beta-$convergence regression of annual average per capita output growth of region j on a constant and the log level of its initial per capita output. It is similar to the long-horizon regression used to find predictors of stock returns. Hodrick (1992) shows this regression has poor small sample properties. A negative and significant slope coefficient is taken as support for the convergence hypothesis because rich economies grow more slowly than less well-off economies. This version of the convergence hypothesis relies on the neoclassical growth model which predicts that per capita output driven by aggregate shocks achieves its steady state in the long-run; see Solow (1956) and Swan (1956). Implicit is the notion the economies being studied are in transition, far away from their steady states.

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

tests is biased toward the null for economies subject to more than one shock. It is reasonable to maintain that Canada fits this class of economies because it is subject to open economy and regional shocks, as well as monetary and fiscal policy disturbances.

3.2 Common Cycle Tests

Our evidence against convergence of Canadian regional outputs indicates there are three cointegrating relations among the five Canadian regional per capita outputs. This suggests three common cycles generate transitory fluctuations in the regional economies of Canada. We use tests for common cycles 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), which are LR tests according to the restricted VECM (8).

Common feature tests rely on canonical correlations, λ, of BC, Ontario, Quebec, Prairies, and Maritime output growth constructed conditional on the VECM(3) information set. The null is growth rates share a common feature, represented by $\lambda = 0$. The tests are $-(T-4)\sum_{i=1}^{f} ln(1-\lambda_i^2)$ which is asymptotically distributed $\chi^2(f^2+5f)$, where f runs from the smallest to largest λ_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 canonical correlations and two tests for common features, a χ^2 test and Rao's $F-$test. These tests indicate the common features null is rejected for the three largest (squared) canonical correlations. The two smallest are not statistically different than zero. We conclude the common feature rank of Canadian regional output growth rates is two. Thus, Canadian regional outputs share three serially correlated common cycles. This suggests there are three business cycle propagation mechanisms in Canada, using the Engle and Issler (1995) multi-sector technology framework.

The existence of three serially correlated common cycles raises questions about Canada being an OCA. Although the cycles are common, we find the common cycles have asymmetric effects. Thus, there is conflicting evidence about a Canadian OCA. The rest of this section presents evidence about the third condition for an OCA: the response of the Canadian regional outputs to the common cycle shocks.

3.3 The Canadian Regional BNSW-VE Decomposition

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 (nonsingular) matrix $[\Psi_{\cdot,3} \quad \Psi_{\cdot,2}]$. Thus, we can compute the BNSW-VE decomposition of (7) to generate the common trends and common cycles of BC, Ontario, Quebec, Prairie, and Maritime outputs.

The correlations of the trend innovations of Ontario, Quebec, and the Maritimes are greater than 0.95. The trend innovations of Ontario, Quebec, and the Maritimes are negatively correlated (-0.34, -0.07, and -0.23, respectively) with Prairie trend innovations. 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 BC and Prairie trend innovations is positive and large, equal to 0.83.

These correlations are reflected in the plots of the log levels of the regional GDPs and the associated trends in figure 2. There are several striking aspects to figure 2. The trend paths of Ontario, Quebec, and the Maritimes are similar, albeit with different initial levels of per capita output in 1965. These trends show a downturn around the time of the second oil price shock and a peak in 1988. The trough that follows occurs in 1993. It is worth pointing out that the 1988 peak and 1993 trough in the Ontario, Quebec, and the Maritimes trends are prior to the dates Fortin (1996, 1999) claims for the ‘Great Canadian Slump’ of $1990-1996$.

The volatility of the Prairies trend and the lack thereof in the BC trend are other features of figure 2 that stand out. Volatility in Prairie trend growth is twice that of the Maritimes, the second most volatile trend. The Prairies trend also shows a peak around 1980-1981, followed by a deep trough that persists for the rest of the 1980s; see the bottom left window of figure 2. The BC trend exhibits similar behavior (see the top left window of figure 2), except that its 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 once again.

We present plots of the common cycles in figure 3.[15] The top window contains the BC, Ontario, and Quebec serially correlated common cycles. The BC, Ontario, and Quebec cycles display a high degree of comovement. The smallest contemporaneous correlation among these three cycles is 0.82. These cycles possess a steep *transitory* contraction during the first half of the 1980s. There is cyclical peak in 1989, a trough in 1991, and the recovery from this contraction peaks in the mid-1990s. These are not the dates on which Fortin (1996, 1999) focuses his arguments about the 'Great Canadian Slump' of $1990 - 1996$. 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. The correlation of these cycles is -0.16. The Prairies cycle is also nearly uncorrelated with BC and Ontario and negatively correlated (-0.43) with the Quebec cycle. The correlation of the BC, Ontario, and Quebec cycles with the Maritime cycle is 0.66, 0.44, and 0.26, respectively.

A focus on these correlations fails to acknowledge the different character of regional cycles across Canada. For example, the Prairie cycle is the most volatile. Its standard deviation is nearly three times larger then the next largest (BC's). Also, the Prairie cycle is the most persistent. Its AR1 coefficient implies the half-life of a shock to the cyclical component is about 3.5 years. The cycles of the other regions are not persistent because the half-lives of these components are only one year.

The BNSW-VE decomposition also helps us resolve questions about specific episodes in Canadian regional economic fluctuations. Recall that figure 1 shows a trough in the level of Maritime output (upper right window) and a spike of -11.63 percent in Maritime output growth (the dotted line of the lower left

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

window) in 1980. The BNSW-VE decomposition reveals that the collapse in Maritime economic activity in 1980 is split between its -4.90 percent trend growth rate (the solid line of the lower right window of figure 2) and a trough of -5.61 percent in its cycle (the solid line of the bottom window of figure 3). Thus, common trends and common cycles provide useful information about the decomposition of the fundamentals of regional output fluctuations.

The correlations of the regional trend innovations and cycles are explained by the factor loadings on the normalized EC terms found in the last three rows of table 4.[16] The factor loadings show that the first and second, first, and second and third cointegrating relations contribute most to cyclical variation in BC, Ontario, and Quebec, respectively. Factor loadings on the first and second normalized Prairie EC terms are large (in absolute value terms) compared to all but the coefficient on the first normalized Maritime EC term. Thus, fluctuations in the latter normalized EC term drives the Maritime cycle. The first and second normalized EC term are responsible for transitory fluctuations in the Prairie region.

3.4 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 a weighted average of the five regional Canadian trends and cycles. The weights are the regional GDP shares (in total regional GDP).[17]

The top window of figure 4 contains the aggregate trend and (log level of the) aggregate per capita GDP in constant 1997 dollars. Aggregate real output is below trend from 1975 to 1985. This relationship is reversed for the $1985 - 1991$ period. Note also that a Canadian 'slump' appears to have occured during 1988-1989, not during the early 1990s. By 2002, aggregate real output and the weighted average trend are

[16]The cointegrating relations are standardized prior to their use as regressors in the VECM(3).

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

nearly equal, subsequent to the latter being below the former in the latter part of the 1990s.

The weighted-average aggregate common cycle and the difference between aggregate Canadian real GDP and the aggregate weighted-average trend appear in the bottom window of figure 3. The former (latter) cycle is plotted as a solid line (dotted line). These cycles move together (the correlation is 0.85), but the weighted-average aggregate cycle shows little persistence. Its AR1 coefficient is 0.54. The 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 recovery from the cyclical trough of 1992 peaks subsequent to 1995, followed by a transitory downturn that has not reached a bottom by 2002. Although the cycle from the mid-1990s through 2002 is long-lived, the business cycle of the late 1980s and early 1990s is three years long from peak to trough (or trough to peak). Since table 8.1 of Abel, Bernanke, and Smith (1999) indicates that a business cycle of this length is typical during the post-World War II period in Canada, we argue that the business cycle of $1989-1995$ was not an extraordinary event.

3.5 Canadian Regional Forecast Error Variance Decompositions

The last bit of information we extract from the BNSW-VE decomposition of Canadian regional outputs are forecast error variance decompositions (FEVDs). The FEVDs are found in table 5.[18] The FEVDs show that the responses of Ontario, Quebec, and the 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

[18] Engle and Issler (1995) and Issler and Vahid (2001) outline methods to calculate the FEVD. These authors set the trend innovation equal to the first difference of the common trend at the one-quarter 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.

by trend shocks. This reflects the Ontario, Quebec, and Maritime trend plots of figure 2.

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 to 90 percent or more of the fluctuations in BC and Prairie outputs. Although trend shocks dominate regional fluctuations in Canada in the medium- to long-run, there are asymmetric responses to trend disturbances across Ontario, Quebec, and the Maritimes and BC and the Prairies. Thus, the lack of symmetry of the FEVDs with respect to the trend shock provides evidence against the OCA hypothesis for Canada.

4. Predicting Canadian Regional Trends and Cycles

There exist a bevy of conjectures that compete to explain the disparity, or lack thereof, of Canadian regional economic activity. This section seeks to resolve these conflicts by testing the ability of some of these propositions to predict future movements in our estimates of Canadian regional trends and cycles. We consider claims about the impact of equalization entitlement payments (e.g., the federal-provincial tax-transfer scheme), aggregate total factor productivity (TFP) growth, and identified money demand and money supply shocks on regional trend growth and regional cycles in Canada.

Tests of these conjectures are conducted using exclusion tests. [19] An exclusion test represents a null that must necessarily be rejected, say, for the hypothesis that equalization payments matter for Canadian regional trend and cycle fluctuations. We also examine claims that greater regional economic activity leads to more immigration and that hosting an Olympic games is a boon to regional economic activity in Canada.

The null hypotheses are that the equalization entitlement program, TFP growth, an identified money demand shock, and an identified money supply shock have no predictive content either for Canadian regional trend growth or for Canadian regional cycles. Test statistics are based the regression

[19] Pesaran, Pierse, and Lee (1993) test similar propositions using cross-equation restrictions in a structural time series model.

$$(9) \qquad W_t \;=\; \theta_0 \;+\; \sum_{i=1}^{\ell}\theta_{\tau,i}\, y^{\tau}_{j,t-i} \;+\; \sum_{i=1}^{\ell}\theta_{X,i}\, X_{t-i} \;+\; \vartheta_t,$$

where W_t is either $\Delta y^{\mu}_{j,t}$ or $y^{\tau}_{j,t}$, j = BC, Ontario, Quebec, Prairies, and Maritimes, X contains the variable identified with the associated hypothesis, and ϑ_t is a mean zero, homoskedastic error. The regressions condition on two lags of the regional cycle, $y^{\tau}_{j,t}$, to eliminate serial dependence in W_t. We compute $F-$statistics that $\theta_{X,1}$ and $\theta_{X,2}$ jointly equal zero to test the null.

To summarize the results of these tests, only an identified money demand shock helps predict future movements in the common cycles of the Canadian regions. Lags of the (log of the) ratio of Quebec, Prairie, and Maritime equalization entitlements to total equalization entitlements, lags of TFP growth, and lags of an identified money supply shock do not yield systematic rejections of the null across the Canadian regions. Thus, we obtain no support for claims that economic development policy or monetary policy matter for regional Canadian fluctuations over either the short-, medium-, or long-run. The inability of TFP growth to predict the common trends and common cycles also suggests the BNSE-VE decomposition has uncovered the fundamentals of regional Canadian outputs.

An important feature of Canadian economic development policy is the equalization entitlement program that attempts to smooth out regional economic disparities. We estimate 30 regressions – trend growth or cycle from the five regions on two lags of the Quebec, Prairie, and Maritime equalization ratios and two lags of the relevant cycle – to discover only lags of the fraction of Prairie equalization entitlements to the total help to predict the Maritime cycle. Since the p-value of the associated $F-$test is 0.12, there is little evidence equalization entitlement payments predict regional fluctuations. These tests question Coulombe's (1999) claim, among others, that the tax and transfer equalization scheme the Canadian national government has operated since the 1950s has helped to promote convergence among the regional economies of Canada. [20]

[20]The Constitution Act of 1982 enshrines this as an objective of fiscal policy; see Coulombe and Lee (1995).

We also find no support for the proposition that this tax-transfer program matters for economic activity in Canada, conditional on our common trend-common cycle decomposition.

There is no evidence that lags of aggregate Canadian TFP growth predict future movements in Canadian regional trend growth or cycle.[21] However, lags of the BC, Ontario, and Quebec regional cycle predict the future path of aggregate TFP growth.[22] The p-values of these $F-$tests are 0.038 or smaller. Note that BC, Ontario, and Quebec represent 65 percent or more of aggregate Canadian output. Thus, one of the three serially correlated common cycles we identify matters for aggregate transitory fluctuations in Canada.

Our identification of money demand and money supply shocks follows standard practice. We estimate an unrestricted VAR(1) of the log of real GDP, $90-$day Canadian T$-$Bills, and the log ratio of currency to the GDP deflator to extract the orthogonalized money demand shock series.[23] These variables reflect the information set of a typical money demand function.[24] The money supply shock is based on an unrestricted VAR(1) of the log of the consumption$-$output ratio, inflation (GDP deflator), the US$-$Canadian dollar exchange rate, and the bank rate.[25] Given the consumption$-$output ratio proxies for transitory aggregate demand, these variables describe the information set used to construct Taylor rules for Canada; see Côté, Lam, Liu, and St-Amant (2002).

We obtain almost no evidence that identified money demand and money supply shocks matter for

[21]TFP equals the log of real GDP minus the sum of the logs of capital's and labor's share.

[22]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 mismeasured. Nonetheless, our TFP measure reflects aggregate fluctuations in Canada, net of capital and labor factor input shares. 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 unknown impact on the properties of the estimators and test statistics.

[23]A constant and a linear time trend are included as regressors in the VAR(1).

[24]The ordering places the money demand shock subsequent to the real-side and financial-side shocks.

[25]The VAR employs an intercept, but not a time trend.

Canadian regional trends. Lags of the identified money demand and money supply shocks fail to predict BC, Ontario, and Quebec trend growth. The former (latter) shock possesses information about the future path of Prairie (Maritime) trend growth, 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 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.

The null that identified money demand shocks do not predict future movements in BC, Ontario, Quebec, and Maritime cycles is rejected. The p-values of the $F-$tests are 0.01, 0.02, 0.10, and 0.05, respectively. The p-value of this test for the Prairies is 0.67. We regard this as evidence that aggregate money demand shocks matter in some way for Canadian regional cycles. This evidence is consistent with results uncovered by Ambler, Dib, and Rebei (2003). They report that money demand shocks account for more than half of the variation of Canadian output. The upshot is this evidence questions claims that Canadian monetary policy – systematic or otherwise – helps to forecast output fluctuations in the aggregate or the regional level. Instead, it is Canadian money demand shocks that have predictive content.

The results of the exclusion tests using lags of identified money supply and demand shocks provides insights into the debate between Fortin (1996, 1999) and Freedman and Macklem (1998) about the impact of the Bank of Canada on economic activity in Canada. Fortin claims that monetary policy created a recession during the late 1980s and early 1990s in Canada that was the deepest in more than 50 years. Freedman and Macklem point to long-run technology and medium- to long-run fiscal factors to explain aggregate fluctuations in Canada during the 1990s. Our results support the Freedman and Macklem's position because the common trends help to predict aggregate output (net of capital's and labor's share). Only money demand shocks can predict future cyclical regional Canadian output fluctuations.

A necessary condition of Fortin's position is that money supply shocks help 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, we reject the contention that the Bank of Canada is to be held responsible for either expansions or contractions in real economic activity across the regions of Canada at any moment in our sample period.

Freedman and Macklem (1998) argue that changes in technology and the poor fiscal position of governments are the culprits most likely responsible for weaknesses in the Canadian economy during the early 1990s. Although we are unable to directly comment on these hypotheses, we are able to examine the nature of the last recession in Canada relative to earlier ones. Figures 3 and 4 provide visual evidence that the recession of the early 1990s in Canada was most severe in the Prairies, followed by Ontario, more moderate in BC and Quebec, and non-existent for the Maritimes. When compared to the recession of the early and mid-1980s, the last recession in Canada appears to be mild given either a regional or aggregate perspective. For example, the Ontario (aggregate) cycle troughs at negative four percent (or more) in the early 1980s and negative one (two) percent ten years later. Thus, a failure to account for the disaggregate dynamics we find in regional common trends-common cycles creates a misleading view of economic activity in Canada.

We test two other claims made about regional trends and cycles in Canada. First, Helliwell (1996) argues that variation in regional growth rates leads to similar immigration patterns across Canada. We find no evidence to support this claim, given W_t is the (log of the) ratio of regional immigration to total immigration. Regional cycles also lack information to forecast regional immigration in Canada because the exclusion tests produce p-values greater than or equal to 0.57.[26] This implies immigration policies meant to promote economic activity should be viewed skeptically.

The last claim we study is that hosting an Olympics game induces greater economic activity. For

[26]Tests that lags of regional immigration predict regional trend growth or cycle have p-values of 0.76 or more.

example, the BC Minister of State for the 2010 Olympic Bid (2002) argues that,

> ... 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.

We examine this conjecture using observations from the 1976 Montreal Summer Olympics and 1988 Calgary Winter Olympics. A sequence of dummy variables is constructed that equals one for the $1971-1976$ $(1983-1988)$ subsample and zero otherwise, that equals one for the $1972-1976$ $(1984-1988)$ subsample, and so on to test the impact of the 1976 Montreal Summer Olympics (1988 Calgary Winter Olympics) on Quebec's (the Prairies') trend and cycle.[27] When trend growth, $\Delta y^{\mu}_{Quebec,t}$ or $\Delta y^{\mu}_{Prairies,t}$, is the dependent variable, the dummy variables are applied to the intercept of regression (9). The $t-$ratio of the intercept dummy is informative about the impact of an Olympic games on mean trend growth. A test of the impact of hosting an Olympic games on the persistence of the cycle interacts the dummy variable with lags of the regional cycle of regression (9), given $W_t = y^{\tau}_{Quebec,t}$ or $y^{\tau}_{Prairies,t}$.

The results of the $t-$ and $F-$tests do not support the hypothesis that hosting an Olympic games has a positive effect on regional economic activity. There is no evidence that the 1976 Montreal Summer Olympics had a non-zero impact on either the Quebec trend or cycle. The p-values of the relevant $t-$ratios and $F-$tests are all greater than 0.31. The same is true for the $F-$ tests of the dummy variables crossed with $y^{\tau}_{Prairies,t-1}$ and $y^{\tau}_{Prairies,t-2}$. The smallest p-value is 0.32 in this case. The p-values of four of the six $t-$tests of the 1988 Calgary Winter Olympics games dummy on Prairie mean trend growth are less than 0.03. It is interesting that the estimates of these dummy variables are negative and larger than the sample mean of Prairie trend growth. Thus, we have evidence that hosting an Olympic games either has no effect on economic activity or lowers mean trend growth. Any guidance we might give about the weight to attach to the latter result is only supposition on our part.

[27] This implies the award of the Olympics was six years prior to its start. The 2010 Olympics was awarded in 2003.

5. Conclusions

This paper studies Canadian regional trends and cycles. Our data consists of BC, Ontario, Quebec, Prairies, and Maritime constant dollar per capita outputs from $1961 - 2002$. We employ the Vahid and Engle (1993) common trends-common cycles model, which builds on the Stock and Watson (1988) common trends model generalization of the Beveridge and Nelson (1981) decomposition. Tests for cointegration follow the maximum likelihood methods of Johansen (1988, 1991). Vahid and Engle (1993) and Engle and Issler (1995) are the sources for the common feature tests. Engle and Issler also provide a macro model framework in which to think about the fundamentals of common trends and common cycles.

We find the five Canadian regional outputs share two common trends (two common feature vectors) and three serially correlated common cycles (three cointegrating vectors). This casts doubt on the convergence hypothesis for the regions of Canada because the source of the impulse to Canadian long-run growth is two fundamental shocks. Canadian regional outputs also reveal trend paths that either fail to catch up, notably Quebec and the Maritimes compared to Ontario, a more volatile path in the Prairies, or a flatter path, which leads BC to lag all but the Maritimes by 2002.

The three serially correlated common cycles indicate that there are three propagation mechanisms across the five regions of Canada. One of the three serially correlated common cycles groups BC, Ontario, and Quebec together. The other two common cycles are found in the Prairie and Maritime regions. The persistence and volatility of the common cycles differ across the Canadian regions. This is not the only source of the asymmetries we find. The asymmetric forecast error variance decompositions of the regional outputs indicate Canada is not an optimal currency area.

The lack of support for a Canadian optimal currency area does not imply there is neither a need for a unitary currency in Canada nor a 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 serially correlated common cycles matter for aggregate fluctuations. Thus, it is not enough for Canadian monetary policy to stress movements in the difference between aggregate output and its trend. Rather, our evidence suggests that the Bank of Canada should focus on the need to balance aggregate price stability against the possible welfare implications of serially correlated common cycles.

We also examine various claims made about the sources and causes of trend and cycle movements across the regions of Canada. The evidence we obtain lends support to the view that fundamentals 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 technology and (money) demand shocks 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 point to a new approach to study regional economies in Canada. Since the time series econometric methods we employ provide a view of Canadian regional trend and cycle in which economic primitives dominate, greater emphasis on building dynamic stochastic general equilibrium models to study regions fluctuations and the welfare effects of monetary, economic development, and fiscal 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

Case 1 of Osterwald-Lenum (1992)

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

* Denotes significance at the five percent level. Tests are based on a Case 1-VECM(3). 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/*.

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.

Table 3. Bases for Cointegration and Common Feature Spaces

	BC	Ontario	Quebec	Prairies	Maritimes
Coint. 1	1.0000	0.8231	-0.2816	-0.2362	-0.9480
Coint. 2	-0.0671	1.0000	-0.8138	0.1184	-0.1642
Coint. 3	-1.0530	0.4553	1.0000	0.2724	-0.9259
Comfeat. 1	2.6237	-10.6280	8.8153	1.0000	0.8274
Comfeat. 2	-1.0909	-1.0811	2.7723	0.2882	1.0000

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

	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
$Std(y_j^{\mu})$	0.0175	0.0235	0.0217	0.0570	0.0237
$Std(y_j^{\tau})$	0.0315	0.0224	0.0195	0.0851	0.0231
$Corr(y_j^{\mu}, y_j^{\tau})$	-0.1003	-0.4929	-0.5760	-0.2344	-0.2815
$AR1(y_j^{\tau})$	0.5328	0.5032	0.6096	0.8195	0.5226
Normalized EC Factors					
Coint. 1	0.0086	-0.0048	-0.0014	0.0168	-0.0282
Coint. 2	-0.0078	-0.0017	0.0026	-0.0220	-0.0043
Coint. 3	0.0010	0.0027	0.0025	0.0024	0.0026

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

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-quarter 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.

A1. Data Appendix

Current dollar provincial GDP data is available from Statistics Canada. We take this data from the Chass-CanSim website supported by the University of Toronto. A problem is that Statistics Canada no longer provides a long-annual continuous and consistent provincial GDP times series. Discontinued current dollar provincial GDP data (income-based) begins in 1961 and end with 1996. Extant current dollar provincial GDP data (income-based) begins in 1981 and end with 2002. On the advice of Ms. Catherine Bertrand (of the Income and Expenditure Accounts Division, Statistics Canada), we splice these series together for each province. The provincial current dollar GDP series we construct runs from 1961 to 2002. The $1981-2002$ subsample is the extant current dollar provincial GDP data (income-based), CanSim table number 3840001. For the $1961-1980$ subsample, the discontinued current dollar provincial GDP series (income-based, CanSim table number 3840014) is multiplied by the ratio of the 1981 extant current dollar provincial GDP observation to the 1981 extant current dollar provincial GDP observation.

Provincial population data is taken from the Chass-CanSim website (CanSim II table number 510005). This data is available quarterly, $1951Q1-2002Q4$. We temporally aggregate from the quarterly to the annual frequency. Per capita provincial GDP series equals the ratio of our BC, Ontario, and Quebec provincial current dollar GDP data to the associated annual population data. Prairie (Maritime) current per capita dollar GDP is the sum of Alberta, Manitoba, and Saskatchewan (New Brunswick, Newfoundland, Nova Scotia, and Prince Edward Island) GDPs divided by the sum of the population series of the same provinces. Note that provincial immigration data is found in CanSim II table number 510008.

Constant dollar per capita GDP series employs the annual implicit GDP deflator, table number 3800056. The base year is 1997. The constant dollar capital stock data is available in CanSim II table number 310002. The employment data is a combination of data made available by the Bank of Canada and Statistics Canada. Consumption equals durables, semi-durables, non-durables, and services is constant dollar, as CanSim II series v1992229. The monetary aggregates and interest rates are found either at the Bank of Canada webpage or StatsCan data bank. The 90 day T-bill is the Treasury bill auction, average yields over three months, CanSim II series V122484. CanSim II series V37426 is the US dollar/Canadian dollar exchange rate. Provincial equalization entitlement data is generously provided by Dr. Jeremy Rudin of the Ministry of Finance, Government of Canada.

Figure 1: Canadian Regional Real GDPs

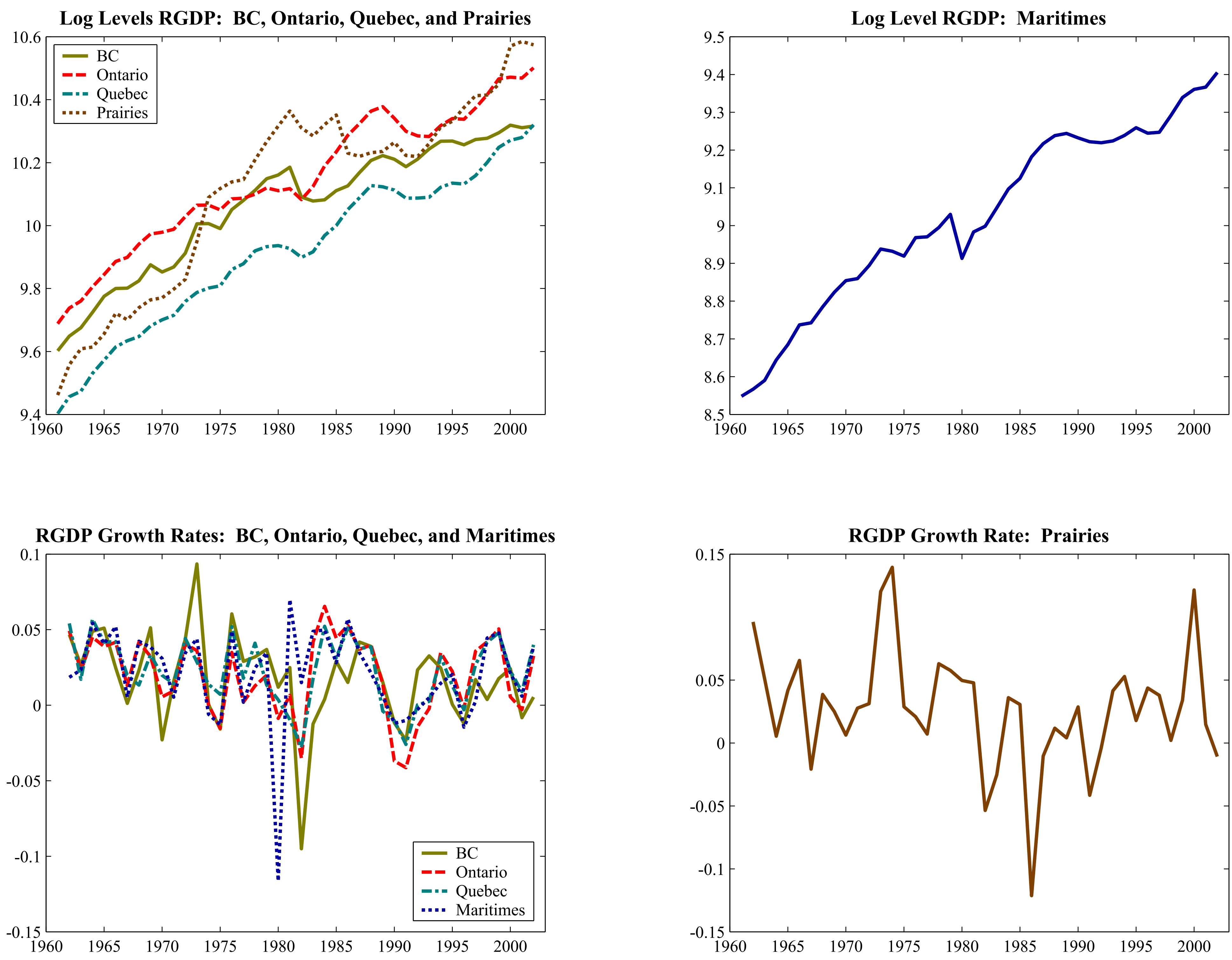

Figure 2: Canadian Regional Trends

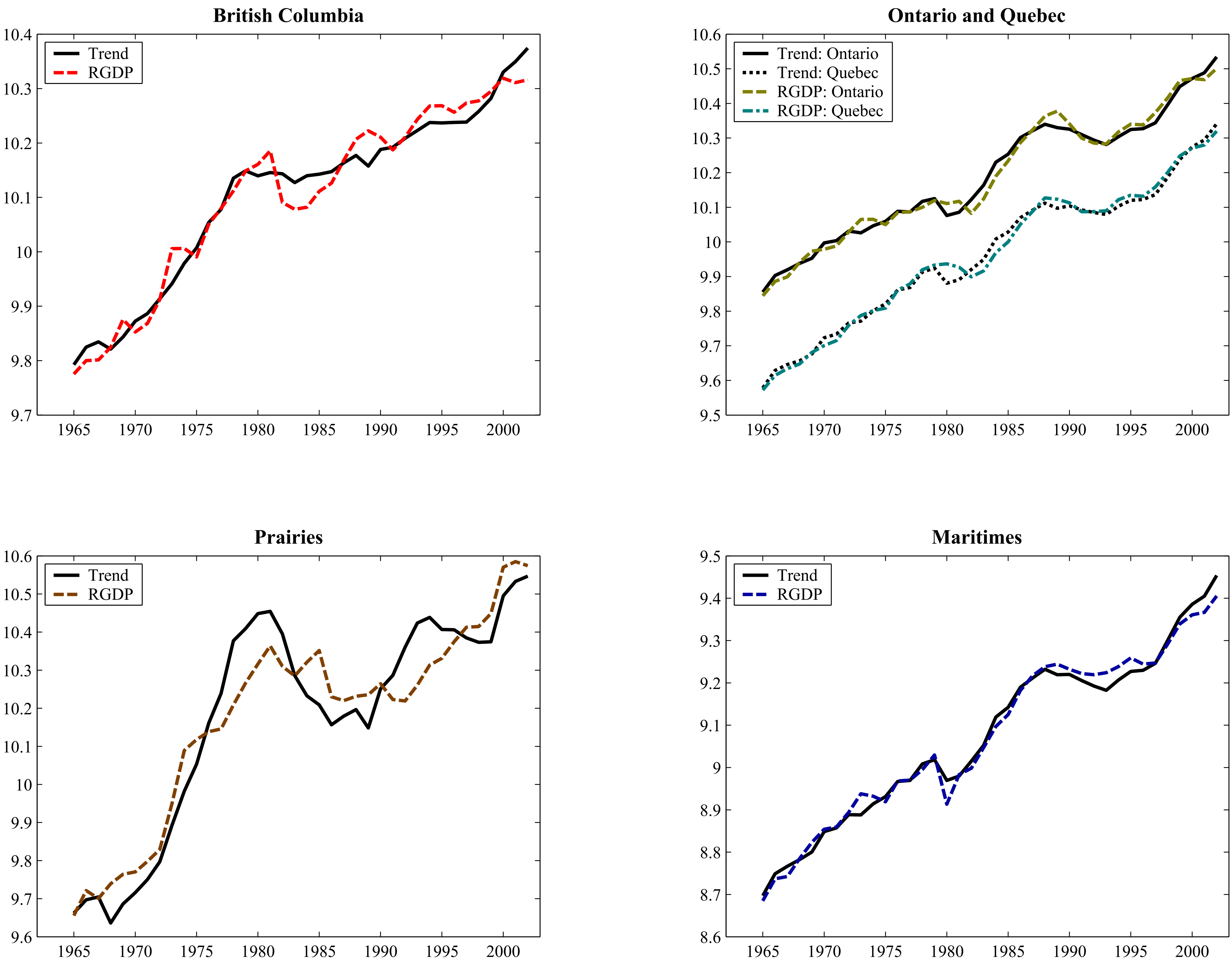

Figure 3: Canadian Regional Cycles

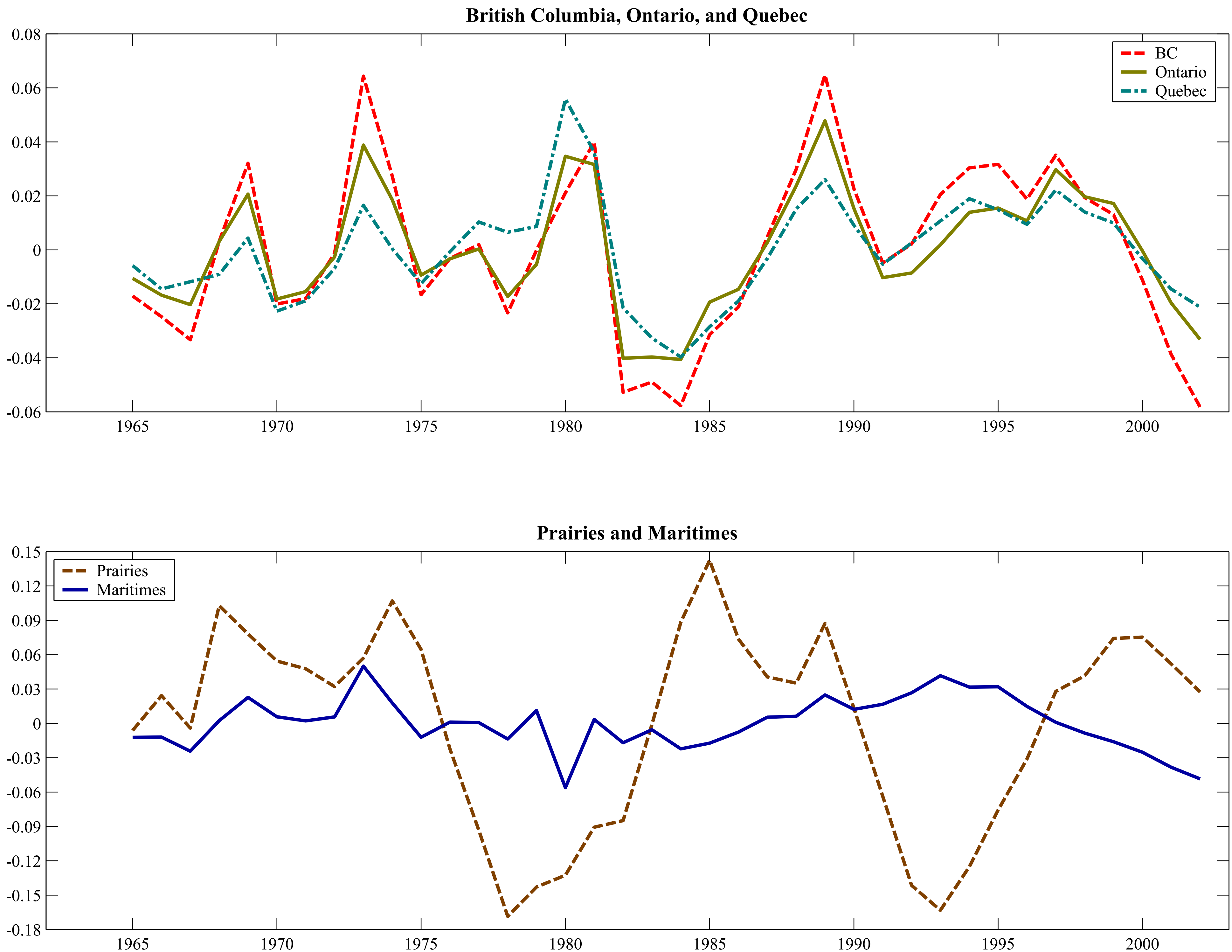

Figure 4: Canadian Trend and Cycle