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VARIATION IN EMPLOYMENT GROWTH IN CANADA: THE ROLE OF EXTERNAL, NATIONAL, REGIONAL AND INDUSTRIAL FACTORS

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ABSTRACT

This paper presents a method for assessing the impact of external, national, and sectoral shocks on Canadian employment fluctuations at the national, industry, and provincial levels. Special attention is given to the contribution of sectoral shocks to aggregate employment fluctuations. Shocks which initially affect specific industries and provinces can induce aggregate fluctuations not only because national employment is the sum of employment in various sectors but also because of feedback across sectors.

The analysis is based on an econometric model relating employment growth in each province and industry to the current and lagged change in U.S. output, the lags of employment growth at the national, industry, and provincial levels, a Canadian national shock, and shocks affecting specific industries, specific provinces, and specific province-industry pairs. The model is estimated using annual data on Canadian employment at the province-industry level.

The results suggest that U.S. shocks are responsible for two-thirds of the steady-state variance in the growth of Canadian national employment, while the Canadian national shock accounts for approximately one quarter of this variance. Taken together, industry specific, province specific and province-industry specific shocks account for about one-tenth of the variance of Canadian national employment growth. Although U.S. shocks are the dominant influence on aggregate employment growth in Canada, sectoral shocks account for about thirty percent of the variance in national employment due to Canadian sources.

Estimates of the contribution of U.S., Canadian national, industry, and provincial shocks to the variance of employment in specific industries and provinces are also provided.

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1. Introduction

The purpose of this paper is to study the sources of employment fluctuations in Canada. To this end, we first present a methodology for investigating the role of aggregate and disaggregate shocks in determining variation in employment growth at the national, regional, and industry levels. Aggregate shocks may arise from either domestic or external sources and are assumed to affect all sectors of the economy, although the impact of these shocks may differ across industries. Disaggregate shocks are specific to particular sectors of the economy. We then apply this methodology to the Canadian economy using annual employment data disaggregated by province and industry for the period 1961-1982.

The paper is organized as follows. Section 2 discusses the motivation for our study. Section 3 presents a disaggregate time series model of employment and demonstrates how the model may be used to analyze the sources of employment variation. In Section 4 we discuss the econometric methods used to estimate the employment model. In Section 5 we describe the data used for estimation and present our empirical results. We conclude the paper in Section 6.

2. Motivation

Our research is motivated by two related issues. The first concerns the relative importance of disaggregate shocks and aggregate shocks in booms and recessions which affect particular industries and regions. To what degree do recessions in a particular industry or a particular region arise from sectoral sources and thus have a sectoral solution? To what degree do recessions in particular industries or regions arise from differences across sectors in the response to an economy wide shock? Many studies of employment growth in a particular region or industry have examined the effects of sector specific influences such as trade policy, local government expenditures and taxes, while controlling for aggregate determinants of economic activity. Consequently, our interest in the first question does not require much explanation. We hope to contribute to this literature by providing a comprehensive assessment of the extent to which employment fluctuations in various industries and provinces are a sectoral phenomena.

The second issue that motivates our work concerns the contribution of sector specific disturbances to aggregate fluctuations in employment growth. This issue has received little attention in the literature. Most macroeconomic studies have investigated the relative importance in business cycles of aggregate supply shocks or demand shocks resulting from changes in monetary and fiscal policy, exogenous shifts in investment demand, changes in consumer confidence, shifts in the supply of raw materials and productivity shocks.[1] Unfortunately, attempts to explain aggregate economic fluctuations in terms of a simple unified model emphasizing a few variables have not been very successful, and a consensus has not emerged on the relative importance of the above factors in business cycles. Better theories, econometric methods and data will undoubtedly lead to improved aggregate models. However, the success of such models is bounded to the extent that business fluctuations are complex phenomena caused by many factors.[2] For this reason, we wish to obtain empirical evidence on the contribution of a diverse set of disaggregate shocks to aggregate fluctuations.

Our focus on disaggregate shocks is partially inspired by the important work of Lilien (1982a, 1982b) on the effect of changes in the dispersion of sectoral shocks on the natural rate of unemployment. (See also Medoff (1983), Lilien and Hall (1984), and Abraham and Katz (1985).) Many economists, including Archibald (1971), Phelps (1971) and Lucas and Prescott (1974), have hypothesized that the amount of frictional and "structural" unemployment in the economy is affected by the rate of change in employment demand in individual firms, industries, and regions. Essentially, the variance in sectoral shocks affects the amount of labor which is in the process of being reallocated across sectors. Lilien hypothesized that the dispersion of sectoral shocks fluctuates over time, leading to variation in both the natural rate and the level of unemployment. The results of empirical work on this hypothesis are mixed.[3]

In contrast to Lilien's emphasis on a linkage between the variance of sectoral shocks and aggregate fluctuations, we investigate the possibility that random fluctuations in the levels (as opposed to the variance) of sectoral shocks induce variation in aggregate employment simply because aggregate employment is a weighted sum of employment in various sectors. If sector specific shocks have a variance that is large relative to aggregate shocks, then sectoral shocks will obviously play an important role in fluctuations of employment growth within a particular sector. However, if the variance of an appropriately weighted average of sector specific disturbances is sufficiently large, then taken together, these shocks may play a significant role in aggregate employment fluctuations. We refer to this role of sectoral shocks as the "collective impact" hypothesis.

For example, consider an economy with five sectors of equal size. Assume that both the aggregate shock and the sectoral shocks are serially uncorrelated, and that there are no feedbacks from past employment changes to current employment changes. Assume further that all shocks are independent. If the variance of the aggregate shock is one half of the variance of the sectoral shocks, and the sectoral shocks have equal variances, then the correlation of employment between sectors would be 1/3 for all pairs of sectors. In this case, the aggregate shock will account for 71.4% of the variance of national employment and the sectoral shocks will account for 28.6% of this variance. If the sectors are of unequal size, the sectoral shocks will be even more important.

While there clearly exists a potential role for disaggregate shocks in aggregate fluctuations via the "collective impact" mechanism, the empirical importance of such shocks is unclear. The influential studies of Burns and Mitchell (1946) and Mitchell (1951) provide evidence that economic activity in various industries and regions moves together. Lehmann (1982) uses modern time series techniques to re-analyze some of the series studied by Mitchell and confirms the earlier findings. As Lucas (1977) emphasizes, results of this type lend support to the view that simple aggregative models ultimately will be able to explain business cycles.

On the other hand, the strength and stability of co-movements in employment across sectors of the economy should not be exagerated. Many economists have noted a diversity in employment growth across regions and industries in both the U.S. and Canada over the past two decades, a diversity which is only partially due to differences in trend growth rates. The numbers above the diagonal in Table 1 are the simple correlations of the annual changes in the log of employment across Canadian one-digit SIC industries. The numbers below the diagonal are the partial correlations after controlling for external shocks as proxied by the current value and first lag of the change in the log of real U.S GNP. The simple correlations are less than .5 in 23 out of 36 cases, although the results also show substantial positive correlations between a number of the industry pairs. While the partial correlations indicate the presence of a common domestic disturbance, they also indicate that there is considerable diversity in employment fluctuations across industries. Table 2 presents the simple and partial correlations (controlling for the current and lagged value of U.S. GNP) for the changes in the log of provincial employment. The correlations for the provinces are considerably stronger than those for the industries.

The limited evidence in these tables suggests that it is unlikely that disaggregate shocks are the main source of aggregate fluctuations. However they also suggest that sectoral shocks play a large enough role in employment behavior at the sectoral level to warrant careful study as a partial explanation for aggregate fluctuations, especially since feedback effects (across sectors) of sector specific shocks will contribute to these correlations.

We are unaware of any systemmatic attempt to measure the overall contribution of industry specific, region specific, and industry-region specific shocks to aggregate fluctuations. This may reflect, in part, the role played by idiosyncratic shocks in many economic models growing out of the work of Phelps (1970) and Lucas (1972, 1977). In these models, idiosyncratic shocks are a source of noise which prevents individuals inferring the level of the money supply, the economy wide price level and aggregate economic activity from a limited information set on prices and output.[4] The variance of these shocks may affect the natural rate of unemployment (see especially Lucas and Prescott (1974)) and the responsiveness of output to monetary shocks. However, these models assume that the shocks are sufficiently independent and affect units which are sufficiently small so as to wash out in the aggregate. On the other hand, some economists (Black (1982), Long and Plosser (1983)) have argued that "real" shocks, rather than monetary shocks, are the dominant force in economic fluctuations. Within such a framework, it is natural to consider shocks directly affecting the demand for or supply of particular goods. Long and Plosser (1983) present a "real business cycle" model in which independent sectoral shocks induce correlation in output across sectors because of feedback effects. However, they do not attempt to measure the relative importance of sectoral and aggregate shocks. Our empirical model bears some similarity to theirs, although our model is consistent with an important role for aggregate shocks (including monetary shocks) which influence all sectors as well shocks to specific sectors. Further, the feedback effects in our model could arise from many sources.

There are a number of possible approaches to studying the sources of employment fluctuations. One approach is to first obtain measures of the different sources of external, national, industry specific, province specific, and province-industry specific shocks. One could then estimate an econometric model relating these measures to employment at various levels of aggregation and perform an analysis of variance. In general, data limitations and lack of adequate degrees of freedom in time series data limit the feasibility of treating the sources of shocks as observed variables. Most studies of specific industries or regions treat national output as exogenous rather than investigate feedbacks from the industry or region to national output. (See Bolton (1980).) While effects of specific shocks such as auto strikes, coal strikes, import quotas, etc. on economic activity have been investigated using large scale econometric models, a summary of the contribution of these shocks has not been calculated.

An alternative approach is to examine a pure time series model of the employment process. Vector autoregressive models have been fruitfully applied to study the sources of variation in economic time series. (See Sims (1980) and Ashenfelter and Card (1982).) Unfortunately, these methods are not well suited to analysis at the sectoral level because they involve too many parameters in large systems of equations (see below). Moreover, the VAR representation of a time series combines the dynamic behavior arising from structural dependence of the economic time series upon its past values and from serial correlation in the disturbances to the time series. The "innovations" in the VAR model do not necessarily correspond to the unobserved variables which drive the economic time series conditional upon feedback effects from past values of the time series. In using an unrestricted VAR model, one assumes that shocks to the economy are uncorrelated (or defines the shock as the residual after all serial correlation has been eliminated from the error term). This restricts the dynamics of the model to come from feedback effects, and leaves no role for dynamics arising from serially correlated shocks. However, in future work it would be useful to compare the results on the importance of various shocks reported here to those obtained using a suitably restricted VAR model.

Index models of the type used by Sargent and Sims (1975), Engle and Watson (1981), and Lehmann (1982) represent another possible approach to the problem. These models attempt to explain the behavior of a vector of economic time series in terms of a small set of unobservable variables and a set of idiosyncratic error components which are specific to the particular series. All of the above studies rule out feedback from past values of the economic time series to the current values. They attribute the dynamic behavior of economic time series to serial correlation in the unobserved factors. However, the general class of index models discussed in Watson and Engle (1982) incorporates direct feedback from past values of the observed variables to the current values as well as serial correlation in the unobserved variables which drive the system. The model which we estimate falls into this class. Basically, we impose some strong assumptions about the way in which employment in a particular province and industry is affected by the lagged values of the employment in other provinces and industries. These assumptions are necessitated by the size of our system and available data. We also assume that shocks to employment arise from current and lagged changes in U.S. GNP as well as: (a) an unobserved national component which affects employment in all industries and provinces with industry specific coefficients; (b) a set of unobserved industry components; (c) a set of unobserved province specific components which affects all industries in the respective province with industry specific coefficients; and (d) a component which affects employment only in the particular province and industry. To some extent, we allow for serial correlation in these components.

Although we emphasize that our model is not a structural economic model, it is useful to discuss both the possible sources of the industry and region specific shocks that we analyze and the possible explanations for the effect of previous employment growth on current employment growth.[5] Industry and region specific shocks may affect either the demand or supply side of employment, although we believe that in general the demand effects will be more important. Changes in tastes may shift the demand curve for the output of an industry outward and increase its demand for labor. Alternatively, positive shocks in the price of raw materials may lower an industry's equilibrium output and reduce its derived demand for labor. Industry specific productivity shocks or technological change may also shift the industry demand for labor.

In our view, region specific shocks are most likely to reflect changes in government policy. Alternate spending and taxation policies of provincial governments can clearly shift the demand for labor in a given region,[6] while changes in minimum wage laws may shift the effective supply of labor in a given region. Regional development programs carried out by the Federal government also can affect the demand for labor, while changes in the treatment of regional unemployment in the unemployment insurance system may affect labor supply in a given region.

The large literature on "propagation mechanisms" for business cycles suggests a variety of explanations for the feedback effects in the model analyzed below. The simplest explanation involves the fact that output demands of different industries and regions are interrelated through the production process. A positive shock to manufacturing leads, in future periods, to an increase in the demand for the output of mining. Further, a demand shock raising employment and wages in a particular industry or region can increase (with a lag) the demand of consumers and firms for goods produced in other industries or regions. (Long and Plosser (1983) emphasize factors such as these.) The need for time to build (Kydland and Prescott (1982)) and costs of adjustment in investment and hiring decisions affect the adjustment process in the economy, as does the time required for workers to move between industries and regions in response to demand shifts. Empirically sorting out the role of these mechanisms is an extremely challenging research problem, and we do not address it here.

3. An Econometric Model for the Analysis of Employment Variation

In this section we present the econometric model of employment variation which serves as the basis for our empirical work. We first present a general time series specification of employment at the province-industry level. The general model consists of an unrestricted relationship between employment in a given province-industry pair and lagged employment in all other province-industry pairs, and an unrestricted disturbance. We then discuss a series of restrictions which are placed upon the form of the feedback in employment among industry-province pairs to obtain an estimable model. Next we consider a decomposition of the employment disturbance into national, province, industry, and province-industry components. Finally, we show how estimates of the model can be used to measure the contribution of each type of disturbance to the variance in the growth of employment at the national, province, industry and province-industry levels.

3.1 Restrictions on the Feedback Across Industries and Provinces

Consider an economy consisting of I industries indexed by i and P provinces indexed by p . Let Y_{pit} denote the change in the log of employment in province p and industry i . Let $\underline{Y}_t$ equal the IP x 1 column vector $(Y_{11t}, Y_{12t}, \ldots Y_{1It}, Y_{21t}, \ldots Y_{PIt})'$. In general, Y_{pit} may depend upon the lagged values of employment in all of the other provinces and industries. We also assume that, in each period, Y_{pit} is influenced by the current and lagged value of the change in the log of real U.S. GNP and by a disturbance ε_{pit} , which may be serially correlated.[7] Assuming for simplicity that only the first lag of $\underline{Y}_t$ matters, this leads to the following specification of the time series process for $\underline{Y}_t$

$$(1)\quad \underline{Y}_t = \underline{\lambda} + \Pi \underline{Y}_{t-1} + \underline{B}_1 US_t + \underline{B}_2 US_{t-1} + \underline{\varepsilon}_t \quad ,$$

where $\underline{\lambda}$ is a IP x 1 unrestricted vector of intercepts, Π is an unrestricted

PI x PI matrix of lag coefficients, $\underline{\varepsilon}_t$ is a vector of error terms, US_t denotes the growth in real US GNP, and $\underline{B}_1$ and $\underline{B}_2$ are IP x 1 unrestricted vectors of coefficients. The elements of Π depend upon the form of the feedback among industries. The row of (1) corresponding to the equation for Y_{pit} is

$$(2)\quad Y_{pit} = \lambda_{pi} + [\Pi^{pi}_{11}\ ,\ \Pi^{pi}_{12}\ ,\ \ldots\ ,\ \Pi^{pi}_{1I}\ ,\ \Pi^{pi}_{21}\ ,\ \ldots,\ \Pi^{pi}_{PI}]\ \underline{Y}_{t-1} + B_{1pi}\ US_t + B_{2pi}\ US_{t-1} + \varepsilon_{pit}\ ,$$

where $\Pi^{pi}_{p'i'}$ is the $((p-1)I + i\ ,\ (p'-1)I+i')$ element of Π . The specification permits feedback in employment changes to depend upon the particular pairs of industries and provinces involved with coefficient $\Pi^{pi}_{p'i'}$.

Unfortunately, given available time series data, an unrestricted model such as (1) is hopelessly underidentified. For each of the IP elements of $\underline{Y}_t$ in (1), there is an equation corresponding to (2) which contains IP lag coefficients in addition to the coefficients on US_t and US_{t-1} . Below we work with nine one-digit industries and six provinces, so this amounts to 54 lag coefficients for each province-industry pair. Since we have only 19 time series observations for each equation after forming the employment change measures and lagged values, we cannot estimate the model as it stands. Consequently, we must impose restrictions on the feedback coefficients Π as well as on the $\underline{\lambda}$, $\underline{B}_1$ and $\underline{B}_2$ vectors.

Let w_{pi} denote the fraction of Canadian employment accounted for by province-industry pair pi.[8] Let the log change in national employment Y_{ct} be defined as a weighted average of the changes in each pi pair

$$(3)\quad Y_{ct} = \textstyle\sum_{pi} w_{pi}\ Y_{pit}\ .$$

Let the change in employment in industry i be denoted by $Y_{.it}$ and defined as the weighted average

(4) $Y_{.it} = \Sigma_p w^i_{p\cdot} Y_{pit}$.

The weights $w^i_{p\cdot}$ correspond to the fraction of employment in industry i accounted for by province p. Similarly, let the change in employment in province p, $Y_{p\cdot t}$, be defined as the weighted average

(5) $Y_{p\cdot t} = \sum_i w^p_{\cdot i} Y_{pit}$

where the weights $w^p_{\cdot i}$ correspond to the fraction of employment in province p accounted for by industry i. We specify the following equation for Y_{pit}

(6) $Y_{pit} = \lambda_i + \gamma_i Y_{ct-1} + \delta_i Y_{p\cdot t-1} + \theta_i Y_{\cdot it-1} + B_{1i} US_t + B_{2i} US_{t-1} + \varepsilon_{pit}$.

We restrict the intercept λ_{pi} in (2) to depend only upon the industry (although this is relaxed in some of the empirical specifications). While we allow the coefficients on Y_{ct-1}, $Y_{p\cdot t-1}$, $Y_{\cdot it-1}$, US_t and US_{t-1} to vary across industries, we assume that they are constant across provinces. Using (3), (4) and (5) it is straightforward to show that (6) implies the following restrictions on the feedback coefficients $\Pi^{pi}_{p'i'}$, relating $Y_{p'i't-1}$ to Y_{pit} in (2)

(7a) $\Pi^{pi}_{p'i'} = \gamma_i w_{p'i'}$ if $p \neq p'$, $i \neq i'$,

(7b) $\Pi^{pi}_{p'i'} = \gamma_i w_{pi'} + \delta_i w^p_{\cdot i'}$ if $p=p'$, $i \neq i'$,

(7c) $\Pi^{pi}_{p'i'} = \gamma_i w_{p'i} + \theta_i w^i_{p'\cdot}$ if $p \neq p$, $i=i'$,

and

(7d) $\Pi^{pi}_{p'i'} = \gamma_i w_{pi} + \delta_i w^p_{\cdot i} + \theta_i w^i_{p\cdot}$ if $p=p'$, $i=i'$.

The term $\gamma_i Y_{ct-1}$ permits feedback effects from all $p'i'$ province-industry pairs to Y_{pit}, even when $p \neq p'$ and $i \neq i'$. As shown in (7a), this term contributes the coefficient $\gamma_i w_{p'i'}$ to the feedback effect of $Y_{p'i't-1}$ on Y_{pit}. This coefficient varies proportionately across $p'i'$ by a factor equal to the weight $w_{p'i'}$ of $p'i'$ in national employment.

The term $\delta_i Y_{p \cdot t}$ allows for the possibility that feedback will be stronger among industries in the same province. This is likely to be the case for industries with regional markets for output, such as construction and services. As shown in (7b) this term contributes the coefficient $\delta_i w_{\cdot i'}$ to the total effect of the lagged employment changes in province-industry pi.

The term $\theta_i Y_{\cdot it-1}$ permits feedback between province-industry pairs in the same industry to be different from feedback between pairs in different industries. Such differences might arise from factors such as differences across industries in costs of adjusting employment, or from industry differences in the degree of wage flexibility and training costs. The effect which lagged employment in $p'i$ has through the term $\theta_i Y_{\cdot it-1}$ is equal to $\theta_i w^i_{p' \cdot}$, where $w^i_{p' \cdot}$ is the weight of province p' in industry i.

For the case in which $P=6$ and $I=9$, the restricted system contains 54 unknown parameters. This represents a drastic reduction from 3078 parameters in the unrestricted system. However, some of the restrictions may be questioned.

First, the specification imposes strong restrictions on the effect of Y_{pit-1} on Y_{pit}. As shown in (7d), the effect of the "own lag" of the employment change in pi depends upon γ_i, δ_i, θ_i and the relative weight of pi in national employment (w_{pi}), employment in p ($w^p_{\cdot i}$), and employment in i ($w^i_{p \cdot}$). To relax these restrictions somewhat, one could add the term $\Phi_i Y_{pit-1}$ to (6), where the lag coefficient Φ_i varies across industries but not provinces. We experimented with this modification in the empirical work but found that it made little difference to our results.

Second, our use of national and provincial lagged employment may not capture sufficiently the effects of regional proximity. Also, feedback between different industries in different provinces may depend upon the particular industries involved. The above specification permits the effects of the lag of Ontario manufacturing and the lag of Ontario services on mining in Alberta to differ only to the extent that the fractions of Canadian employment accounted for by employment in manufacturing and by employment in services in Ontario differ. (See (7a).)

Third, if the industrial compositions of provinces were the same, the specification would imply that the effect of lagged employment changes for industries in the same province is independent of the size of the province. For industries with national markets, one might expect the influence of lagged employment in the province to be less in small provinces than in large ones.

In any econometric study, one must balance a desire for generality in the model against the limitations that the data place on empirical identification. Our preliminary experiments indicated that the usable variation in the data is not sufficient to identify specifications more complex than (6), and so this specification, with some minor variations, forms the basis for our empirical work.[9]

3.2 Restrictions on the Error Structure of the Model

Given that one of our main objectives is to assess the relative importance of U.S., national, industry, and provincial shocks in Canadian employment variation, we decompose the employment disturbance ε_{pit} into

$$\varepsilon_{pit} = f_i c_t + \eta_{it} + g_i v_{pt} + u_{pit} , \tag{8}$$

where c_t = Canadian national shock affecting all province-industry pairs with industry specific coefficient f_i ; $Var(c_t) = \sigma_c^2$.

η_{it} = industry specific shock affecting industry i ; $Var(\eta_{it}) = \sigma_{\eta i}^2$.

v_{pt} = province specific shock affecting all industries in province p with industry specific weight g_i ; $Var(v_{pt}) = \sigma_{vp}^2$.

u_{pit} = indiosyncratic disturbance reflecting special conditions affecting only pi ; $Var(u_{pit}) = \sigma_{upi}^2$.

We assume that the national shock c_t , the vector $(\eta_{1t}, \ldots, \eta_{It})'$ of industry disturbances, the vector $(v_{1t}, \ldots v_{Pt})'$ of provincial disturbances, and the vector $(u_{11t}, \ldots, u_{PIt})'$ of province-industry shocks are mutually uncorrelated at all leads and lags. It is natural to decompose the variance of the employment disturbances in this way. However, in our empirical work we also make the stronger assumption that the industry shocks η_{it} are uncorrelated across industries, that the province shocks v_{pt} are uncorrelated across provinces, and that the province-industry shocks u_{pit} are uncorrelated across province and industry pairs.

Identifying restrictions are necessary to estimate any factor model. For example, in (8) one can trivially exhaust all degrees of freedom simply by allowing the idiosyncratic errors u_{pit} to have an unrestricted covariance matrix. In our case, the orthogonality assumptions allow us to identify the model, and our interpretation of the results is conditional on these assumptions. Our approach can be interpreted as taking a model with national shocks as the baseline, and then asking whether orthogonal industry and provincial shocks also affect the variation in employment growth at the national, industrial or provincial levels in an economically meaningful way. We believe that this is a reasonable approach, since it will be extremely difficult to distinguish, (either theoretically or empirically) a national shock-model (perhaps with multiple indices of national shocks) from a model which allows for correlated industrial and provincial shocks.

The assumption that there is only one index of shocks at each level is another identifying restriction. Given the number of candidates for national shocks, this may be an especially strong assumption at the national level. On the other hand, we do allow for observable aggregate shocks arising from the United States. Moreover, the use of one (unobserved) national shock gives sectoral shocks their best chance to play a role in variations in aggregate economic activity. If sectoral shocks do not play a major role in this model, for our purposes there seems little point in moving to a model with several unobservable national shocks.

Let Σ denote the IP x IP covariance matrix of $\underline{\varepsilon}_t$ and let $\sigma_{pip'i'}$ denote the element of Σ corresponding to the covariance of ε_{pit} and $\varepsilon_{p'i't}$. Our assumptions imply the covariance structure in Figure 1.

Figure 1

Covariances of ε_{pit} and $\varepsilon_{p'i't}$ $(\sigma_{pip'i'})$

Same industry, Same province $(p=p', i=i')$

$$f_i^2\sigma_c^2 + \sigma_{\eta i}^2 + g_i^2\sigma_{vp}^2 + \sigma_{upi}^2$$

Same Industry, Different Province $(p\neq p', i=i')$

$$f_i^2\sigma_c^2 + \sigma_{\eta i}^2$$

Different Industry, Same Province $(p=p', i\neq i')$

$$f_i f_{i'}\sigma_c^2 + g_i g_{i'}\sigma_{vp}^2$$

Different Industry, Different Province $(p\neq p', i\neq i')$

$$f_i f_{i'}\sigma_c^2$$

Two examples may be helpful for understanding the covariance structure in Figure Figure 1. This structure rules out contemporaneous correlation between manufacturing in Ontario and transportation in Ontario once US_t , US_{t-1} , the feedback terms in lagged employment and the shocks c_t and v_{pt} (p for Ontario) are controlled for. It also rules out correlation between manufacturing in Ontario and manufacturing in Quebec conditional on US_t , US_{t-1} , the feedback terms, and the shocks c_t and η_{it} (i for manufacturing).

The coefficients f_i and g_i determine the responsiveness of each industry to national and provincial shocks respectively and are of central interest. (In estimation it is necessary to normalize the f and g vectors, for example, by setting f_1 and g_1 equal to one.) The elements of f and g are industry specific since one would expect manufacturing (a highly cyclical industry with a national market) to be more responsive to v_{pt} and especially c_t than services.

We now discuss how the estimates of feedback parameters, the coefficients on the error components, and the variances of the error components may be used to allocate the variance of national employment, industry employment and provincial employment to various sources.

3.3 Sources of the Variance in Employment

We first present a formula for the contribution of US_t, c_t, η_{it}, v_{pt}, and u_{pit} to the variance of the innovation in $\underline{Y}_t$. These abstract from the feedback effects of the shocks on $\underline{Y}_t$ through $\underline{Y}_{t-1}$. From the moving average representation of the model we then derive an expression for the total contribution of each of these factors to the steady state variance of $\underline{Y}_t$. Since Y_{ct}, $Y_{p.t}$, $Y_{.it}$ are linear combinations of $\underline{Y}_t$, we can use these formulae to measure the contribution of the shocks to the innovation variance and steady state variance of national, provincial, and industrial employment growth respectively.

In this section we assume that c_t, η_{it}, v_{pt} and u_{pit} are white noise shocks for all p and i. This allows for considerable simplification in the expressions for the steady state variance of $\underline{Y}_t$. Moreover, in our empirical work, we allow for the possibility that Y_{pit-1} enters (6) and the possibility that c_t, η_{it} and v_{pt} each follow first order autoregressive processes. None of these modifications affects our empirical results for the variance decompositions.

To begin, assume that US_t follows a second-order autoregressive process

$$(9)\quad US_t = \rho_o + \rho_1 US_{t-1} + \rho_2 US_{t-2} + \varepsilon_{ust}, \quad E(\varepsilon_{ust}^2) = \sigma_{us}^2 .$$

Substituting (9) and (8) into (1) yields

$$(10)\quad \underline{Y}_t = \underline{\lambda} + \Pi \underline{Y}_{t-1} + (\underline{B}_1\rho_1 + \underline{B}_2)US_{t-1} + \underline{B}_2\rho_2\, US_{t-2}$$

$$+ \underline{B}_1\varepsilon_{ust} + \underline{f}\, c_t + \underline{\eta}_t + G\, \underline{v}_t + \underline{u}_t$$

where $\underline{\lambda}$ is redefined as the new vector of constant terms and

$$\underline{B}_1 = [B_{11}, \ldots, B_{1I}, B_{11}, \ldots, B_{1I}, \ldots, B_{11}, \ldots, B_{1I}]' ,$$

$$\underline{B}_2 = [B_{21}, \ldots, B_{2I}, B_{21}, \ldots, B_{2I}, \ldots, B_{21}, \ldots, B_{2I}]' ,$$

$$\underline{f} = [f_1, \ldots, f_I, f_1, \ldots, f_I, \ldots, f_1, \ldots, f_I]' ,$$

$$\underline{\eta}_t = [\eta_{1t}, \ldots, \eta_{It}, \ldots, \eta_{1t}, \ldots, \eta_{It}, \ldots, \eta_{1t}, \ldots, \eta_{It}] ,$$

$$\underline{v}_t = [v_{1t}, v_{1t}, \ldots v_{1t}, v_{2t}, v_{2t} \ldots, v_{2t}, \ldots, v_{Pt}, v_{Pt}, \ldots, v_{Pt}]' ,$$

$$\underline{u}_t = [u_{11t}, u_{12t}, \ldots u_{1It}, u_{21t}, \ldots, u_{PIt}] ,$$

and G is a PI x PI diagonal matrix with $g_{i'}$ on the diagonal for rows in which Y_{pit} is from industry i'. Then under the assumption ε_{ust}, c_t, $\underline{\eta}_t$, $\underline{v}_t$ and $\underline{u}_t$ are independently distributed, the innovation variance of $\underline{Y}_t$ may be written as

$$(11)\quad V(\underline{Y}_t) = \sigma^2_{us}\, \underline{B}_1\, \underline{B}_1' + \sigma^2_c\, \underline{f}\, \underline{f}' + \Omega_\eta + G\, \Omega_v\, G' + \Omega_u ,$$

where Ω_η, Ω_v, Ω_u are the covariance matrices for $\underline{\eta}$, $\underline{v}$ and $\underline{u}$, respectively. To calculate the contribution of each of these shocks to the innovation variance of Y_{ct}, $Y_{p\cdot t}$ and Y_{it}, note that

$$(12)\quad Y_{ct} = \underline{w}_c'\, \underline{Y}_t \; ; \quad Y_{p\cdot t} = \underline{w}_p'\, \underline{Y}_t \; ; \text{ and } \; Y_{.it} = \underline{w}_i'\, \underline{Y}_t$$

where

(13a) $\underline{w}_c' = (w_{11}, w_{12}, \ldots, w_{1I}, w_{21}, \ldots, w_{PI})$

(13b) $\underline{w}_p' = (0, \ldots, 0, w^p_{.1}, \ldots, w^p_{.I}, 0, \ldots, 0)$ and

(p-1) x I elements

(13c) $\underline{w}_i' = (0,\ldots,0,w^i_{1.},0,\ldots,0,0,\ldots,0,w^i_{2.},0,\ldots,0,\ldots0,w^i_{P.},\ldots,0).$

i^{th} element $\uparrow$ $\quad$ $I+i^{th}$ element $\uparrow$

Then, if $Z_t = \underline{w}'\underline{Y}_t$, $V(Z_t) = \underline{w}'V(\underline{Y}_t)\underline{w}$. For example, the contribution of the provincial shocks $(v_{1t}, \ldots, v_{Pt})$ to the innovation variance of national employment Y_{ct} is given by

(14) $\sum_{p'=1}^{P} [\sum_i (w_{p'i})^2 (g_i)^2\sigma^2_{vp'} + \sum_i \sum_{i'\neq i} (w_{p'i}w_{p'i}) g_i g_{i'}\sigma^2_{vp'}]$.

To assess the overall contribution of each of the shocks to the steady state variance of employment, it is necessary to take account of feedback effects through lagged employment. To do this, we combine the system in (10) and the time series process for US_t given by (9) into one system of equations, and maintain the assumption that c_t , $\underline{n}_t$, $\underline{v}_t$ and $\underline{u}_t$ are serially uncorrelated. We have

(15) $$\begin{bmatrix} \underline{Y}_t \\ US_t \\ US_{t-1} \end{bmatrix} = \tilde{\underline{\lambda}} + A \begin{bmatrix} \underline{Y}_{t-1} \\ US_{t-1} \\ US_{t-2} \end{bmatrix} + \tilde{\underline{B}}\,\varepsilon_{ust} + \tilde{\underline{f}}c_t$$

$$+ \tilde{\underline{n}}_t + \begin{bmatrix} G & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \tilde{\underline{v}}_t + \tilde{\underline{u}}_t$$

where $$A = \begin{bmatrix} \Pi & (\rho_1 \underline{B}_1 + \underline{B}_2) & \rho_2 \underline{B}_2 \\ 0 & \rho_1 & \rho_2 \\ 0 & 1 & 0 \end{bmatrix},$$

the elements of Π are defined in (7a)-(7d) ,
$\tilde{\underline{B}} = [\underline{B}_1', 1, 0]'$, and $\tilde{\underline{f}}$, $\tilde{\underline{n}}_t$, $\tilde{\underline{v}}_t$ and $\tilde{\underline{u}}_t$ equal $\underline{f}$, $\underline{n}_t$, $\underline{v}_t$ and $\underline{u}_t$ with two zeros added.

Assuming the process is stationary, and defining I_{PI} to be the PI x PI identity matrix, one may express the deviation $\underline{Y}_t$ from its mean as

$$(16) \quad \underline{Y}_t - \text{mean}\,(\underline{Y}_t) = [\; I_{PI} \; 0 \; 0 \;] \sum_{k=0}^{\infty} A^k \tilde{\underline{B}} \varepsilon_{ust-k} + \sum_{k=0}^{\infty} \Pi^k \, \underline{f} \, c_{t-k} + \sum_{k=0}^{\infty} \Pi^k \, \underline{n}_{t-k} + \sum_{k=0}^{\infty} (\Pi^k G) \, \underline{v}_{t-k} + \sum_{k=0}^{\infty} \Pi^k \, \underline{u}_{t-k} \,.$$

Our previous assumptions and (16) imply that the steady state variance of $\underline{Y}_t$, $V^s(\underline{Y}_t)$, takes the form

$$(17) \quad V^s(\underline{Y}_t) = \{\sigma_{us}^2 \, [\, I_{PI} \; 0 \; 0 \,] \, (\sum_{k=0}^{\infty} A^k \, \tilde{\underline{B}} \, \tilde{\underline{B}}'(A^k)')[\, I_{PI} \; 0 \; 0 \,]'\} + \{\sigma_c^2 \, (\sum_{k=0}^{\infty} \Pi^k \, \underline{f} \, \underline{f}'(\Pi^k)')\} + \{\sum_{k=0}^{\infty} \Pi^k \, \Omega_n \, (\Pi^k)'\} + \{\sum_{k=0}^{\infty} \Pi^k \, G \, \Omega_v \, G'(\Pi^k)'\} + \{\sum_{k=0}^{\infty} \Pi^k \, \Omega_u \, (\Pi^k)'\} \,.$$

The expressions for the variance of Y_{ct}, $Y_{p\cdot t}$ and $Y_{.it}$ are obtained by applying the relevant weighting vector to (17). Through the use of (11) and (17), we can measure the relative importance of US shocks, national shocks, province specific shocks, industry specific shocks and province-industry specific shocks to the innovation and steady state variance of the growth in Canadian employment at the national, industry and province levels.

4. Estimation Methodology

Our model consists of 54 parameters which enter linearly in (6) as well as the 32 parameters which enter nonlinearly in (8).[10] We carry out the estimation in two stages. First, we estimate the regression parameters of (6) using instrumental variables and least squares procedures. The resulting parameter estimates are used to provide estimates $\hat{\varepsilon}_{pit}$ of the error ε_{pit}. Second, we estimate the coefficients and variances in the model for the ε_{pit} from the sample covariances of $\hat{\varepsilon}_{pit}$ and $\hat{\varepsilon}_{p'i't}$. Both steps of the procedure require discussion.

4.1 Estimation of the Coefficients on Lagged Employment, US_t, and US_{t-1}

Since the parameters of (6) are constant across provinces but differ across industries, it is useful to begin by focusing on estimating the parameters for a specific industry. The appropriate method of estimation depends on one's assumptions and interpretation of (6). While (6) is not a structural equation (in the conventional sense), one could argue that the restrictions on Π implied by (6) are appropriate once $\underline{Y}_{t-1}$ has been purged of any correlation with $\underline{\varepsilon}_t$ arising from autocorrelation in the components of the error. Further, one could argue that ignoring this correlation will diminish the role of these components in explaining the variance of $\underline{Y}_t$. In this case, TSLS should be used for estimation. On the other hand, OLS will be the appropriate estimation strategy if one is willing to assume that the components of $\underline{\varepsilon}_t$ are serially uncorrelated or if one simply interprets (6) as a restricted projection and $\underline{\varepsilon}_t$ as the residual from this projection. Fortunately, our qualitative results are insensitive to whether we use OLS or TSLS to estimate (6).

To implement the TSLS procedure, we assume that the national shock c_t follows a first order autoregressive process

$$c_t = rc_{t-1} + \varepsilon_{ct} .$$

To eliminate the serial correlation in c_t , we quasidifference (6) to obtain

$$(18) \quad Y^*_{pit} = \lambda_i(1-r) + \gamma_i Y^*_{ct-1} + \delta_i Y^*_{p.t-1} + \theta_i Y^*_{.it-1} + B_{1i} US^*_t + B_{2i} US^*_{t-1} + \varepsilon^*_{pit} ,$$

where $\varepsilon^*_{pit} = f_i \varepsilon_{ct} + \eta^*_{it} + g_i v^*_{pt} + u^*_{pit}$

and $X^*_t = X_t - rX_{t-1}$ for any variable X_t . All elements of $\underline{Y}_{t-1}$ are uncorrelated with ε_{ct} , as is any linear combination of the elements of $\underline{Y}_{t-1}$. The assumption of independence among the industry specific shocks, the province specific shocks, and the province-industry specific shocks implies that linear combinations of $Y_{p'i't-1}$ are also uncorrelated with η^*_{it} , v^*_{pt} , and u^*_{pit} when $p \neq p'$ and $i \neq i'$. Consequently such linear combinations are valid instrumental variables for (18). Note that the set of valid instrumental variables is specific to each province-industry pair.

Given our stochastic assumptions, we are left with a large number of potential instrumental variables. We use the following set of instrumental variables:

$[US_t, US_{t-1}, US_{t-2}, {}_pY_{\cdot 1t-1}, {}_pY_{\cdot 3t-1}, \ldots, {}_pY_{\cdot It-1}, {}_pY_{1t-2}, {}_pY_{\cdot 3t-2}, \ldots, {}_pY_{\cdot It-2}]$

where ${}_pY_{\cdot i't-1}$ and ${}_pY_{\cdot i't-2}$ are the employment changes in industry i' (in t-1 and t-2 respectively) averaged over all provinces _except_ p and we have used industry 2 as an example. (Note that the average for industry i is not used as an instrumental variable.) Instruments are formed for Y_{ct-1}, $Y_{p.t-1}$, and $Y_{.it-1}$ from industry specific regressions of these variables (across provinces and time periods) against the above set of instrumental variables. Since the parameter r is common to all industries, we estimate (18) across all industries by nonlinear two stage least squares. Although quasidifferencing eliminates serial correlation arising from c_t, the composite error ε^*_{pit} will not be white noise unless all of the components of ε_{pit} happen to obey the same autoregressive process.[11]

4.2 Estimating the Error Components Model

The error components model in (8) has the form of a factor model with _a priori_ restrictions on the vector of coefficients or factor loadings of the model.[12] The model (8) predicts that Σ, the covariance matrix of $\underline{\varepsilon}_t$, takes the form given in Figure 1 above. Thus the model places restrictions on Σ such that it can be expressed as $\Sigma(\underline{\beta})$, where $\underline{\beta}$ is the $m \times 1$ parameter vector

$$(19) \quad \underline{\beta} = [f_1, \ldots, f_I, g_1, \ldots g_I, \sigma^2_c, \sigma^2_{\eta 1}, \ldots, \sigma^2_{\eta I}, \sigma^2_{v1}, \ldots \sigma^2_{vP}, \sigma^2_{u11}, \ldots, \sigma^2_{uPI}]' .$$

We use an unweighted miniumum distance procedure to estimate $\underline{\beta}$. Let $\hat{\underline{\varepsilon}}_t$ denote the $PI \times 1$ vector of regression residuals from (6) in period t. We first form S, a consistent estimate of Σ, using

$$S = \textstyle\sum_t \hat{\underline{\varepsilon}}_t \hat{\underline{\varepsilon}}_t'/T .$$

We next stack the elements of S into a $K \times 1$ vector $\underline{\tilde{S}}$. The covariance terms are counted only once, so that $K = PI \cdot (PI + 1)/2$. For a given value of $\underline{\beta}$, we use the same procedure to stack the predicted covariances $\Sigma(\underline{\beta})$ into a vector $\underline{\tilde{\Sigma}}(\beta)$. Then analagous to least squares estimation (where the elements of $\underline{\tilde{S}}$ play the role of the dependent variable), we choose $\hat{\underline{\beta}}$ to minimize the sum of squared differences between the sample and predicted covariances,[13]

$$(20) \quad Q = \sum_{k=1}^{K} (\tilde{S}_k - \tilde{\Sigma}(\underline{\beta})_k)^2 \quad .$$

We estimate the asymptotic covariance matrix of $\hat{\underline{\beta}}$ from

$$(21) \quad V(\hat{\underline{\beta}}) = (D'D)^{-1} (D'V(\underline{\tilde{S}})D) (D'D)^{-1} ,$$

where D is the $K \times m$ matrix of derivatives of $\tilde{\Sigma}(\underline{\beta})$ with respect to $\underline{\beta}$ evaluated at $\hat{\underline{\beta}}$ and $V(\underline{\tilde{S}})$ is an estimate of the $K \times K$ variance covariance matrix of the vector $\underline{\tilde{S}}$. (See Chamberlain (1984).)

In estimating $\underline{\beta}$ and calculating the standard errors, we face the problem that $V(\underline{\tilde{S}})$ is a 1485 x 1485 matrix. As a result, evaluating expressions involving $V(\underline{\tilde{S}})$ can be extremely demanding in terms of computer time and storage, and this limits our options in choosing an estimation strategy. To reduce the computational burden (and because T is much smaller than K) we use a large sample normality approximation and $\hat{\underline{\beta}}$ to estimate $V(\underline{\tilde{S}})$.[14] Further, we do not attempt to improve the efficiency of our estimates of $\underline{\beta}$ by using an optimal (weighted) minimum distance procedure, since this procedure requires repeatedly evaluating expressions involving $V(\underline{\tilde{S}})^{-1}$.[15] (These efficiency gains are analogous to those obtained from using GLS instead of OLS when estimating a regression model.) The lack of an optimal minimum distance estimator rules out performing standard chi-square goodness of fit tests, and alternatives such as those suggested by Newey

(1985a) are computationally infeasible.[16] Instead, below we present informal evidence concerning goodness of fit.

5. **Empirical Analysis**

This section presents the empirical results. It is organized as follows. Section 5.1 describes the data. Section 5.2 discusses the estimates of the regression parameters of the model. Section 5.3 discusses the estimates of the coefficients on the national and province specific shocks and the variances of the national, provincial, industry, and province-industry shocks. In Section 5.4, we use the moving average representation of our model and the parameter estimates from 5.2 and 5.3 to illustrate the cumulative impact of various shocks on Canadian employment growth at the national and industrial levels. In Section 5.5, we estimate the contribution of the respective shocks to the variance of the growth in Canadian national employment, industrial employment and provincial employment.

5.1 Data

As mentioned earlier, the data for the study are annual employment in Canada disaggregated by one digit SIC industry (Forestry, Mining, Manufacturing, Construction, Transportation, Trade, Finance, Services, and Government) and by province. Employment in the Yukon, Northwest Territories and Prince Edward Island are excluded. New Brunswick and Nova Scotia are combined in the analysis, as are Manitoba and Saskatchewan. Although it would have been desirable to disaggregate further along industry lines, particularly in manufacturing and construction, the necessary data are not available by province.

The data are available from 1961 to 1982 and are taken from CANSIM. Three years are lost in the construction of first difference and lagged values of the variables. Consequently, the effective sample for estimation covers 1964-1982.[17]

Table 3 presents a summary of the average composition during our sample period of employment in Canada by industry and province.[18] Manufacturing, services and trade are the largest sectors, with 24.5, 27.9 and 16.8 percent of employment respectively. Forestry and Mining account for only 1.0 and 1.9 percent of employment. Newfoundland accounts for only 1.6 percent of employment in Canada. It is important to note that our estimation procedure gives equal weight to Newfoundland in the estimation of many of the parameters. This is probably undesirable, especially in light of the large estimated variance of v_{pt} for Newfoundland.[19] Consequently, we focus upon estimates of the model with Newfoundland excluded.[20]

Tables 1 and 2 present information on the sample means and standard deviations of provincial employment $Y_{p.t}$ and industrial employment $Y_{.it}$.

5.2 Estimates of the Regression Parameters

We initially estimated (6) by nonlinear TSLS, using the instrumental variables discussed in Section 4. Since we obtained an estimate of the autocorrelation parameter r of only -.05, we set r equal to 0 and used OLS and TSLS to estimate (6). The TSLS results are reported in Table 4a, and the OLS estimates are reported in Table 4b. The estimated coefficients on US_t and US_{t-1} indicate that U.S. GNP has a strong effect on forestry, manufacturing, construction, and a moderate effect on trade and finance. The (relatively) weak response of mining to U.S. GNP is surprising. U.S. GNP has a positive impact on all sectors except government. To determine the overall impact of U.S. GNP on employment in a given industry it is necessary to take into account feedback effects through past employment changes. We do this in Section 5.4.

The effects of lagged provincial employment, lagged Canadian employment, and lagged industry employment on the dynamic behavior of employment growth are interdependent, and thus it is very difficult to interpret the coefficients of these variables by themselves. In Section 5.4 we present a discussion of the moving average representation of the response of employment to various disturbances. However, a few observations can be made at this point. First, note that the TSLS and OLS point estimates are generally similar, but they do differ by large amounts in several cases. As one would expect, the reported standard errors, (which are approximate at best for the reasons discussed in footnote 11), are usually considerably larger for the TSLS estimates than for the OLS estimates. They are especially large for forestry, mining, and construction as a result of the large residual variances for these equations.

We find that the lagged change in provincial employment has a substantial positive effect on the current employment change in most industries. The effect is especially large in mining, construction, transport, and finance. The results are consistent with the notion that there is substantial interdependence among industries at the regional level. Indeed, we find the TSLS estimate of the response of mining to lagged provincial employment to be unreasonably large. The effect of lagged own industry employment is smaller in absolute value in most cases and mixed in sign. The response of employment to the lagged change in Canadian employment is negative for all industries except construction, government and services. The point estimate for construction is very large but is subject to a very large standard error.

Neither the inclusion of the own lag of the employment change nor the inclusion of a provincial trend significantly affects the results.[21]

5.3 The Employment Responses to National, Province, and Industry Shocks

Table 5a reports estimates of the response coefficients f_i , g_i , to the national and provincial shocks, as well as estimates of the variances of the national, industry, and provincial shocks for the TSLS residuals. Table 5b reports the corresponding results for the OLS residuals. The results are similar, and we focus upon the OLS results. We have normalized the response of forestry to the national and provincial shocks to be 1. The response of each industry to the industry specific shocks is normalized to 1 for all industries.

The responses to the national shock are estimated relatively precisely and are in accord with a priori expectations. Forestry, mining, and construction are the most responsive to the national shock, followed by manufacturing and transportation. Trade, finance, and services are only about 1/4 as responsive to a national shock as construction. Government has a small negative response, which would be consistent with counter-cyclical use of manpower programs (among other explanations).

The variances of some of the industry specific shocks are substantial given that the response coefficients have been normalized to one in each industry. A number of these point estimates have relatively small standard errors. By comparing the point estimate for the industry specific variance to the product of the estimate of the variance of the national shock and the square of the estimated national response coefficient for the particular industry, one may assess the relative importance of national and industry shocks in the covariance of ε_{pit} across provinces for the industry. The industry specific shock is more important than the national shock for finance, services, trade and government.

However, the national shock is more important for mining, manufacturing (in the OLS case), forestry and construction, even though the variances of the mining and manufacturing industry specific shocks are quite large. (The estimated variance for forestry is slightly negative, but this estimate is only marginally larger than its standard error.)

The parameter estimates for the provincial shocks are imprecise. The large response coefficients for forestry and mining are somewhat surprising given that one would expect these industries to have national or international markets. These large point estimates could indicate a strong impact of provincial policy changes on mining and forestry. The number of negative point estimates for variance parameters is somewhat troubling and may reflect misspecification. On the other hand, all of these estimates are associated with large standard errors, and thus may simply reflect sampling error.

Since we cannot calculate a chi-square goodness-of-fit test, in Table 6 we compare the predicted values of the covariances of the errors across industry and province pairs (when the province is different) based upon the parameter estimates in Table 5b to the unrestricted estimates, which are the average value across different provinces of the covariance for the given industry pairs. The restricted and unrestricted estimates correspond reasonably closely.[22]

We considered several other modifications when estimating the parameters of the error components model. We estimated the parameters from the moment matrices based on the residuals for i) the case where the own lag of Y_{pit} enters (6) and, ii) the case where a provincial trend enters (6). We also re-estimated the parameters while constraining to zero the variances that were estimated as negative numbers in Table 5a.[23] None of these modifications had a significant effect on the parameter estimates.

5.4 Dynamic Response of Employment Growth

In this section we use our parameter estimates and the moving average representation (16) to illustrate the cumulative impact of various shocks to Canadian employment growth at the national and industry levels. We report results based on the OLS estimates (Newfoundland excluded) but the general results are not sensitive to changing the estimation method or sample. The time horizon refers to the number of years following the shock.

In Table 7a, we trace out the response of the growth rate in Canadian employment at the national and industry levels to a one time, one standard deviation increase in ε_{ust} (the size of the increase is .0246). In terms of national employment, the growth rate rises above its initial level for years 0 through 3, at which point the effect of the US shock essentially stops. In several industries the impact of the shock is always positive, while in forestry, manufacturing and, to a lesser extent, construction and finance the effect in later years becomes negative before the growth rate returns to its initial value. Initially the shock has a small negative effect on government, followed by an increase in employment growth in this industry.

Table 7b indicates the effect of a one time, one standard deviation increase in the national shock c_t on the growth rate of national and industry employment. (The size of the hypothetical shock is .0339). The response pattern to this experiment is qualitatively similar to the response pattern to the US shock.

Table 7c reports the response of the growth rate of national employment to a one time rise in each industry specific shock. The size of the hypothetical shock is set equal to the square root of the industry specific variance (reported in Table 5b). If the point estimate of the industry's variance is negative, the shock is set equal to the square root of the average of the estimated variances of the industry specific shocks reported in Table 5b.[24] (In the latter case the size of the shock equals .0111.) For example, column 1 indicates the impact on national employment growth of a one-time, one standard deviation increase in the Forestry specific shock. In general, national employment growth rises in response to the industry shocks, but these effects disappear after three years. The responses are smaller than the response to a one standard deviation national shock.

In Table 7d, we show the impact on the growth rate of each industry's employment of a one-time, one standard deviation shock to each industry's error η_{it}. (For each industry the shock is the same as in Table 7c.) The impact of the shock is generally positive and virtually all effects disappear after five years. A comparison of Tables 7d and 7c establishes that the industry shock has a much larger impact on the specific industry than on national employment growth. The response to an industry shock is positively related to the weight of the industry in national employment growth and to the size of the shock.

Finally, in Table 7e we illustrate the impact on employment growth of one experiment involving the provincial shocks. Specifically, we calculate the impact on national and industry employment growth of a one time increase in the provincial error for Nova Scotia/New Brunswick equal to .0281, the square root of the average of the estimated regional variances reported in Table 5b. We then repeat the calculation for the other provincial shocks, again using the square root of the average value of the regional variances. In Table 7e, we report the average effect on the employment growth rates of these seven experiments. The effect of the provincial shocks on national employment essentially disappears after three years. Again there are differences in the size and timing of the industry responses to the provincial shock.

The analysis of the dynamic response carried out in this section and the steady state variance decompositions reported in the next section are based on the assumption that all shocks are white noise errors. Given the estimates of the residuals, we checked for autocorrelation in the industrial and provincial shocks. Assuming a constant autocorrelation parameter across industries, we obtained an estimate of approximately -.02 for this parameter. We obtained an estimate of -.18 for the provincial autocorrelation parameter. When we recalculated the response coefficients and the variance decompositions to allow for autocorrelation in the industrial and provincial shocks, the results were quite similar.

5.5 Accounting for the Variance in Canadian Employment

We now discuss estimates of the contributions of various sources to the variance in employment growth at the national, industry, and provincial levels. Using (11) from Section 3, we compute the contribution of the various shocks to the variance of the innovation in Y_{ct}, $Y_{p\cdot t}$, $Y_{.it}$ conditional on past employment levels, US_{t-1} and US_{t-2}. We also compute the contribution of various shocks to the steady state variances of Y_{ct}, $Y_{p\cdot t}$, and $Y_{.it}$ using (17).

Table 8a reports the contributions of the shocks to the variance of the innovation in Y_{ct}, $Y_{.it}$ and $Y_{p\cdot t}$ respectively when OLS is used to estimate

(6) and data on Newfoundland are excluded. Column 1 is the variance contribution of the US shock ε_{ust}, while column 2 is the contribution of c_t and column 3 reports the combined effect of the industry shocks $\eta_{1t} \ldots \eta_{It}$. Column 4 reports the combined effect of the provincial shocks $v_{1t} \ldots v_{Pt}$, and column 5 reports the combined effect the province/industry shocks $u_{11t} \ldots u_{PIt}$.

In these calculations (and the ones that follow) we have set negative variances to zero, although this makes little difference in practice. For the only case that we considered, (TSLS estimation, no Newfoundland data), we found that using minimum distance estimates where these negative parameters were constrained to zero had no significant impact on the calculations. The first row of the table indicates that the US shock and the Canadian national shock account for 43.2% and 43.8% (respectively) of the variance in the innovation of national employment. The industry shocks, the provincial shocks, and the province-industry shocks account for 6.6%, 3.7%, and 2.9% of this variance, respectively. (The contributions sum to 100.2% because of rounding.) Sectoral shocks represent for only 13.2% of Canadian employment fluctuations due to all sources, but account for 23.1% of the variance due to Canadian sources. Thus, the results indicate that while sectoral shocks play only a modest role in national employment fluctuations, they play a more significant role in Canadian employment fluctuations due to Canadian sources.

The results in Table 8b for the steady state variances tell a similar story. The U.S. and Canadian shocks account, respectively, for 61.7% and 26.8% of the national variance. The industry shocks, the province shocks, and the province-industry shocks account, respectively, for 6.4%, 2.7% and 2.4% of the steady state variance in Canadian employment growth. Sectoral shocks account for 11.5% of the steady-state variance due to all sources and 30.0% of the variance due to Canadian sources. Thus, the dominant influences are the US shock and (to a lesser extent) the Canadian national shock. Nevertheless, the sectoral shocks contribute a significant fraction of the variance which arises from Canadian sources. One might speculate that sectoral shocks would be more important in a more closed economy, such as that of the U.S.

The results in the tables show considerable differences in the relative importance of the shocks to the total industry variances. In no case are provincial shocks very important. The results on the importance of the province-industry shocks to the industry variances are sensitive to the estimation procedure and whether or not Newfoundland is included. However, in all cases these shocks contribute more than 20% of the steady-state variance of Forestry, Mining, and Government and more than 10% for Trade and Finance. For several industries, industry shocks account for a non-trivial fraction of the employment innovations, with transportation and forestry being exceptions.

The industry shocks account for relatively little of the variation in provincial employment growth, although these results are somewhat sensitive to the estimation method and sample. The contribution of industry shocks to both the innovation and steady-state variance of provincial employment growth is similar to their contribution to the national employment variance. Both province shocks and industry-province shocks play a more important role at the provincial level than at the national level.

In summary, we have estimated the model using both TSLS and OLS estimation procedures and have performed the analysis both with and without data on Newfoundland. We have also considered separately allowing for a lagged dependent variable in (6) and allowing serial correlation in the national and sectoral shocks. We have investigated different treatments of negative point estimates of some of the variances. The results reported above are representative of our results in each of the various cases.[25]

6. Conclusion

In this paper, we propose a method for assessing the contribution of various shocks to the variance of Canadian employment growth at the national, industry, and provincial levels. Specifically, this procedure analyzes the relative degree to which U.S. shocks, Canadian national shocks, and shocks to specific industries, specific provinces and specific province-industry pairs cause fluctuations in employment growth at various levels of aggregation. We apply this methodology to annual data on Canadian employment at the industry-province level. Our results suggest U.S. shocks are responsible for approximately two-thirds of the steady-state variance in the growth of national employment, while the Canadian national shock accounts for approximately a quarter of this variance. Taken together, industry specific, province specific and province-industry specific shocks account for approximately a tenth of the variance in Canadian employment growth. Thus our analysis indicates that the dominant influences on aggregate employment growth in Canada are US shocks, and to a lessor extent, national shocks. Nevertheless, sectoral shocks would appear to account for a substantial fraction of the variance in national employment due to Canadian sources. Industry specific shocks play an economically significant role in several industries, while provincial shocks play an important role in the variance of employment growth in most provinces. Idiosyncratic shocks are also important in several provinces and industries.

We view our study as a first approach to the problem, and there is a large agenda for future research. Within the present framework, development of a feasible weighted minimum distance would be very useful. Expanding the analysis to incorporate monthly or quarterly data would involve significant complications, but would also offer substantial benefits. First, the greater sample sizes would enable us to allow for a more flexible feedback mechanism between current and lagged employment. Second, the lower degree of time aggregation would allow us to more sharply separate sectoral shocks from the national shock. (For example, a specific shock to Ontario in January may look very much like a national shock by mid-year.) Finally, it would be very interesting to apply this approach to the U.S. economy, where one would expect the role of external shocks to be much smaller.

Footnotes

[1]Examples of studies using structural or reduced form econometric models to investigate the role of one or more of these factors are Barro (1977, 1978), Mishkin (1984) and Sargent (1976). Examples of the literature using descriptive time series methods to investigate the role of money shocks, investment shifts, or other aggregate factors are Gordon and Veitch (1984), Lawrence and Siow (1985), Litterman and Weiss (1984) and Sims (1972, 1980).

[2]The recent paper by Blanchard and Watson (1984) is one of a number of studies which suggest that aggregate shocks arise from a number of sources.

[3]See for example Lilien (1982a, 1982b) for evidence in favor of the hypothesis and Abraham and Katz (1985) for evidence against it.

[4]See Zarnowitz (1985, pp. 551-562) for a recent survey of this literature.

[5]In a companion paper (Altonji and Ham (1985)), we present a structural market clearing model which generates the econometric specification used below. We also investigate how relaxing the market clearing assumption along the lines of Fischer (1977) and Phelps and Taylor (1977) affects our specification.

[6]Changes in provincial governments may affect investor confidence and capital formation in a region, and this will have an effect on the demand for labor. Of course, regional shocks also may arise from non-governmental sources. For example, in industries such as agriculture, changes in weather conditions will represent a region specific shock.

[7]See Burbidge and Harrison (1985) for a careful analysis of the relationship between aggregate Canadian and U.S. economic variables. They find that the U.S. variables have a significant effect on the Canadian variables

(in a causality sense) but find that the Canadian variables have no economically significant effect on the U.S. variables.

[8] In the estimation, w_{pi} is allowed to vary over time. It is calculated as $(SHARE_{pit} + SHARE_{pit-1})/2$ where $SHARE_{pit}$ is the share of total Canadian employment in pi in year t .

[9] One could relax the specification (6) in a restricted way by making use of data from an input-output table to provide a priori information on the industry weights. (The necessary data appears to be available. See Whalley (1983).) In the same spirit, one might make use of information from an input-output table cross-classified by province to capture the most important differences across provinces in feedback among province-industry pairs. This would parallel the approach taken in some large scale multiregion econometric models for the U.S., (see the Bolton (1980) survey), and would be an interesting topic for future research. Long and Plosser (1983) present a model of output by industry in which the input-output matrix across industries plays a key role in the determination of the Π matrix in (1).

[10] For the reason discussed in Section 5.1, we present estimates based on a sample with Newfoundland excluded. This exclusion has no important effect on our conclusions, and results for the case where data on Newfoundland are contained in the Appendix tables.

[11] In Tables 4a and 4b, we present standard errors based on the standard OLS and TSLS expressions. In principle, these standard errors should be corrected for any remaining autocorrelation (which we find to be small) and for the covariance structure of the errors described in Figure 1. Given our emphasis on the variance decomposition presented below, we have not made these corrections.

It is worth noting that it may also be possible to improve efficiency by adapting the two-step two stage least squares procedures discussed in Hansen (1982) and Cumby et al (1983) to the present problem, although we leave this to future research.

[12]See, for example, Aigner et al. (1984) and Chamberlain (1984) for discussions of these models and references to the literature.

[13]An alternative strategy for estimating the response coefficients to the national shock would involve using the average of the residuals across all pi as an estimate $\hat{c}_t$ of c_t and estimating the f_i (with the normalization $\sum f_i = 1$) from regressions for each industry of the form

$$\hat{e}_{pit} = f_i \hat{c}_t + \eta_{it} + g_i v_{pit} + u_{pit}$$

treating $\eta_{it} + g_i v_{pi} + u_{pit}$ as an error term. Unfortunately, the estimate of $\hat{c}_t$ is contaminated by the presence of the industry, province, and province-industry shocks and is correlated with composite error. Consequently, $\hat{c}_t$ might pick up the effects of these shocks. A similar problem (and some additional ones) arises with the use of Y_{ct} or the change in Canadian GNP as a proxy for c_t. Although one may reduce these problems through various instrumental variables schemes, we prefer to treat c_t as an unobservable and use the minimum distance estimator.

[14]Let ε_j, ε_k, ε_ℓ, ε_m have a joint normal distribution with zero mean. Then $\text{cov}(\varepsilon_j \cdot \varepsilon_k, \varepsilon_\ell \cdot \varepsilon_m) = \text{cov}(\varepsilon_j, \varepsilon_\ell) \cdot \text{cov}(\varepsilon_k, \varepsilon_m) + \text{cov}(\varepsilon_j, \varepsilon_m) \cdot \text{cov}(\varepsilon_k, \varepsilon_\ell)$, (see, for example, Magnus and Neudecker (1984)), and we use our parameter estimates and the expressions in Figure 1 to calculate the covariances on the right-hand side of this equation. Alternatively, one could use the elements of S to calculate these covariances, and we did this for three

cases. In the case of OLS residuals, data on Newfoundland excluded, using the elements of S lead to a moderate reduction in the standard errors. In the case of OLS and TSLS residuals including Newfoundland, this had no effect on the estimate standard errors. We should note that we have not made an adjustment to (21) when TSLS residuals are analyzed (see Newey (1985b).

[15]The weighted estimator chooses β to minimize

$$Q_w = (\underline{\tilde{S}} - \underline{\tilde{\Sigma}}(\underline{\beta}))' \, (V(\underline{\tilde{S}}))^{-1} \, (\underline{\tilde{S}} - \underline{\tilde{\Sigma}}(\underline{\beta})) \, .$$

Under the normality assumption, the results of Magnus and Neudecker (1984) can be used to obtain an expression for the 1485 x 1485 matrix $V(\underline{\tilde{S}})^{-1}$ which only involves inverting the 54 x 54 matrix Σ , and $\Sigma(\hat{\underline{\beta}})$ is a nonsingular estimate of Σ .

[16]Even with an optimal minimum distance estimator, it is unclear how one would calculate the degrees of freedom for the test, since the sample moment matrix is of dimension PI, but is only of rank T . Thus, one could obtain a perfect fit of this matrix by parameterizing the Tx PI residuals used to calculate the moment matrix.

[17]It should be mentioned that the data are available on a monthly basis. We have chosen to work with annual data for two reasons. First, employment in Canada is highly seasonal. Treatment of seasonality in a satisfactory way would greated complicate the econometric analysis. Second, with a quarterly or monthly model it would probably be necessary to add additional employment lags to the employment equation (6), and allow the composite error ε_{pit} to depend upon lagged values of national, provincial, industry and province-industry shocks. This would add greatly to the number of parameters to be estimated. Since our model is already very large and costly to estimate, we leave an analysis using quarterly data to future research.

[18]The government figures appear low because government employment is spread over other categories, including services, construction, and manufacturing. See Ashenfelter and Card (1985) for a recent comparison of the US and Canadian labor markets. Employment data for US are also available by industry and state from the Bureau of Labor Statistics. An analysis for the US along the lines of the present paper would be an interesting topic for future research.

[19]This large variance may reflect the fact that data on fishing are unavailable and thus we cannot include this industry in our analysis.

[20]As noted in footnote 10, results including Newfoundland are reported in the Appendix tables. They are qualitatively similar to those excluding Newfoundland.

[21]Estimation of the basic model required significant expenditure of computer funds. Since the results were quite similar across estimation methods and samples, and to keep the computer budget from growing even larger, we did not investigate each modification for each of the four possible specifications: TSLS including Newfoundland; OLS including Newfoundland; TSLS excluding Newfoundland; and OLS excluding Newfoundland. The addition of the own lag and the provincial trend were considered only for TSLS and OLS including Newfoundland.

[22]Each of the average sample covariances in Table 6 is based on the average of 30 sample covariances across different provinces for the same pair of industries. The correlation coefficient between the (non-diagonal) average sample covariances and predictions from the factor model reported in Table 6 is .96. (The diagonal elements are excluded in this calculation since the factor model estimate of each diagonal element is equal to the average sample

covariance.) The correlation coefficient between the individual sample moments and the predicted moments (for different provinces) is .50. One would expect this correlation coefficient to be lower than the first because of sampling errors in the individual sample moments. These sampling errors in the individual moments tend to cancel out when one takes the average of covariances across different provinces for a given industry pair.

[23]Case i) was investigate for the OLS and TSLS residuals when data on Newfoundland are included. Case ii) was investigated for the TSLS residuals including Newfoundland. The constrained estimation (for the negative variances) was carried out on the TSLS residuals excluding Newfoundland.

[24]In taking this average, we have set the negative variances to 0.

[25]The Appendix tables contain the variance decompositions for TSLS and OLS including Newfoundland and TSLS excluding Newfoundland. The lagged dependent variable and autocorrelated error components cases (not reported) were analyzed for the OLS and TSLS residuals including Newfoundland. As noted above, the error components model was re-estimated with negative variances set to zero for the TSLS residuals excluding Newfoundland.

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Table 1

Means, Standard Deviations and Correlations for Industry Employment Growth[a/]

A. Mean and Standard Deviation

	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
Mean	-.0113	.0171	.0128	.0179	.0168	.0349	.0476	.0482	.0317
Standard Deviation	(.0760)	(.0514)	(.0364)	(.0560)	(.0179)	(.0218)	(.0231)	(.0165)	(.0223)

B. Simple Correlations Above the Diagonal / Partial Correlations Below the Diagonal[b/]

	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
Forestry	1.	.497	.689	.478	.590	.396	.468	.296	-.097
Mining	.596	1.	.451	.462	.533	.373	.077	.307	-.194
Manufacturing	.397	.572	1.	.793	.621	.821	.472	.589	-.150
Construction	.365	.486	.788	1.	.567	.692	.369	.523	-.057
Transportation	.523	.548	.692	.649	1.	.614	.410	.276	.142
Trade	.115	.365	.812	.642	.582	1.	.563	.570	.105
Finance	.180	.028	.198	.265	.286	.437	1.	.403	.325
Services	-.071	.296	.444	.494	.123	.457	.204	1.	-.050
Government	-.104	-.190	-.174	-.027	.157	.145	.397	-.042	1.

a/ Measured as the log first difference of industry employment. The sample period is 1963-1982.

b/ The partial correlations are based on the correlations of the residuals of regressions of the log first difference of employment in each of the industries on the current value and first lag of the change in the log of U.S. GNP.

Table 2

Means, Standard Deviations and Correlations for Provincial Employment Growth[a/]

A. Mean and Standard Deviation

	NFLD[b/]	NS/NB[c/]	QUEBEC	ONTARIO	MAN/SASK[d/]	ALBERTA	BC[e/]
Mean	.0293	.0214	.0241	.0295	.0244	.0525	.0395
Standard Deviation	(.0287)	(.0206)	(.0241)	(.0182)	(.0175)	(.0213)	(.0290)

B. Simple Correlations Above the Diagonal / Partial Correlations Below the Diagonal[f/]

	NFLD	NS/NB	QUEBEC	ONTARIO	MAN/SASK	ALBERTA	BC
NFLD	1.	.853	.830	.818	.610	.263	.764
NS/NB	.799	1.	.896	.768	.639	.558	.868
QUEBEC	.731	.868	1.	.884	.707	.579	.877
ONTARIO	.695	.697	.815	1.	.644	.493	.853
MAN/SASK	.582	.601	.705	.672	1.	.519	.673
ALBERTA	.069	.497	.491	.351	.482	1.	.662
BC	.617	.831	.802	.742	.669	.605	1.

[a/] Measured as the log first difference of industry employment. The sample period is 1963-1982.

[b/] NFLD denotes Newfoundland.

[c/] Data for Nova Scotia (NS) and New Brunswick (NB) combined.

[d/] Data for Manitoba (MAN) and Saskatchewan (SASK) combined.

[e/] BC denotes British Columbia.

[f/] The partial correlations are based on the correlations of the residuals of regressions of the log first difference of employment in each of the provinces on the current value and first lag of the change in the log of U.S. GNP.

TABLE 3

AVERAGE PERCENTAGE SHARE IN CANADIAN EMPLOYMENT[a/]
BY PROVINCE AND INDUSTRY: 1961-1982

	NFLD	NS/NB	QUEBEC	ONTARIO	MAN/SASK	ALBERTA	BC	ROW TOTALS[b/]
FORESTRY	.042	.132	.281	.170	.027	.034	.306	.992
MINING	.078	.129	.369	.509	.175	.427	.172	1.859
MANUFACTURING	.200	.934	7.499	12.078	.984	.844	1.956	24.495
CONSTRUCTION	.123	.339	1.445	2.125	.432	.689	.606	5.759
TRANSPORTATION	.229	.680	2.715	3.402	1.095	.883	1.272	10.276
TRADE	.281	.969	4.168	6.620	1.488	1.464	1.803	16.793
FINANCE	.040	.203	1.320	2.163	.366	.369	.527	4.988
SERVICES	.461	1.616	7.282	10.746	2.360	2.486	2.942	27.893
GOVERNMENT	.143	.521	1.607	2.761	.623	.587	.703	6.945
COLUMN TOTALS[b/]	1.597	5.523	26.686	40.574	7.550	7.783	10.287	

a/ Defined as sum over industries and provinces listed.

b/ May not sum to 100% because of rounding.

Table 4A

TSLS Results for Employment[a/] by Industry and Province (Newfoundland Excluded)

Industry / Variable[b/]	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
Intercept	-0.0191 (0.0434)	-0.0371 (0.0303)	-0.0124 (0.0224)	-0.1234 (0.0367)	-0.0133 (0.0102)	-0.0037 (0.0116)	0.0062 (0.0130)	0.0077 (0.0086)	-0.0043 (0.0108)
Current Real U.S. GNP	0.7953 (0.5163)	0.4855 (0.3327)	1.1157 (0.1037)	1.9591 (0.3837)	0.1836 (0.1263)	0.4132 (0.1342)	0.3702 (0.1526)	0.2068 (0.0908)	-0.0928 (0.1469)
Lagged Real U.S. GNP	1.5409 (0.6164)	-0.0856 (0.3793)	-0.0407 (0.2541)	-0.4132 (0.4238)	0.1721 (0.1615)	0.1377 (0.1470)	0.1726 (0.1749)	0.1536 (0.1054)	-0.0523 (0.1589)
Lagged Own Province Employment[c/]	-0.1374 (1.3112)	2.8884 (1.0252)	0.8001 (0.4828)	1.0831 (0.9388)	1.3834 (0.3392)	0.2916 (0.3217)	1.1294 (0.4263)	0.3192 (0.2502)	0.2811 (0.3354)
Lagged Canadian Employment[c/]	-1.7568 (1.4672)	-1.5875 (1.0173)	-1.4558 (0.6888)	2.4403 (1.2768)	-0.8138 (0.4410)	-0.0642 (0.4885)	-0.9940 (0.4625)	0.1204 (0.2957)	0.4687 (0.3853)
Lagged Own Industry Employment[c/]	0.4481 (0.2097)	-0.2245 (0.2526)	0.8460 (0.4447)	-0.8788 (0.3251)	-0.0809 (0.2762)	0.3274 (0.3601)	0.3955 (0.1928)	0.2695 (0.1933)	0.5746 (0.1500)
R^2	0.1887	0.0942	0.4182	0.2130	0.1783	0.1402	0.1785	0.2108	0.2036
S.E.E.	0.1166	0.0736	0.0343	0.0851	0.0288	0.0292	0.0351	0.0206	0.0305
n	114	114	114	114	114	114	114	114	114

[a/] Dependent variable measured in log first-differences. Standard errors in parentheses.

[b/] Independent variables measured in log first-differences.

[c/] Treated as endogenous. See text for the list of instrumental variables.

Table 4B

OLS Results for Employment[a/] by Industry and Province (Newfoundland excluded)

Industry Variable[b/]	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
Intercept	-0.0128 (0.0393)	-0.0302 (0.0246)	-0.0125 (0.0175)	-0.1156 (0.0334)	-0.0023 (0.0086)	-0.0062 (0.0102)	0.0136 (0.0120)	0.0092 (0.0077)	-0.0047 (0.0100)
Current Real U.S. GNP	0.6308 (0.5023)	0.4496 (0.2996)	1.0521 (0.1573)	1.9238 (0.3747)	0.1355 (0.1142)	0.4251 (0.1278)	0.3360 (0.1483)	0.2213 (0.0870)	-0.0547 (0.1423)
Lagged Real U.S. GNP	1.7187 (0.6021)	0.0974 (0.3483)	0.0539 (0.2285)	-0.4333 (0.4210)	0.1466 (0.1454)	0.1373 (0.1447)	0.2022 (0.1722)	0.1496 (0.1023)	-0.0731 (0.1566)
Lagged Own Province Employment	-1.2531 (0.6863)	1.3706 (0.4113)	0.4660 (0.2028)	1.1056 (0.5085)	0.7324 (0.1582)	0.5692 (0.1727)	0.8197 (0.2076)	0.5839 (0.1202)	0.4445 (0.1813)
Lagged Canadian Employment	-0.8058 (1.2367)	-0.5555 (0.7274)	-1.0531 (0.6252)	2.1110 (1.1124)	-0.2254 (0.3388)	-0.2799 (0.4131)	-0.8038 (0.3837)	-0.0448 (0.2510)	0.3622 (0.3269)
Lagged Own Industry Employment	0.3108 (0.1940)	0.0545 (0.1869)	0.6860 (0.3619)	-0.7206 (0.2743)	-0.3243 (0.2262)	0.3157 (0.3021)	0.3392 (0.1700)	0.1569 (0.1642)	0.5007 (0.1364)
R^2	0.2050	0.1203	0.4214	0.2329	0.2223	0.2160	0.2196	0.3266	0.2385
S.E.E.	0.1149	0.0688	0.0339	0.0849	0.0264	0.0289	0.0347	0.0201	0.0303
n	114	114	114	114	114	114	114	114	114

[a/] Dependent variable measured in log first-differences. Standard errors in parentheses.

[b/] Independent variables measured in log first-differences.

Table 5A

Minimum Distance Estimates TSLS Residuals (Newfoundland Excluded)

A. Industry Coefficients on National, Province and Industry Shocks

Industry	National Shock		Province Shock		Industry Shock
Forestry	1.0[a]		1.0[a]		1.0[a]
Mining	.6967	(.3393)[c]	.8561	(.5367)	1.0[a]
Manufacturing	.5090	(.2317)	.4267	(.2579)	1.0[a]
Construction	1.3912	(.5958)	.2122	(.3018)	1.0[a]
Transportation	.5149	(.2019)	.2376	(.1532)	1.0[a]
Trade	.3132	(.1653)	.2593	(.1663)	1.0[a]
Finance	.3113	(.1826)	.3282	(.2321)	1.0[a]
Services	.2221	(.1182)	.1396	(.0962)	1.0[a]
Government	-.1347	(.1111)	.0359	(.1008)	1.0[a]

B. Variances of National, Province and Industry Shocks

i) Variance of Canadian Shock[b]: .1085 (.0859)

ii) Variances of Province Shocks[b]:

NS/NB	QUEBEC	ONTARIO	MAN/SASK	ALBERTA	BC
-.1395	.1492	-.0353	.3574	.1781	.0582
(.1593)	(.1793)	(.1582)	(.4299)	(.2104)	(.1308)

iii) Variances of Industry Shocks[b]:

FOR.	MIN.	MANU.	CONST.	TRANS.	TRADE	FIN.	SERV.	GOV.
-.0680	.0362	.0289	-.0129	.0028	.0166	.0228	.0084	.0024
(.0766)	(.0386)	(.0142)	(.0632)	(.0060)	(.0089)	(.0125)	(.0045)	(.0053)

[a] Normalized to 1.0.

[b] Multiplied by 100.

[c] Standard errors of parameter estimates in parentheses.

Table 5B

Minimum Distance Estimates OLS Residuals (Newfoundland Excluded)

A. **Industry Coefficients on National, Province and Industry Shocks**

Industry	National Shock		Province Shock		Industry Shock
Forestry	1.0[a]		1.0[a]		1.0[a]
Mining	.7303	(.3221)[c]	.7578	(.5608)	1.0[a]
Manufacturing	.5431	(.2292)	.5820	(.4075)	1.0[a]
Construction	1.286	(.5105)	.5747	(.4296)	1.0[a]
Transportation	.5020	(.1898)	.2122	(.1657)	1.0[a]
Trade	.3278	(.1610)	.3803	(.2683)	1.0[a]
Finance	.3012	(.1771)	.3085	(.2576)	1.0[a]
Services	.1940	(.1110)	.1963	(.1519)	1.0[a]
Government	-.1339	(.1345)	.2284	(.2148)	1.0[a]

B. **Variances of National, Province and Industry Shocks**

i) Variance of Canadian Shock[b]: .1152 (.0877)

ii) Variances of Province Shocks[b]:

NS/NB	QUEBEC	ONTARIO	MAN/SASK	ALBERTA	BC
-.1196	.1175	-.0840	.1395	.1570	.0621
(.1500)	(.1594)	(.1405)	(.2204)	(.2080)	(.1216)

iii) Variances of Industry Shocks[b]:

FOR.	MIN.	MANU.	CONST.	TRANS.	TRADE	FIN.	SERV.	GOV.
-.0792	.0302	.0237	.0043	.0018	.0152	.0230	.0098	.0024
(.0759)	(.0341)	(.0131)	(.0500)	(.0053)	(.0085)	(.0123)	(.0047)	(.0059)

[a] Normalized to 1.0.

[b] Multiplied by 100.

[c] Standard errors of parameter estimates in parentheses.

Table 6

Fitted Industry Covariances[a/] across Different Provinces[b/] (OLS Residuals, Newfoundland Excluded)

	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
Forestry	.0360[c/]	.1208[d/] .0842	.0457 .0626	.1187 .1482	.0294 .0579	.0348 .0377	.0517 .0347	.0274 .0224	-.0280 -.0154
Mining		.0917	.0394 .0457	.1123 .1083	.0309 .0423	.0709 .0276	.0240 .0254	.0149 .0163	-.0304 -.0127
Manufacturing			.0577	.0615 .0805	.0382 .0314	.0355 .0205	.0071 .0189	.0104 .0121	-.0142 -.0084
Construction				.0195	.0686 .0744	.0481 .0486	.0206 .0447	.0290 .0288	-.0273 -.0198
Transportation					.0309	.0230 .0189	.0225 .0174	.0114 .0122	-.0143 -.0077
Trade						.0276	.0077 .0114	.0109 .0073	-.0076 -.0051
Finance							.0334	.0090 .0068	.0059 -.0047
Services								.0142	-.0081 -.0030
Government									.0045

a/ Multiplied by 100.

b/ Diagonal elements are estimates of $f_i^2\sigma_c^2 + \sigma_{\eta i}^2$ while off-diagonal elements estimate $f_i f_j \sigma_c^2$.

c/ Minimum distance and sample averages produce identical estimates of diagonal elements. These estimates are presented to provide the reader with an idea of the relative magnitudes.

d/ For the off-diagonal elements, bottom number is based on minimum distance estimator and top number is based on the sample average of the covariances.

Table 7A

Cumulative Impact of U.S. Shock (OLS Residuals, Newfoundland Excluded)[a/]

Time Horizon	National	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
0	1.342	1.554	1.108	2.592	4.740	.334	1.047	0.828	.545	-.135
1	1.486	2.548	1.729	2.058	1.509	1.032	1.425	1.098	1.368	.782
2	1.131	-1.778	1.393	.890	4.214	.451	1.029	.536	1.104	1.558
3	.367	-4.083	.860	-.239	.608	.293	.496	.016	.649	1.748
4	.050	-2.553	.298	-.549	.597	.025	.164	-.095	.227	1.201
5	-.044	-.699	.134	-.418	-.311	.035	.079	-.017	.078	.639
10	-.017	.070	-.001	-.031	-.026	-.008	-.011	-.004	-.016	-.017
15	-.001	.006	.001	-.001	-.003	.000	.000	.000	.000	-.005

a/ All entries are multiplied by 100.

Table 7B

Cumulative Impact of Canadian Shock (OLS Residuals, Newfoundland Excluded)[a/]

Time Horizon	National	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
0	1.348	3.395	2.479	1.843	4.367	1.704	1.113	1.022	.658	-.454
1	.634	-1.728	1.230	.475	1.188	.097	.740	.368	.829	.858
2	.352	-1.824	.601	-.047	1.187	.286	.417	.135	.472	.941
3	.127	-1.272	.364	-.243	.286	.083	.235	.050	.265	.756
4	.036	-.641	.178	.249	.213	.041	.113	.017	.112	.483
5	-.012	.264	.093	-.199	-.025	.010	.049	.004	.040	.272
10	-.008	.042	.002	-.012	-.016	.004	-.005	-.001	-.008	-.015
15	.000	.003	.001	.001	-.001	.000	.000	.000	.000	-.003

a/ All entries are multiplied by 100.

Table 7C

Impact of Industry Shock on National Employment Growth (OLS Residuals, Newfoundland Excluded)[a]

Time Horizon	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
0	.011	.031	.381	.038	.044	.207	.076	.276	.034
1	.007	.013	.389	-.014	.000	.136	.052	.138	.029
2	.001	-.002	.242	.008	-.003	.028	.012	.002	.012
3	.000	-.001	.155	-.007	-.001	.002	.002	-.010	.005
4	.000	-.003	.075	.001	-.004	-.019	.006	.027	-.001
5	.000	-.002	.037	-.003	-.001	-.016	.006	-.018	-.002
10	.000	.000	-.004	.000	.000	-.001	-.001	-.002	-.001
15	.000	.000	.000	.000	.000	.000	.000	.000	.000

a/ All entries are multiplied by 100.

Table 7D

Impact of Industry Shock on Own Industry Employment Growth (OLS Residuals, Newfoundland Excluded)[a]

Time Horizon	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
0	1.108	1.737	1.540	.654	.430	1.232	1.515	.991	.494
1	.312	.137	.845	.349	.124	.449	.516	.305	.275
2	.073	.032	.364	.207	.043	.183	.176	.123	.161
3	.014	.011	.117	.124	.016	.067	.060	.022	.091
4	.001	.007	-.006	.068	.006	.023	.020	.000	.050
5	.000	.003	-.046	.044	-.003	.003	.006	-.014	.025
10	.000	.000	-.011	.028	.000	-.002	.000	-.002	-.001
15	.000	.000	.000	.000	.000	.000	.000	.000	.000

a/ All entries are multiplied by 100.

Table 7E

Average Impact of Provincial Shocks (OLS Residuals, Newfoundland Excluded)[a]

Time Horizon	National	Forestry	Mining	Manu-facturing	Con-struction	Trans-portation	Trade	Finance	Services	Government
0	.175	.470	.364	.273	.270	.100	.179	.145	.092	.107
1	.113	-.213	.158	.086	.366	.054	.107	.052	.108	.194
2	.053	-.295	.101	-.007	.098	.038	.066	.020	.078	.188
3	.025	-.198	.055	-.037	.102	.014	.037	.007	.041	.138
4	.006	-.109	.031	-.041	.008	.008	.019	.003	.020	.089
5	-.001	-.044	.015	-.033	.015	.001	.008	.001	.007	.050
10	-.001	.007	.000	-.002	-.004	.000	-.001	.000	-.001	-.002
11	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

[a] All entries are multiplied by 100.

Table 8A

Variance in Innovation of Canadian Employment Growth (OLS Residuals, Newfoundland Excluded)

Employment Change Variable	Sum of Variance from all Sources x 100 (1)	Share of Variance Due to: U.S. (ε_{ust}) (2)	National (c_t) (3)	All Industry ($\eta_{1t} \cdots \eta_{It}$) (4)	All Province ($v_{1t} \cdots v_{Pt}$) (5)	All Idiosyncratic ($u_{11t} \cdots \cdots u_{PIt}$) (6)
National	.0417	.432	.438	.066	.037	.029
Forestry	.3806	.064	.303	0.[a]	.044	.589
Mining	.2004	.061	.306	.151	.049	.433
Manufacturing	.1342	.501	.253	.177	.030	.040
Construction	.4726	.475	.404	.009	.008	.104
Trans./Util.	.0350	.032	.829	.053	.016	.070
Trade	.0495	.222	.250	.307	.031	.190
Finance	.0517	.133	.202	.444	.020	.201
Services	.0207	.144	.210	.475	.021	.150
Government	.0272	.007	.076	.090	.018	.809
N.S./N.B.	.0467	.307	.368	.045	0.	.281
Quebec	.0618	.313	.304	.050	.273	.060
Ontario	.0454	.444	.399	.073	0.	.085
Man./Sask.	.0495	.242	.312	.042	.309	.094
Alberta	.0632	.231	.295	.032	.307	.136
B.C.	.0588	.268	.319	.038	.144	.230

[a] In this table (and Tables A-5, A-7, and A-9), 0. denotes a value that is zero because a negative point estimate for a variance has been set to zero.

Table 8B

Steady-State Variance of Employment Growth (OLS Residuals, Newfoundland Excluded)

Employment Change Variable	Sum of Variance from all Sources × 100	Share of Variance Due to:				
		U.S. (ε_{ust})	National (c_t)	All Industry ($\eta_{1t} \cdots \eta_{It}$)	All Province ($v_{1t} \cdots v_{Pt}$)	All Idiosyncratic ($u_{11t} \cdots \cdots u_{PIt}$)
	(1)	(2)	(3)	(4)	(5)	(6)
National	.0880	.617	.268	.064	.027	.024
Forestry	.8795	.407	.227	.041	.032	.293
Mining	.2888	.243	.284	.116	.048	.309
Manufacturing	.2098	.589	.182	.164	.024	.041
Construction	.7883	.550	.279	.050	.015	.105
Trans./Util.	.0515	.285	.582	.057	.016	.059
Trade	.0967	.462	.210	.189	.024	.115
Finance	.0728	.301	.165	.357	.016	.161
Services	.0710	.544	.201	.177	.021	.057
Government	.1605	.502	.170	.078	.032	.217
N.S./N.B.	.0912	.494	.245	.042	.000	.218
Quebec	.1194	.482	.201	.054	.216	.046
Ontario	.0978	.614	.240	.075	.001	.070
Man./Sask.	.0979	.403	.219	.041	.257	.080
Alberta	.1328	.379	.214	.033	.259	.115
B.C.	.1070	.443	.219	.036	.116	.185

Table A-1

TSLS Results for Employment[a/] by Industry and Province (Newfoundland Included)

INDUSTRY VARIABLE[b/]	FORESTRY	MINING	MANUFACTURING	CONSTRUCTION	TRANSPORT	TRADE	FINANCE	SERVICES	GOVERNMENT
INTERCEPT	-0.0202 (0.0393)	-0.0332 (0.0309)	-0.0151 (0.0233)	-0.1264 (0.0351)	-0.0196 (0.0104)	-0.0066 (0.0114)	0.0049 (0.0127)	0.0054 (0.0080)	0.0029 (0.0102)
CURRENT REAL U.S. G.N.P.	0.8449 (0.4892)	0.6036 (0.3652)	1.0708 (0.1754)	1.8040 (0.3761)	0.2370 (0.1352)	0.4021 (0.1378)	0.3372 (0.1525)	0.2818 (0.0847)	-0.0292 (0.1443)
LAGGED REAL U.S. G.N.P.	1.5229 (0.5834)	-0.3044 (0.4286)	0.0670 (0.2750)	-0.3140 (0.4163)	0.1980 (0.1738)	0.2621 (0.1504)	0.3426 (0.1760)	0.1130 (0.0987)	-0.1441 (0.1565)
LAGGED OWN PROVINCE EMPLOYMENT	0.2010 (1.3286)	3.4424 (1.2458)	1.1268 (0.5675)	1.6077 (0.9935)	1.6639 (0.3811)	0.2420 (0.3558)	0.9844 (0.4490)	0.3694 (0.2485)	0.2357 (0.3566)
LAGGED CANADIAN EMPLOYMENT	-2.1992 (1.5303)	-1.9791 (1.2985)	-1.6055 (0.7376)	1.9686 (1.3205)	-1.0702 (0.5081)	-0.1287 (0.5258)	-1.099 (0.5136)	0.1264 (0.3089)	0.4495 (0.4173)
LAGGED OWN INDUSTRY EMPLOYMENT	0.4154 (0.1956)	-0.5323 (0.2830)	0.5962 (0.4891)	-0.9131 (0.3139)	-0.0101 (0.2916)	0.3838 (0.3558)	0.5683 (0.1878)	0.2508 (0.1752)	0.4994 (0.1460)
R^2	0.1773	0.1051	0.3508	0.1794	0.1885	0.1483	0.2015	0.2326	0.1539
S.E.E.	0.1196	0.0889	0.0395	0.0902	0.0332	0.0324	0.0382	0.0209	0.0325
n	133	133	133	133	133	133	133	133	133

[a/] Dependent Variable measured in log first-differences.

[b/] Independent Variables measured in log first-differences.

Table A-2

OLS Results for Employment[a/] by Industry and Province (Newfoundland Included)

INDUSTRY / VARIABLE[b/]	FORESTRY	MINING	MANUFACTURING	CONSTRUCTION	TRANSPORT	TRADE	FINANCE	SERVICES	GOVERNMENT
INTERCEPT	-0.01811 (0.0370)	-0.0332 (0.0258)	-0.0099 (0.0174)	-0.1143 (0.0326)	-0.0106 (0.0088)	-0.0091 (0.0104)	0.0102 (0.0121)	0.0082 (0.0073)	0.0030 (0.0098)
CURRENT REAL U.S. G.N.P.	0.6865 (0.4775)	0.5798 (0.3244)	1.0130 (0.1585)	1.7467 (0.3677)	0.1890 (0.1182)	0.4204 (0.1323)	0.3168 (0.1496)	0.2882 (0.0830)	-0.0040 (0.1410)
LAGGED REAL U.S. G.N.P.	1.7089 (0.5705)	-0.0480 (0.3824)	0.1126 (0.2303)	-0.3299 (0.4131)	0.1802 (0.1515)	0.2547 (0.1487)	0.3641 (0.1740)	0.1100 (0.0974)	-0.1644 (0.1551)
LAGGED OWN PROVINCE EMPLOYMENT	-0.8888 (0.6414)	1.3692 (0.4415)	0.2384 (0.1996)	1.4854 (0.4920)	0.7537 (0.1604)	0.4834 (0.1749)	0.7310 (0.2061)	0.5109 (0.1131)	0.2413 (0.1769)
LAGGED CANADIAN EMPLOYMENT	-1.1804 (1.1917)	-0.3479 (0.8042)	-0.8021 (0.6204)	1.6475 (1.0972)	-0.1819 (0.3589)	-0.3477 (0.4273)	-0.8772 (0.3936)	0.0357 (0.2436)	0.4853 (0.3284)
LAGGED OWN INDUSTRY EMPLOYMENT	0.2821 (0.1818)	-0.1389 (0.2007)	0.5505 (0.3651)	-0.7077 (0.2696)	-0.2508 (0.2349)	0.4106 (0.3078)	0.4885 (0.1710)	0.1553 (0.1561)	0.4512 (0.1363)
R^2	0.1830	0.1106	0.3655	0.2080	0.2233	0.1995	0.2300	0.3125	0.1675
S.E.E.	0.1179	0.0811	0.0367	0.0900	0.0295	0.0321	0.0379	0.0207	0.0325
n	133	133	133	133	133	133	133	133	133

[a/] Dependent Variable measured in log first-differences.

[b/] Independent Variables measured in log first-differences.

Table A-3

Minimum Distance Estimates 2 SLS Residuals (Newfoundland Included)

A. Industry Coefficients on National, Province and Industry Shocks

Industry	National Shock		Province Shock		Industry Shock
Forestry	1.0[a]		1.0[a]		1.0[a]
Mining	.8938	(.4064)[c]	1.3176	(.5991)	1.0[a]
Manufacturing	.5638	(.2242)	.6245	(.2744)	1.0[a]
Construction	1.1037	(.5247)	-.3268	(.3815)	1.0[a]
Transportation	.4651	(.1744)	.4121	(.1930)	1.0[a]
Trade	.2290	(.1494)	.0060	(.1425)	1.0[a]
Finance	.2127	(.1656)	.0941	(.1662)	1.0[a]
Services	.2020	(.1111)	.1157	(.0799)	1.0[a]
Government	-.1570	(.1911)	.0648	(.1325)	1.0[a]

B. Variances of National, Province and Industry Shocks

i) Variance of Canadian Shock[b]: .1234 (.0924)

ii) Variances of Province Shocks[b]:

NFLD	NS/NB	QUEBEC	ONTARIO	MAN/SASK	ALBERTA	BC
.4517 (.3894)	-.0799 (.0857)	.0656 (.0832)	.0065 (.0919)	.2510 (.2444)	.1179 (.1191)	-.0172 (.0672)

iii) Variances of Industry Shocks[b]:

FOR.	MIN.	MANU.	CONST.	TRANS.	TRADE	FIN.	SERV.	GOV.
.0173 (.0739)	.0756 (.0594)	.0159 (.0127)	.0596 (.0774)	-.0031 (.0062)	.0168 (.0097)	.0239 (.0134)	.0096 (.0048)	.0059 (.0067)

[a] Normalized to 1.0.

[b] Multiplied by 100.

[c] Standard errors of parameter estimates in parentheses.

Table A-4

Minimum Distance Estimates OLS Residuals (Newfoundland Included)

A. Industry Coefficients on National, Province and Industry Shocks

Industry	National Shock		Province Shock		Industry Shock
Forestry	1.0[a]		1.0[a]		1.0[a]
Mining	.9366	(.3599)[c]	1.3317	(.7875)	1.0[a]
Manufacturing	.5934	(.2062)	.5286	(.2863)	1.0[a]
Construction	.1053	(.4303)	-.2948	(.4921)	1.0[a]
Transportation	.4566	(.1498)	.3527	(.2159)	1.0[a]
Trade	.2272	(.1353)	-.0853	(.1926)	1.0[a]
Finance	.2030	(.1525)	-.0233	(.2061)	1.0[a]
Services	.1639	(.0983)	.1003	(.1011)	1.0[a]
Government	-.1475	(.1068)	.0254	(.1700)	1.0[a]

B. Variances of National, Province and Industry Shocks

i) Variance of Canadian Shock[b]: .1357 (.0916)

ii) Variances of Province Shocks[b]:

NFLD	NS/NB	QUEBEC	ONTARIO	MAN/SASK	ALBERTA	BC
.4352	-.0967	.0402	-.0048	.0665	.0666	.0431
(.4414)	(.1001)	(.0809)	(.0966)	(.1195)	(.0993)	(.0766)

iii) Variances of Industry Shocks[b]:

FOR.	MIN.	MANU.	CONST.	TRANS.	TRADE	FIN.	SERV.	GOV.
.0200	.0495	.0134	.0568	-.0012	.0160	.0242	.0111	.0058
(.0643)	(.0482)	(.0114)	(.0661)	(.0049)	(.0094)	(.0134)	(.0051)	(.0066)

[a] Normalized to 1.0.

[b] Multiplied by 100.

[c] Standard errors of parameter estimates in parentheses.

Table A-5

Variance in Innovation of Canadian Employment Growth (TSLS Residuals, Newfoundland Included)

Employment Change Variable	Sum of Variance from all Sources x 100 (1)	Share of Variance Due to: U.S. (ε_{ust}) (2)	National (c_t) (3)	All Industry ($\eta_{1t} \ldots \eta_{It}$) (4)	All Province ($v_{1t} \ldots v_{Pt}$) (5)	All Idiosyncratic ($u_{11t} \ldots \ldots u_{PIt}$) (6)
National	.0407	.487	.416	.061	.013	.022
Forestry	.3967	.109	.311	.044	.016	.521
Mining	.2875	.077	.343	.263	.075	.242
Manufacturing	.1287	.541	.305	.124	.025	.006
Construction	.4550	.434	.330	.131	.002	.103
Trans./Util.	.0377	.091	.708	0.	.042	.159
Trade	.0425	.231	.152	.394	.000	.223
Finance	.0490	.141	.114	.488	.001	.256
Services	.0223	.216	.226	.433	.005	.120
Government	.0294	.002	.103	.199	.001	.695
Newfoundland	.0853	.190	.212	.026	.318	.254
N.S./N.B.	.0472	.346	.333	.046	0.	.275
Quebec	.0508	.421	.350	.052	.093	.084
Ontario	.0439	.499	.388	.064	.010	.039
Man./Sask.	.0455	.302	.302	.048	.229	.118
Alberta	.0538	.305	.315	.047	.096	.236
B.C.	.0539	.332	.320	.041	0.	.307

Table A-6

Steady-State Variance of Canadian Employment Growth (TSLS Residuals, Newfoundland Included)

Employment Change Variable	Sum of Variance from all Sources × 100	Share of Variance Due to:				
		U.S. (ε_{ust})	National (c_t)	All Industry ($\eta_{1t} \cdots \eta_{It}$)	All Province ($v_{1t} \cdots v_{Pt}$)	All Idiosyncratic ($u_{11t} \cdots \cdots u_{PIt}$)
	(1)	(2)	(3)	(4)	(5)	(6)
National	.0895	.670	.251	.051	.011	.017
Forestry	.9361	.446	.211	.059	.012	.272
Mining	.4183	.167	.256	.258	.066	.253
Manufacturing	.1960	.628	.221	.115	.023	.013
Construction	.9195	.480	.196	.180	.020	.123
Trans./Util.	.0825	.463	.414	.017	.024	.082
Trade	.0837	.511	.112	.241	.000	.136
Finance	.0951	.368	.067	.369	.001	.194
Services	.0790	.589	.199	.160	.007	.045
Government	.1241	.488	.149	.106	.010	.247
Newfoundland	.2823	.176	.091	.017	.396	.320
N.S./N.B.	.1072	.458	.192	.035	.003	.312
Quebec	.1174	.551	.201	.045	.108	.095
Ontario	.1009	.653	.223	.059	.016	.049
Man./Sask.	.1085	.403	.175	.043	.247	.133
Alberta	.1546	.368	.173	.044	.118	.297
B.C.	.1230	.439	.180	.030	.004	.347

Table A-7

Variance in Innovation of Canadian Employment Growth (OLS Residuals, Newfoundland Included)

Employment Change Variable	Sum of Variance from all Sources × 100	Share of Variance Due to:				
		U.S. (ε_{ust})	National (c_t)	All Industry ($\eta_{1t} \ldots \eta_{It}$)	All Province ($v_{1t} \ldots v_{Pt}$)	All Idiosyncratic ($u_{11t} \ldots \ldots u_{PIt}$)
	(1)	(2)	(3)	(4)	(5)	(6)
National	.0401	.463	.449	.066	.004	.024
Forestry	.3694	.077	.367	.005	.010	.539
Mining	.2641	.077	.451	.188	.044	.240
Manufacturing	.1267	.492	.377	.105	.009	.017
Construction	.4358	.425	.345	.130	.001	.098
Trans./Util.	.0340	.064	.832	0.	.016	.088
Trade	.0438	.245	.160	.365	.060	.229
Finance	.0477	.128	.117	.508	.000	.247
Services	.0226	.224	.162	.493	.002	.120
Government	.0293	.000	.101	.199	.000	.700
Newfoundland	.0754	.202	.250	.029	.233	.287
N.S./N.B.	.0460	.332	.357	.047	0.	.263
Quebec	.0488	.408	.389	.052	.037	.115
Ontario	.0430	.476	.426	.062	0.	.036
Man./Sask.	.0375	.347	.376	.060	.041	.175
Alberta	.0487	.321	.359	.052	.037	.231
B.C.	.0523	.317	.347	.042	0.	.294

Table A-8

Steady-State Variance of Canadian Employment Growth (OLS Residuals, Newfoundland Included)

Employment Change Variable	Sum of Variance from all Sources × 100 (1)	Share of Variance Due to: U.S. (ε_{ust}) (2)	National (c_t) (3)	All Industry ($\eta_{1t} \cdots \eta_{It}$) (4)	All Province ($v_{1t} \cdots v_{Pt}$) (5)	All Idiosyncratic ($u_{11t} \cdots \cdots u_{PIt}$) (6)
National	.0796	.649	.283	.047	.003	.018
Forestry	.7846	.411	.267	.031	.006	.285
Mining	.3331	.214	.390	.161	.035	.200
Manufacturing	.1764	.587	.288	.099	.007	.019
Construction	.7268	.509	.248	.143	.005	.096
Trans./Util.	.0578	.390	.522	.017	.010	.061
Trade	.0913	.527	.120	.217	.000	.136
Finance	.0822	.355	.072	.385	.000	.187
Services	.0708	.576	.186	.188	.002	.048
Government	.1090	.458	.170	.107	.002	.264
Newfoundland	.1328	.351	.185	.026	.195	.242
N.S./N.B.	.0859	.527	.240	.039	.000	.194
Quebec	.0914	.591	.257	.043	.027	.082
Ontario	.0845	.652	.270	.050	.000	.027
Man./Sask.	.0762	.545	.244	.051	.030	.130
Alberta	.1015	.504	.243	.046	.028	.179
B.C.	.0935	.510	.234	.034	.000	.222

Table A-9

Variance in Innovation of Canadian Employment Growth (TSLS Residuals, Newfoundland Excluded)

Employment Change Variable	Sum of Variance from all Sources × 100 (1)	Share of Variance Due to: U.S. (ε_{ust}) (2)	National (c_t) (3)	All Industry ($\eta_{1t} \cdots \eta_{It}$) (4)	All Province ($v_{1t} \cdots v_{Pt}$) (5)	All Idiosyncratic ($u_{11t} \cdots \cdots u_{PIt}$) (6)
National	.0416	.462	.420	.072	.026	.021
Forestry	.4049	.095	.268	0.	.048	.590
Mining	.2053	.070	.256	.176	.075	.423
Manufacturing	.1362	.555	.206	.212	.020	.006
Construction	.4952	.470	.424	0.	.001	.104
Trans./Util.	.0380	.054	.757	.073	.026	.090
Trade	.0464	.224	.229	.359	.021	.167
Finance	.0532	.156	.198	.429	.029	.188
Services	.0194	.134	.276	.435	.015	.139
Government	.0265	.020	.074	.090	.001	.815
N.S./N.B.	.0470	.324	.358	.046	0.	.272
Quebec	.0573	.363	.313	.059	.196	.068
Ontario	.0440	.489	.390	.084	0.	.036
Man./Sask.	.0546	.230	.280	.039	.375	.076
Alberta	.0584	.260	.318	.034	.198	.190
B.C.	.0574	.296	.318	.041	.075	.269

Table A-10

Steady-State Variance of Canadian Employment Growth (TSLS Residuals, Newfoundland Excluded)

Employment Change Variable	Sum of Variance from all Sources × 100	Share of Variance Due to:				
		U.S. (ε_{ust})	National (c_t)	All Industry ($\eta_{1t} \cdots \eta_{It}$)	All Province ($v_{1t} \cdots v_{Pt}$)	All Idiosyncratic ($u_{11t} \cdots \cdots u_{PIt}$)
	(1)	(2)	(3)	(4)	(5)	(6)
National	.0997	.641	.239	.086	.019	.015
Forestry	1.0441	.438	.177	.070	.026	.289
Mining	.3201	.264	.232	.139	.062	.303
Manufacturing	.2531	.611	.139	.215	.019	.016
Construction	.9316	.544	.268	.057	.012	.120
Trans./Util.	.0737	.396	.462	.066	.022	.054
Trade	.0870	.459	.190	.230	.017	.104
Finance	.0917	.377	.168	.302	.023	.131
Services	.0716	.551	.212	.173	.015	.049
Government	.1927	.537	.146	.106	.017	.194
N.S./N.B.	.1010	.505	.227	.049	.001	.219
Quebec	.1309	.527	.186	.080	.156	.051
Ontario	.1110	.646	.211	.110	.003	.031
Man./Sask.	.1155	.382	.194	.042	.316	.067
Alberta	.1369	.407	.218	.039	.171	.166
B.C.	.1182	.465	.204	.043	.065	.225