CANADIAN REGIONAL CYCLES AND THE PROPAGATION OF U.S. ECONOMIC CONDITIONS*

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Introduction

Business cycles are an economic phenomenon of many dimensions. Usually, they are investigated at the aggregate level, where the main objective is to uncover stylized facts about the relationships between key national variables. To get a better idea of the source and dynamics of business cycles, international studies have been undertaken where national models were explicitly linked. However, for many countries, the analysis must be disaggregated at the regional level: a measure like G.N.P. is not necessarily a good indicator of the true economic conditions prevailing in a particular region. Considering Canada's institutional organization and the diversity of its industrial base, a regional analysis is eminently appropriate.

Previous work on the question was based on regressions of the movements of regional economic indicators with respect to the national ones. Using annual data on total employment (1945-68), Swan [8] found that the severity of the cycles (with respect to the national

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average) was highest in British Columbia, followed by the Atlantic region, Quebec and Ontario. For the Prairies, his analysis broke down, and no conclusion was reached. With unemployment data covering the 1953-70 period, Thirsk [9] obtained a similar ranking: the Atlantic region, B.C., Quebec, Ontario, and the Prairies. In *Living Together* [3], an analysis of the Canadian regional programs published in 1977, the Economic Council of Canada reported that a 2 percent increase of the national unemployment rate is typically associated with a 3.7 percent increase in the Atlantic region, 2.6 percent in Quebec, 1.9 percent in B.C., 1.7 percent in the Prairies, and 1.3 percent in Ontario (based on a 1953-75 sample). Despite some differences, a strong conclusion has emerged: Ontario should be less affected by the cyclical fluctuations. Thirsk went further and put forward the "widening" hypothesis, which states that in a downturn the gap between the high variability and the low variability regions (like Ontario) should increase.

Most of the work reported in these studies was completed by the middle of the 1970s. In light of the turbulent events that have affected the Canadian economy in the last ten years, a study incorporating the latest data is clearly warranted. The empirical regularities observed before are not necessarily valid today. Descriptive analyses should be updated periodically, since they depend heavily on the nature and size of the shocks that have occurred during the period of investigation. This paper intends to fill this gap and re-examine the question of regional cycles in Canada. Specifically, the monthly movements of total employment in the five Canadian regions (Atlantic, Quebec, Ontario, Prairies, and B.C.) over the period 1966.1-1984.7 will be investigated using a Bayesian Vector Autoregression model (BVAR). The influence of the U.S. economy will be specifically introduced, leading to a more "structural" analysis than the simple correlation methods used previously. An upturn will then be associated to a U.S. positive shock and its impact traced in all regions; spill-over across regions will also be incorporated. The BVAR methodology is well suited to the analysis of cyclical fluctuations, since it can separate the impact from the propagation mechanism. Using monthly rather than annual data will also allow a richer analysis, since cyclical movements of short duration can be identified. The BVAR approach is not, however, a structural investigation in the usual sense, since many important economic factors related to the nature and the composition of the economic bases of the various regions are not taken into account.

The next section proceeds directly to the presentation of the data, the BVAR methodology and the empirical results. The third section will summarize the findings and provide some concluding remarks.

The Empirical Results

Data Description

This paper follows the convention of dividing the Canadian economy into five separate regions: the Atlantic region, Quebec, Ontario, the Prairie region and British Columbia. Regional economic activity is measured by monthly total employment, since no broad monthly measure like GNP is currently available at the regional level. The unemployment rate, retained in previous studies, was not adopted, because of the important structural shifts that have affected this variable over the years. For symmetry, U.S. activity is also approximated by the total employment numbers. All data cover the period 1966.1-1984.7 (223 observations) and are seasonally adjusted.[1] A logarithmic transformation was also performed.

A Simple Correlation Analysis

Following earlier studies, Table 1 presents simple correlation results, where the variations of each regional employment level was regressed on the corresponding changes of the national level. According to the empirical consensus described in the Introduction, the Ontario coefficient should be less than one, indicating that its cyclical movements are less volatile than national ones. The results reported do not support this view, since the Atlantic region, Quebec and Ontario all have coefficients greater than one. B.C. and the Prairie region follow. However, one must be careful in interpreting this ranking, since this empirical approach is subject to a serious limitation: the national indicator used on the right-hand side contains, by definition, the dependent variable. This has an impact on the size of the estimated coefficients.[2] A more appropriate approach would be to use a truly exogenous variable. Table 1 also reports a similar regression where the changes of U.S. employment were used. Using this benchmark, we find that B.C. is the more volatile region, followed by Ontario, Quebec, the Atlantic and Prairie regions. Again, the empirical consensus is not confirmed. It appears that the seventies and eighties have witnessed important changes. To get a better understanding of the reasons that can explain

[1]Ideally, one should use raw data. However, the BVAR methodology retained in this paper requires the use of adjusted data. Seasonal data involves the inclusion of more subtle a priori information in the estimation of the BVAR, and this problem has not yet been worked out. See the appendix for a description of the data used and the seasonal adjustment procedure adopted.

[2]This impact will depend on the relative importance of a region and might not be constant over time.

the actual correlations, it is necessary to impose more structure in the analysis, and we now turn to the BVAR analysis.

Table 1

CORRELATION BETWEEN REGIONAL, NATIONAL AND U.S. CHANGES OF TOTAL EMPLOYMENT*

$(E_{it} - E_{it-1}) = \alpha + \beta (E_j - E_{j\,t-1}) + e_t$

	U.S.		CANADA	
Region	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\alpha}$	$\hat{\beta}$
Atlantic	0.0013	0.1347	-0.0004	1.0200
	(2.01)	(0.76)	(0.77)	(7.56)
Quebec	0.0010	0.2244	-0.0007	1.0913
	(2.23)	(1.79)	(2.07)	(13.6)
Ontario	0.0016	0.2826	0.0001	1.0080
	(4.07)	(2.67)	(0.36)	(16.2)
Prairies	0.0024	0.0616	0.0011	0.7208
	(5.40)	(0.50)	(2.83)	(7.79)
BC	0.0021	0.3348	0.0009	0.8937
	(3.04)	(1.81)	(1.39)	(6.04)

*E_i is the log of total employment in the i^{th} region; E_j corresponds to U.S. and Canadian total employment. Each regression is based on a sample of 222 observations. Absolute values of t-statistics are given in parentheses.

The BVAR Methodology

Dealing with a system of six monthly variables (U.S. and the five Canadian regions) requires a special methodology; a complete characterization of the dynamics necessitates the inclusion of a large number of coefficients. To avoid the loss of precision typically associated with the over-parameterization problem, Litterman [4;5] has proposed a Bayesian approach where some a priori information is incorporated in the estimation process. This methodology is presented briefly.

A BVAR model can be written as follows:

$$H(L)\, Z_t = H + e_t \qquad (t=1, \ldots, T) \qquad (1)$$

where Z_t is a vector of 6 economic variables and e_t is a vector of 6 random errors identically and independently distributed with a zero mean and a variance covariance matrix Σ. Furthermore,

$$H(L) = I - H_1 L - \ldots - H_{18} L^{18} \qquad (1.1)$$

is a (6x6) matrix polynomial in the lag operator L ($L^k Z_t = Z_{t-k}$). H is a (6x1) vector of constants. VAR models also correspond to unrestricted reduced form models, where each Z_{it} variable is related to its past values and the past values of all the other variables. In our application, 18 is the longest lag permitted and is constant across equations.

Each equation of system (1) will be estimated separately, taking into account the following a priori information:[3]

i. the prior mean of the $h_{ij,\ell}$s will be 1 if i=j and ℓ=1 and 0 otherwise, so each equation will be centered on a random walk specification (with no influence coming from other variables);[4]

ii. the standard errors associated with the prior means will be given by $T(ij,\ell)$ which basically depends on two coefficients: an overall tightness parameter w and a relative weight factor f(i,j). For example, in the present case, the w parameter has been fixed to 0.2 and the f(i,j) coefficients are given in Table 2. Basically, the a priori information that the Canadian variables affect the U.S. economy is extremely tight around zero. For the Canadian regions, a pattern dictated by trade considerations and geographical proximity is followed. For example, since the Atlantic region does not trade very much with B.C. and is not close to it, the prior information on the $h_{ij,\ell}$s coefficients of the Atlantic region in the B.C. equation is very tight. For neighboring provinces or important trading partners, this has been relaxed.[5]

Table 2

A PRIORI f(i,j) WEIGHTS USED IN THE ESTIMATION*

	Variable j					
Equation i	**US**	**A**	**Q**	**Q**	**P**	**BC**
US	1.0	0.1	0.1	0.1	0.1	0.1
A	1.0	1.0	0.8	0.6	0.4	0.2
Q	1.0	0.8	1.0	0.6	0.4	0.4
O	1.0	0.6	0.8	1.0	0.8	0.6
P	1.0	0.4	0.6	0.8	1.0	0.8
BC	1.0	0.2	0.4	0.6	0.8	1.0

*Each column represents a variable included in a particular equation (row). For example, all the own variables (diagonal entries) have a loose prior where f(i,j) = 1. This also applies to the U.S. variable included in all the equations (first column). The Atlantic region variable in the B.C. equation (sixth row, second column) has a tight coefficient of 0.2, reflecting its relatively few exchanges and geographical remoteness. The Ontario influence in the Quebec equation is less constrained, with a coefficient of 0.8.

[3]For a complete description of the imposition of the a priori information see Litterman [4;5].

[4]In $h_{ij,\ell}$, j refers to the variable and i to the equation while ℓ corresponds to the delay.

[5]In usual applications of the BVAR methodology, the exact form of the a priori information is somehow arbitrary. Doan, Litterman and Sims [2] have proposed

For each of the six equations, this a priori information was then combined in the estimation process using the Theil-Goldberger mixed estimation procedure. All equations were estimated over the period 1967.7-1984.7 (206 observations).[6] Considering the large number of coefficients estimated (109 coefficients per equation), we only present the F-tests that a block of 18 coefficients is significantly different from zero (see Table 3). The results indicate that the U.S. economy has considerable influence on all the regions except Quebec and B.C. There is also some impact across regions. For example, Quebec, the Prairie region and, to a lesser extent, B.C., are significantly linked to Ontario.

Table 3

TESTS RESULTS THAT ALL LAGS OF A VARIABLE HAVE ZERO COEFFICIENTS*

	Equation i				
Variable j	A	Q	O	P	BC
US	0.329E-01	0.2764	0.3298E-01	0.6747E-03	0.2898
A	0.0000	0.5135E-01	0.2420	0.9864	0.9991
Q	0.7513E-01	0.2775E-16	0.4313E-01	0.8363E-01	0.5249
O	0.3789	0.1542E-02	0.0000	0.5526E-01	0.1518
P	0.7236E-01	0.2798	0.3165	0.1387E-16	0.2311
BC	0.7784	0.1866	0.3079	0.3307	0.0000

* This table reports α^*, the marginal significance level of an F-test indicating the probability of getting that value of the F-statistic or higher under the null hypothesis. A marginal significance level of 0.05 or less indicates a rejection of the null hypothesis at the 5 percent level.

The estimated variance-covariance matrix of the residuals across regions is an interesting source of information. Since it corresponds to the unexplained movements of employment, the estimated standard error of the residuals can be used as a measure of volatility; the numbers reported on the main diagonal of Table 4 rank B.C. first, followed by Quebec, the Atlantic and Prairie regions and Ontario. It is striking to note that the Ontario equation has the smallest standard

choosing the a priori information on the basis of an ex ante forecasting exercise. In our case, the a priori information is based on economic consideration, which is a departure with respect to normal practice. It is interesting to note that our a priori information led to an improvement of the forecasting performance over an unconstrained BVAR.

[6]All the statistical computations were performed using RATS 4.11, an econometric package written by Doan and Litterman [1].

error; Ontario cyclical movements can be well explained by the BVAR model. Correlation is also observed between residuals (see Table 4): Ontario has the largest correlation coefficient (0.2291) with the U.S. residuals.[7] Ontario is also correlated to the Prairie region, as illustrated by a 0.2835 coefficient. We now turn to the analysis of the dynamic properties of the BVAR model.

Table 4

STANDARD ERROR, COVARIANCE AND CORRELATION OF THE COMPUTED INNOVATIONS*

	US	A	Q	O	P	BC
US	0.0028	-0.7362E-06	0.1045E-05	0.2192E-05	0.1539E-05	0.1746E-05
A	-0.0470	0.0054	0.4652E-05	0.2519E-05	0.2030E-06	0.2944E-05
Q	0.0878	0.2029	0.0041	0.1824E-05	0.1521E-05	0.4309E-05
O	0.2291	0.1366	0.1302	0.0033	0.3485E-05	-0.1226E-05
P	0.1474	0.1012	0.0995	0.2835	0.0036	-0.1684E-07
BC	0.0977	0.0855	0.1647	-0.0583	-0.0007	0.0062

* Entries on the diagonal represent the standard error of the estimated residuals. The covariances are presented above the diagonal (to be used later in the impulse response section), while the correlations are given below the diagonal.

Impulse Response Coefficients

What is the impact of a U.S. employment shock on the five Canadian regions? Are there any important differences? By calculating the moving average representation of model (1) as:

$$Z_t = \text{Constant} + M(L)\, e_t \qquad (2)$$

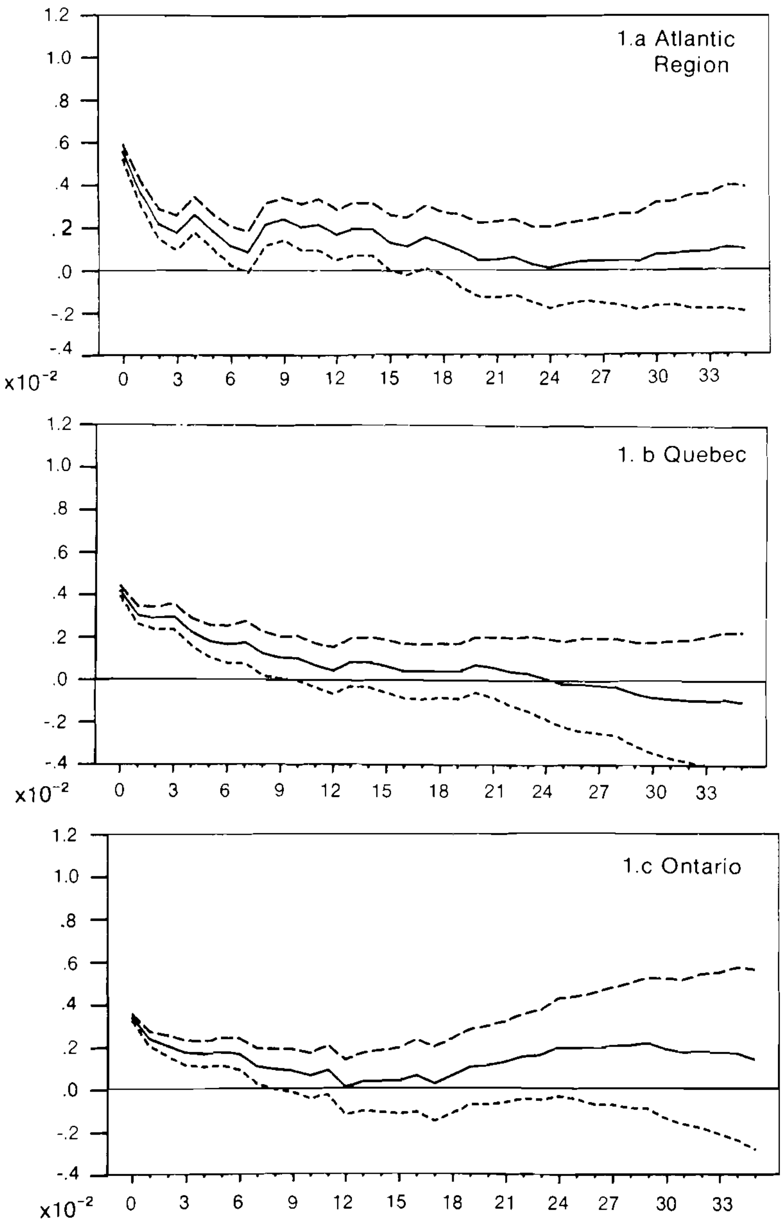
where $M(L) = I + M_1 1 + M_2 L^2 + \ldots$, the BVAR methodology can provide some answers to these questions. The M_ℓ matrices can be obtained recursively from the H_ℓ ones. The $m_{ij,\ell}$ (ℓ=1, ...) trace the response over time of variable i (a specific region) following a unit shock to variable j; that is, e_j equals one in the initial shock period and zero afterwards (for example, a U.S. shock). In practice, one standard error shocks are analyzed. To assess the importance of the estimated responses, we also provide 75 percent confidence intervals.[8] A summary of the results is as follows:

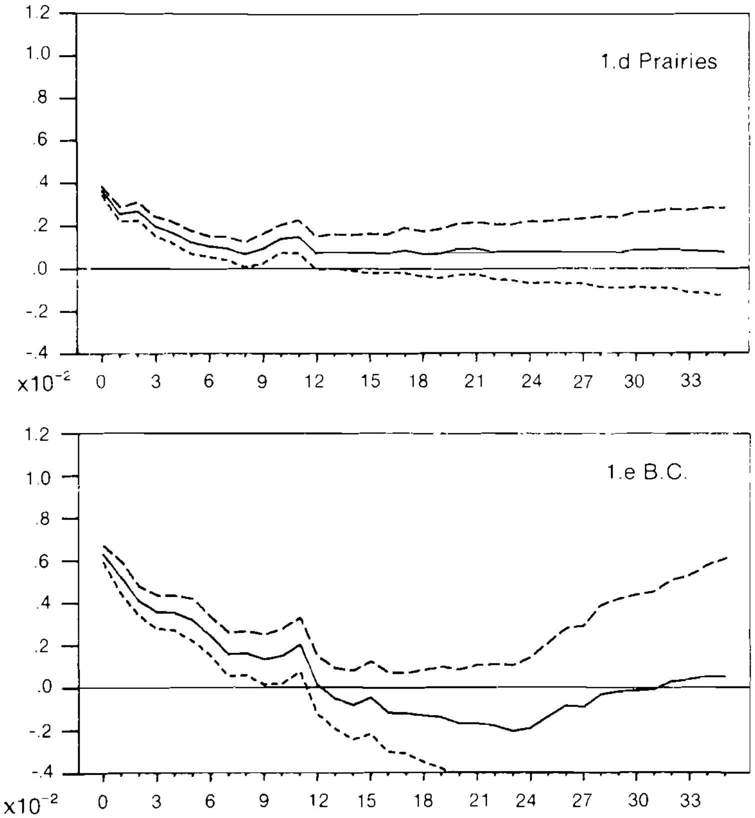
i. An own shock does not display the same persistance in all regions (see Figures 1.a to 1.e). In the Atlantic region, a shock has a short

[7]Since no t-tests are readily available, the correlation numbers must be interpreted with caution.

[8]The confidence intervals were calculated using a Monte-Carlo procedure explained in Doan and Litterman [1].

and oscillating impact. The Quebec and Ontario responses are smoother, but not significantly different from zero beyond the 8th or 9th period. The Prairie region and B.C. display a much longer persistence (almost a full year).





*The vertical axis corresponds to the size of the response in units of percentages: i.e. 0.004 is 0.4%; the horizontal axis represents the number of months elapsed after the shock; the impulse coefficients are plotted within 75% confidence intervals. The initial shock corresponds to a one standard deviation (see diagonal entries of Table 4).

Figure 1

IMPULSE RESPONSE COEFFICIENTS FOLLOWING AN OWN SHOCK

ii. A one standard error U.S. shock (3.4 percent on an annual basis or 3,641,094 jobs) has the following impact (see Figures 2.a to 2.f): the responses of the Atlantic region and Quebec are flat, even negative, at the beginning and only pick up after nine months. Most of the Quebec and Atlantic region coefficients are not statistically different from zero. The Ontario economy is rapidly and significantly influenced.[a] The Prairie region and B.C. (after a delay of five to six months) benefit strongly from the U.S. recovery.

[a]The results reported for Quebec and Ontario are consistent with those obtained in Raynauld [6], where the effects of the other Canadian regions were not taken into account.

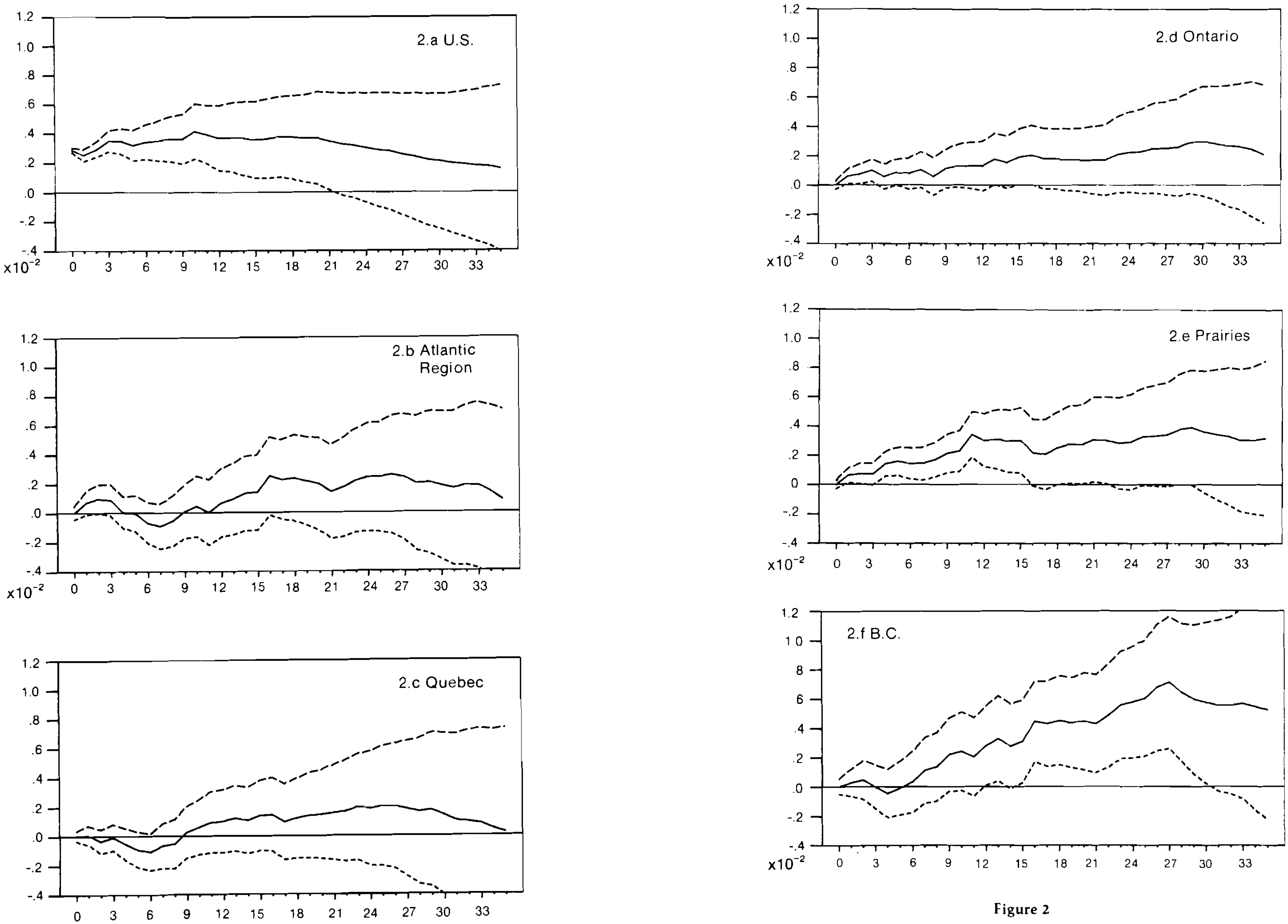


Figure 2

IMPULSE RESPONSE FOLLOWING A U.S. SHOCK

iii. The long run responses (after a 2-year span) are quite similar for the Atlantic region (2.6 percent or 21,368 jobs), Quebec (2.3 percent or 62,964 jobs) and Ontario (2.5 percent or 106,341 jobs). These numbers indicate that the Canadian economy is rather well integrated; each region, through its direct ties with the U.S. or the other regions, will eventually benefit from a U.S. recovery. Only the Prairie region and B.C. depart from this 2.5 percent range by having respectively 3.4 percent (73,855 jobs) and 6.6 percent (79,050 jobs). The B.C. results deserve additional comments. In Table 3, the F-tests indicate that this region was not closely related to the U.S. A closer inspection reveals that some estimated coefficients are important although not statistically different from zero. This can explain the large response computed and its corresponding wide confidence interval. This high voltaility of B.C. cycles is consistent with previous findings and may be explained in part by its volatile resource based sector.

Summary and Concluding Remarks

The regional business cycles picture given in this paper does not conform exactly to the prevailing view. Since the end of the sixties (where most of the previous work ends), important changes have made the Ontario economy more volatile. In an upturn, Ontario will rapidly benefit from the improving U.S. conditions, increasing its relative positions with respect to Quebec and to the Atlantic region. In the long run, this gap will close, since most of the regions are similarly affected. B.C. appears to gain more in the long run from a U.S. shock, and this illustrates its known high volatility. In a downturn, the opposite scenario will be observed; Ontario will be the first to experience the negative impact of the worsening U.S. conditions, and the long-run negative impact in B.C. will be more severe than elsewhere.

Despite the introduction of the U.S. economy and the interregional links, the analysis undertaken in this paper is descriptive. It should be viewed as a first step that will be completed in a more "structural" environment. For instance, specific industry composition (like the oil industry in the Prairies and the wood sector in B.C.) and associated factors (world price of oil, etc.) should be taken into account to get a clearer picture of the forces underlying the facts highlighted in this paper.

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Appendix

Data Description

The Canadian data are taken from the CANSIM data base and correspond to the population employed, 15 years and over in each region. The U.S. variable, which is available from Data Resources, is the total persons employed from the household survey. All data are seasonally adjusted using the spectral approach of Sims [7] and Doan, Litterman and Sims [2]. Contrary to the official X-11 seasonal adjustment procedure, the spectral approach is not subject to the Sims [7] critique; it does not introduce a bias in the dynamic relationships uncovered. A RATS subroutine, available from the Federal Reserve Bank of Minneapolis research department, was used. All data and detailed results are available from the author upon request.