8 THE COLLECTIVE IMPACT OF SECTORAL SHOCKS ON AGGREGATE EMPLOYMENT FLUCTUATIONS

Joseph G. Altonji and John C. Ham

I. Introduction

This chapter examines the role of sectoral shocks in employment fluctuations. We discuss theory and evidence regarding two mechanisms through which sectoral shifts may influence growth. The first mechanism is based upon the role in the natural rate of unemployment of reallocation of labor across markets. A number of economists, including Alchian [1970], Archibald [1970], and Lucas and Prescott [1974], argued in the late 1960s and '70s that the position of the short-run Phillips curve is affected by the rate at which shocks arrive in specific sectors of the economy. The basic idea is that idiosyncratic shocks to specific firms and to specific sectors influence the

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natural rate of unemployment because it is costly and time-consuming to reallocate resources across sectors in response to shifts in labor demand. Consequently, the natural rate of unemployment depends in part upon the variance of these sectoral shocks. In an important set of papers David Lilien [1982a, 1982b] has presented empirical evidence on the extent to which changes over time in unemployment have been due to changes in the natural rate resulting from changes in the variance of sectoral shocks. This "Reallocation Hypothesis" has attracted growing attention, as demonstrated by the recent work of Lilien, Abraham, and Katz [1985], Medoff [1983], and Neelin [1985].

Second, disaggregate shocks to particular sectors of the economy may collectively induce fluctuations in aggregate employment even in the absence of reallocation. Since aggregate employment is the sum of employment in the individual sectors, sectoral shocks may account for some of the variance in aggregate employment growth if the shocks to specific sectors have sufficiently high variance. This mechanism, which we refer to as the "Collective Impact" hypothesis, is the main focus of the chapter. Most macro-economic analyses (including the discussions of the effects of the variance of sectoral shifts on the natural rate of unemployment) have assumed that such sectoral shocks are small enough to cancel out at the aggregate level, but there is little evidence on the validity of this assumption.

In an earlier study, we began an investigation of the collective impact hypothesis by estimating an empirical model which allowed us to measure the influence of sectoral shocks on the variation in aggregate employment growth. In this chapter we have three objectives. The first is to provide a theoretical foundation for our empirical work and to consider alternate theoretical models which lead to different specifications. We hope that this theoretical model will not only clarify the benefits and limitations of our earlier work but will also prove helpful in developing more structural approaches to the problem.

Our second objective is to provide an accessible summary of the methodology and empirical results in our previous work. This work involves some difficult econometric issues as well as estimation of dynamic models involving almost 100 parameters for several specifications. This, in turn, may impose a large cost on those readers who have little interest in technical issues and are concerned primarily with the main results of the study. Here we also take the opportunity to contrast the reallocation mechanism with the collective impact mechanism, since these mechanisms are in no way mutually exclusive. Our final objective is to extend our earlier work to analyze the role played by sectoral, national, and external shocks in the greater economic instability of the 1970s and '80s.

The chapter is organized as follows. Section II provides an overview of

the reallocation hypothesis and the collective impact hypothesis and our motivation for examining them. Section III presents a disaggregate theoretical model of employment growth. The model serves as the basis for a more formal discussion of the collective impact hypothesis and provides a foundation for the econometric model used to examine the role of sectoral shocks in employment fluctuations. In section IV we summarize an econometric model developed and implemented in Altonji and Ham [1985] to investigate the collective impact hypothesis and discuss our main findings. In section V we extend this methodology to provide a preliminary investigation of changes over time in the importance of aggregate and sectoral shocks in aggregate employment growth. In section VI we review the results of recent studies investigating the reallocation mechanism. We then conclude the chapter.

II. The Potential Role of Sectoral Shocks in Aggregate Fluctuations

Our main interest in this study is in assessing the role of sectoral specific disturbances in *aggregate* fluctuations of employment growth. In this section, we discuss two reasons for examining the role of sectoral shocks in aggregate fluctuations. The first is that aggregate models of economic fluctuations have not been entirely successful. The second is that there are several plausible mechanisms through which sectoral shocks may be expected to influence aggregate employment. It would, of course, make a great deal of difference to policy whether national business cycles result from aggregate sources (such as changes in monetary policy, changes in investor confidence, or other aggregate sources), result from a combination of unrelated shocks to particular sectors, or result from a combination of aggregate and sectoral factors.

Over the past few decades most business cycle analyses have emphasized factors that shift aggregate demand and supply. As James Tobin [1971] has noted, a basic assumption underlying this work is that "this [macroeconomics] can be done without much attention to the constituents of the aggregate, that is to the behavior and fortunes of particular households, business firms, industries or regions."[1]

A number of aggregate economic variables have been suggested as the main cause of business cycles. The most prominent of these include unstable fiscal policy, swings in expectations about the profitability of capital (e.g., animal spirits), changes in consumer confidence, and shocks to the availability of raw materials. There would be less cause for studying disaggregate shocks if the models examining the above aggregate factors produced consistent evidence on the sources of economic fluctuations. Many economists have used structural and reduced form econometric models (e.g. Barro [1977, 1979], Mishkin [1984], and Sargent [1976]) to assess the importance of monetary policy, fiscal policy, "productivity" shocks, real interest rate shocks, changes in consumption, and other factors in explanations for aggregate fluctuations. Others have investigated these issues using descriptive time series methods (e.g., Sims [1973, 1980], Litterman and Weiss [1984], and Lawrence and Siow [1985]). Unfortunately, these studies produce conflicting results, and no clear answer has emerged on the primary causes of business cycles. In part the inconsistency in the evidence may reflect the limitations of current econometric tools, data problems, and the inadequacy of current aggregate theoretical models of economic activity. More satisfactory results may emerge as the search continues for a tight, unified explanation of business cycles. However, it is also possible that aggregate fluctuations arise from a variety of sources and simply do not have a tight, unified aggregate explanation.[2] Consequently, there may be a payoff to research on the role of disaggregate shocks in economic fluctuations.

In the remainder of this section, we discuss mechanisms through which disaggregate shocks may influence aggregate fluctuations.

A. Sectoral Shocks, Aggregate Employment, and the Reallocation Hypothesis

Lilien [1982a, 1982b] has explored one mechanism through which disaggregate shocks may influence aggregate employment and unemployment. (See also the discussion in Lilien and Hall [1984].) Lilien hypothesized and provided some empirical support for the view that the level of unemployment at any point in time is related to the variance of shocks affecting specific industries because of the time that is required for resources to be reallocated among industries. This view is related to a number of earlier discussions of the natural rate of unemployment, including Alchian [1971], Archibald [1971], Lucas and Prescott [1974], and others. (See the studies cited in Lilien [1982a].)

The formal model in Lilien [1982b] has the following features. First, the labor market is segmented into different sectors because of costs of information about opportunities in other sectors, transportation costs, and human capital that is specific to firms in a particular sector. Consequently, the supply of labor to a particular sector adjusts only slowly to shifts in the demand for labor. Second, there are important sector-specific shocks. Third, these shocks have a multiplicative rather than additive effect on the revenue generated by a given quantity of labor in the sector. Consequently,

sectoral specific shocks alter the efficient allocation of labor among sectors. Until the supply of labor adjusts to the changes in the marginal revenue product of labor in the various sectors, the overall productivity of labor is reduced. This occurs because of a worsening in the match between where labor is located and where labor is most productive. Consequently, employment and output fall and, with a fixed labor force, unemployment rises following a shift in the composition of demand.

In a world in which sectoral shifts occur continuously, the rate at which the shifts occur will affect the overall demand for labor and thus the unemployment rate. Lilien hypothesized that the volatility (variance) of sectoral shifts varies considerably over time and is responsible for a substantial part of the movement in both the natural rate of unemployment and the total amount of employment.

Sectoral Shocks with Segmented Labor Markets and Downward Wage Rigidity. It is interesting to explore the relationship between Lilien's model and discussions of unemployment in the Phillips Curve literature, such as Lipsey (1960), Archibald (1970) and Tobin (1972), since this earlier literature emphasizes that the position of the Phillips curve is affected by mismatches between employment demand in various sectors and the supply of labor to these sectors.

Lilien's (1982b) model assumes that the short run supply of labor and the demand for labor in each sector are continuously in equilibrium. Wage stickiness does not play a role in his analysis. Unemployment arises because the lower productivity of labor (resulting from mismatching across markets) lowers the sum (across sectors) of the employment levels which clear the sectoral labor markets. While the earlier Phillips curve literature also is based upon the view that labor markets are highly segmented, it assumes (in contrast to Lilien) an asymetric wage adjustment process in which downward adjustments in wages take longer than upward adjustments. The unemployment rate within a given sector rises if demand falls to the point that the constraint on downward wage adjustment becomes binding. The overall unemployment rate is related to the fraction of labor markets in which the downward wage adjustment is slow or in which wage floors are binding.

How would an increase in the dispersion of sector specific shocks to labor demand or supply affect the unemployment rate in an economy with segmented labor markets and an asymetric wage adjustment mechanism? An increase in the variance in these shocks will increase the variance of the market clearing wage level for any given sector. This, in turn, will increase the probability that the wage floor will be binding for a given market. Thus, the fraction of labor markets with binding constraints on wage adjustments will increase and the unemployment rate will rise with an increase in the variance in shocks affecting specific sectors. This will be true even if there is no reallocation of labor.

B. Sectoral Shocks and Aggregate Employment: The Collective Impact Hypothesis

In models such as those of Lilien and Lucas and Prescott, sectoral shocks may have a positive effect on unemployment as a result of the reallocation process even if they sum to zero in every period. This is also true in the segmented labor market models with asymmetric wage adjustment discussed by Lipsey, Tobin, and others. In this chapter and in Altonji and Ham [1985] we investigate a somewhat different question, namely, the extent to which independent sectoral specific shocks affect the overall level of business activity simply because the weighted average of a set of independent shocks need not equal zero in every period.

Suppose that sectoral specific shocks have a large variance relative to aggregate shocks. In this case sectoral shocks will obviously be important for employment variation in a particular sector. However, since the national employment change is a weighted sum of industry and regional components, it is possible that the variance of the appropriately weighted sum of the sectoral disturbances may be large enough to explain a significant amount of the variance of the national employment change. For example, consider an economy with I sectors of equal size. Assume that the employment change Y_{it} in each sector is the sum of an aggregate shock c_t with variance σ_c^2 and a sectoral shock η_{it} with variance $\sigma_{\eta i}^2$. Thus

$$Y_{it} = c_t + \eta_{it}, \ i = 1, \ \ldots, \ I.$$

For simplicity, assume that the aggregate and sectoral shocks are serially uncorrelated, that there are no feedbacks from past employment changes to current employment changes, that all shocks are independent, and that $\sigma_{\eta i}^2 = \sigma_\eta^2$ for all sectors. Then the variance in employment in sector i is

$$\mathrm{Var}(Y_{it}) = \sigma_c^2 + \sigma_\eta^2,$$

and the variance in the change in aggregate employment $Y_{ct} = \Sigma_i Y_{it}$ is

$$\mathrm{Var}(Y_{ct}) = I^2\sigma_c^2 + I\sigma_\eta^2.$$

The correlation of employment changes across sectors is

$$\mathrm{Corr}\ (Y_{it}, Y_{i't}) = \frac{\sigma_c^2}{\sigma_c^2 + \sigma_\eta^2}, \qquad (i \neq i'),$$

Table 8–1. Correlation Across Sectors and Fraction of Aggregate Employment Variation Due to Sectoral Shocks

	σ_η^2/σ_c^2			
	.5	*1*	*2*	*3*
A. Correlation across sectors[a]	.667	.500	.333	.250
B. Share of aggregate employment variation due to sectoral shocks[b]				
I = 3	.182	.250	.400	.500
I = 5	.118	.167	.286	.375
I = 10	.063	.091	.167	.231
I = 20	.032	.050	.091	.130

[a]Correlation across sectors = $1/(1 + \sigma_\eta^2/\sigma_c^2)$.
[b]Share due to sectoral shocks = $(\sigma_\eta^2/\sigma_c^2)/(I + \sigma_\eta^2/\sigma_c^2)$.

and the fraction of the variance in the aggregate employment change accounted for by the sectoral shocks is

$$\frac{\sigma_\eta^2/\sigma_c^2}{[I + \sigma_\eta^2/\sigma_c^2]}$$

In table 8–1 we have computed the correlation in employment across sectors and the fraction of the variance in aggregate employment which is due to sectoral shocks for various values of I and the relative variance of η_t and c_t.

A role for disaggregate shocks in aggregate fluctuations through the collective impact mechanism is clearly a theoretical possibility. However, the empirical importance of such shocks is unclear. The early studies of Burns and Mitchell [1946] and Mitchell [1951], and the more recent work of Lehmann [1982] suggest that economic activity in different industries and regions of the economy moves together, which is an important reason for believing that the construction of simple aggregative models of economic activity will ultimately be successful. (See for example, the discussion in Lucas [1977].) On the other hand, the extent and stability of the co-movements may be exaggerated. As many have noted, over the last 20 years there has been great diversity in the behavior of employment across regions and industries in both the United States and Canada. This diversity is only partially accounted for by differences in trend growth rates, with service industries growing faster than manufacturing, the sunbelt states growing more rapidly than the Northcentral states in the United States, and the Western provinces growing more rapidly than the Central and Maritime provinces in Canada.

To shed some light on this issue, we present the correlation of annual changes in the log of Canadian employment by one-digit SIC industry in

Table 8–2. Correlation Matrix for Industrial Employment[a]

	Forestry	*Mining*	*Manufacturing*	*Construction*	*Transportation*	*Trade*	*Finance*	*Service*	*Government*
Forestry	1.	.497	.689	.478	.590	.396	.468	.296	−.097
Mining		1.	.451	.462	.533	.373	.077	.307	−.194
Manufacturing			1.	.793	.621	.821	.472	.589	−.150
Construction				1.	.567	.692	.369	.523	−.057
Transportation					1.	.614	.410	.276	.142
Trade						1.	.563	.570	.105
Finance							1.	.403	.325
Service								1.	−.050
Government									1.

[a]Measured in log first differences.

Table 8–3. Correlation Matrix for Industrial Employment[a] After Accounting for United States Effects

	Forestry	*Mining*	*Manufacturing*	*Construction*	*Transportation*	*Trade*	*Finance*	*Service*	*Government*
Forestry	1.	.596	.397	.365	.523	.115	.180	−.071	−.104
Mining		1.	.572	.486	.548	.365	.028	.296	−.190
Manufacturing			1.	.788	.692	.812	.198	.444	−.174
Construction				1.	.649	.642	.265	.494	−.027
Transportation					1.	.582	.286	.123	.157
Trade						1.	.437	.457	.145
Finance							1.	.204	.397
Service								1.	−.042
Government									1.

[a]Measured in log first differences.

Table 8–4. Correlation Matrix for Provincial Employment[a]

	Newfoundland	*Nova Scotia/ New Brunswick*	*Quebec*	*Ontario*	*Saskatchewan/ Manitoba*	*Alberta*	*British Columbia*
Newfoundland	1.	.853	.830	.818	.610	.263	.764
Nova Scotia/ New Brunswick		1.	.896	.768	.639	.558	.868
Quebec			1.	.884	.707	.579	.877
Ontario				1.	.644	.493	.853
Saskatchewan/ Manitoba					1.	.519	.673
Alberta						1.	.662
British Columbia							1.

[a]Measured in log first differences.

Table 8–5. Correlation Matrix for Provincial Employment[a] After Accounting for United States Effects

	Newfoundland	*Nova Scotia/ New Brunswick*	*Quebec*	*Ontario*	*Saskatchewan/ Manitoba*	*Alberta*	*British Columbia*
Newfoundland	1.	.799	.731	.695	.582	.069	.617
Nova Scotia/ New Brunswick		1.	.868	.697	.601	.497	.831
Quebec			1.	.815	.705	.491	.802
Ontario				1.	.672	.351	.742
Saskatchewan/ Manitoba					1.	.482	.669
Alberta						1.	.605
British Columbia							1.

[a]Measured in log first differences.

table 8–2. While the results show substantial positive correlations between many of the industry pairs, the correlations are less than .5 in 23 out of 36 cases. In table 8–3 we present the partial correlations between industry pairs after controlling for the influence of an aggregate external disturbance proxied by the current value and first lag of the change in the log of United States GNP. Again, while significant correlations arising from a common domestic disturbance remain, there is much movement that is uncorrelated across industries.

On the other hand, the correlations for the provinces are considerably stronger than those for the industries (see tables 8–4 and 8–5). While one can debate whether these correlations are large or small, these results indicate that sectoral shocks potentially play a large enough role in employment behavior at the industry and province level to warrant a careful evaluation as a possible source of aggregate fluctuations. This is especially true given that these correlations could arise, in part, from feedback effects across provinces or industries of shocks that are initially province or industry specific. This chapter and Altonji and Ham [1985] are the first systematic attempts to measure the overall contribution of industry-specific, region-specific, and combined industry- and region-specific shocks to aggregate fluctuations.

III. A Disaggregate Model of Employment Growth

In this section we present a simple structural model of the labor market. The model serves as a basis for discussion of how aggregate shocks and disaggregate shocks affect the economy over time. The formal model is basically consistent with the econometric framework developed in Altonji and Ham [1985] that is discussed below. Thus, it serves as a concrete example of a model that is consistent with the empirical work on the collective impact hypothesis below, and makes it easier to assess the pluses and minuses of this framework.

A. Basic Equations

We assume that each province p and industry i of the labor market constitutes a specific sector denoted by pi. The model consists of equations for the position of the output demand function of sector pi, the demand for labor in sector pi, the supply of labor in sector pi, the wage in sector pi, and employment in sector pi. In the initial discussion we assume that the labor market in sector pi clears each period. We then consider the nonmarket clearing case.

The Demand for Output. Let D_{pit} denote an index of the change in the position of the output demand function of sector pi. D_{pit} is determined by

$$D_{pit} = a_{opi} + a_{1pi}Y_{ct-1} + a_{2pi}Y_{p\cdot t-1} + \varepsilon^D_{pit}, \qquad (8\text{–}1a)$$

where

$$\varepsilon^D_{pit} = a_{4pi}c^D_t + a_{5pi}\eta^D_{it} + a_{6pi}\nu^D_{pt} + u^D_{pit}, \qquad (8\text{–}1b)$$

where Y_{ct-1} is the change in the growth of aggregate employment in $t-1$, and $Y_{p\cdot t-1}$ is the change in employment growth in province p in period $t-1$. In equation (8–1b), ε^D_{pit} is a composite demand shock that depends upon a national component c^D_t, an industry component η^D_{it}, a province component ν^D_{pt}, and a combined province-industry component u^D_{pit}. The shock c^D_t is an index of determinants of aggregate demand, including monetary and fiscal policy, the expectations of consumers and investors, and foreign demand.[3]

We specify that Y_{ct-1} affects D_{pit}, with a combined province-industry specific coefficient, since Y_{ct-1} is related to current and future labor and nonlabor income in the economy and thus to consumer demand.[4] Since some industries, such as retail trade, services, and finance, have local markets, we also permit lagged employment in province p, $Y_{p\cdot t}$, to affect D_{pit} with a combined province-industry-specific coefficient. Demand is affected also by the industry-specific shock η^D_{it}. This variable captures changes in the composition of demand for goods resulting from changing technology of production and consumption, changes in preferences, and changes in export demand or import competition that are specific to particular sectors. A change in tariffs or quotas affecting a particular industry, such as textiles, would be one example. Demand is also affected, with a coefficient that is larger for goods with local markets, by the province-specific shocks ν^D_{pt}. The province shocks are most likely to reflect changes in government policy. Alternate spending and taxation policies, including regional development programs of the Federal government, shift the demand for an industry's output in a given region.

The Demand for Labor. The growth of demand for labor in sector pi is denoted by Y^d_{pit} and is determined by

$$Y^d_{pit} = b_{opi} + b_{1pi}D_{pit} + b_{2pi}Y_{pit-1} + b_{3pi}\omega_{pit} + \varepsilon^d_{pit}, \qquad (8\text{–}2a)$$

where

$$\varepsilon^d_{pit} = b_{4pi}c^d_t + b_{5pi}\eta^d_{it} + b_{6pi}\nu^d_{pt} + u^d_{pit}. \qquad (8\text{–}2b)$$

Labor demand depends upon the output demand index D_{pit} for obvious reasons. The slope coefficient b_{1pi} depends on the parameters of the production function and the product demand curve. Lagged employment growth enters the equations since there are likely to be adjustment costs associated with hiring and training, severance pay, and unemployment insurance payments. We expect this variable to enter with a positive sign, with $b_{2pi} > 0$.

Employment demand depends negatively upon the wage ω_{pit}, with $b_{3pi} < 0$. Finally, national, industry, and province-specific shocks to productivity, costs of other inputs of production, and nonwage labor costs, such as unemployment insurance payments, affect employment demand. Note that one might expect some correlation between these shocks and the factors in equation (8–1) that influence labor demand through the product demand function. After substituting for D_{pit} from equation (8–1a) one may write Y^d_{pit} as

$$\begin{aligned} Y^d_{pit} = {} & (b_{opi} + b_{1pi}a_{opi}) + b_{1pi}a_{1pi}Y_{ct-1} \\ & + b_{1pi}a_{2pi}Y_{p\cdot t-1} + b_{2pi}Y_{pit-1} \\ & + b_{3pi}\omega_{pit} + b_{1pi}\varepsilon^D_{pit} + \varepsilon^d_{pit}. \end{aligned} \quad (8-3)$$

The Supply of Labor. The supply of labor Y^s_{pit} is determined by

$$\begin{aligned} Y^s_{pit} = {} & q_{opi} + q_{1pi}Y_{ct-1} + q_{2pi}Y_{p\cdot t-1} + q_{3pi}Y_{\cdot it-1} \\ & + q_{4pi}Y_{pit-1} + q_{5pi}\omega_{pit} + \varepsilon^s_{pit}, \end{aligned} \quad (8-4a)$$

where

$$\varepsilon^s_{pit} = q_{6pi}c^s_t + q_{7pi}v^s_{pt}. \quad (8-4b)$$

In equation (8–4a), $Y_{\cdot it-1}$ is the lagged growth rate of employment in industry *i*. Labor supply is a function of an aggregate labor supply shift index c^s_t that summarizes the effects of demographic shifts, such as the baby boom and changes in the labor supply behavior of young workers, married women, and older men and women, as well as the effects of taxes and subsidies and the unemployment insurance system. To some extent, these shifts may be region specific as in the Canadian worker disability programs and entitlement provisions in the unemployment insurance legislation, and thus the variable v^s_{pt} is included. Due to moving costs and costs of changing firms (seniority-based fringe benefits, wages, job security provisions, and vacation pay), Y^s_{pit} is a positive function of Y_{pit-1}. The variable Y^s_{pit} can also be positively related to $Y_{\cdot it-1}$ and $Y_{p\cdot t-1}$ due to industry-specific human capital and the costs of geographic mobility.

Labor supply will also depend positively upon perceived current and future employment opportunities in *pi*, and negatively upon perceived employment opportunities in other provinces and other industries. If lagged employment is positively related to employment opportunities in *pi* after controlling for the wage, this is a second reason to expect Y^s_{pit} to depend (in a positive fashion) on Y_{pit-1}. By the same reasoning, higher levels of employment in other provinces and industries in the previous period will

have a negative effect on Y^s_{pit}. Consequently, the variable Y_{ct-1} appears in equation (8–4a) with a negative coefficient. (The coefficients on $Y_{\cdot it-1}$, $Y_{p\cdot t-1}$, and Y_{pit-1} are net of the effects that these variables have through Y_{ct-1}.)

B. *Market Equilibrium: The Market Clearing Case*

Initially, we assume the wage ω_{pit} in each sector adjusts to equate labor supply and demand, with $Y_{pit} = Y^s_{pit} = Y^d_{pit}$. The implied equation for the growth in the wage is

$$\begin{aligned} \omega_{pit} = {} & \alpha_{pi}[b_{opi} + b_{1pi}a_{opi} - q_{opi}] + \alpha_{pi}[b_{1pi}a_{1pi} \\ & - q_{1pi}]Y_{ct-1} + \alpha_{pi}[b_{1pi}a_{2pi} - q_{2pi}]Y_{p\cdot t-1} - \alpha_{pi}q_{3pi}Y_{\cdot it-1} \\ & + \alpha_{pi}[b_{2pi} - q_{4pi}]Y_{pit-1} + \alpha_{pi}b_{1pi}\varepsilon^D_{pit} + \alpha_{pi}\varepsilon^d_{pit} \\ & - \alpha_{pi}\varepsilon^s_{pit}, \end{aligned} \quad (8-5)$$

where $\alpha_{pi} = 1/(q_{5pi} - b_{3pi})$.
Substituting (8–5) into equation (8–3) or (8–4) leads to the employment equation

$$\begin{aligned} Y_{pit} = {} & [\alpha^d_{pi}(b_{opi} + b_{1pi}a_{opi}) + \alpha^s_{pi}q_{opi}] + [\alpha^d_{pi}b_{1pi}a_{1pi} \\ & + \alpha^s_{pi}q_{1pi}]Y_{ct-1} + [\alpha^s_{pi}q_{2pi} + \alpha^d_{pi}b_{1pi}a_{2pi}]Y_{p\cdot t-1} \\ & + \alpha^s_{pi}q_{3pi}Y_{\cdot it-1} + [\alpha^s_{pi}q_{4pi} + \alpha^d_{pi}b_{2pi}]Y_{pit-1} \\ & + \alpha^s_{pi}\varepsilon^s_{pit} + \alpha^d_{pi}b_{1pi}\varepsilon^D_{pit} + \alpha^d_{pi}\varepsilon^d_{pit}, \end{aligned} \quad (8-6)$$

where

$$\alpha^s_{pi} = -b_{3pi}\alpha_{pi} \text{ and } \alpha^d_{pi} = 1 - \alpha^s_{pi}.$$

A few observations can be made about equation (8–6). First, note that the relationship between Y_{pit} and the lagged employment terms could arise through the effects of these variables on product demand, labor demand, and labor supply. Second, the greater the wage responsiveness of labor supply, the larger the effect of product demand shocks and labor demand shocks on Y_{pit}. If the labor supply response to the wage is large, then the amount of labor supplied accommodates the shift in labor demand without a large wage increase.

Third, although industry shocks and province shocks have only a local effect in the initial period, they affect employment in other industries and provinces in subsequent periods through the lagged employment terms. In part, the lagged employment terms enter because adjustment costs affect the response of the supply of and the demand for labor to ε^s_{pit} and ε^d_{pit}. This mechanism, particularly in the labor supply equation, is closely related to the discussion of reallocation costs in Lilien and others. In part, the lagged employment terms enter because past employment affects the demand for output. This might occur through the mechanism discussed by Long and Plosser [1983]. In their work, interrelationships among industries in the production process imply a link between past employment levels in a given industry and product demand in other industries. These lagged terms could also enter through the effect of lagged employment on consumer income and consumer demand, as discussed above. Finally, the lagged employment terms could enter because they are correlated with current and future employment prospects, and thus influence the supply of labor to various industries.

The fourth point, which is closely related to the third, is that the behavior of employment in a given market cannot be analyzed independently of the other markets. Let $\underline{Y}_t$ denote the $PI \times I$ vector of the Y_{pit} for the P provinces and I industries. Since Y_{ct}, $Y_{p\cdot t}$, and $Y_{\cdot it}$ are weighted sums of the Y_{pit}, one may express Y_{ct}, $Y_{p\cdot t}$, and $Y_{\cdot it}$ in terms of $\underline{Y}_t$. The expression for national employment growth is given by

$$Y_{ct} = \Sigma_{pi} w_{pi} Y_{pit}, \qquad (8-7a)$$

where w_{pi} is the share of Canadian employment accounted for by province p-industry i. Employment growth in industry i equals

$$Y_{\cdot it} = \Sigma_p w^i_{p\cdot} Y_{pit}, \qquad (8-7b)$$

where $w^i_{p\cdot}$ is the share of industry i employment accounted for by employment in province p-industry i. Provincial employment growth equals the weighted sum of growth rates over the industries in province p,

$$Y_{p\cdot t} = \Sigma_i w^p_{\cdot i} Y_{pit} \qquad (8-7c)$$

where $w^p_{\cdot i}$ is the fraction of employment in province p due to employment in province p-industry i.

Consequently, one may combine equation (8–6) for each pi into a system of equations given by equation (8–8)

$$\underline{Y}_t = \underline{\lambda} + \pi \underline{Y}_{t-1} + \underline{\bar{\varepsilon}}^s_t + \underline{\bar{\varepsilon}}^D_t + \underline{\bar{\varepsilon}}^d_t \qquad (8-8)$$

where the pi^{th} elements of $\underline{\bar{\varepsilon}}^s_t$, $\underline{\bar{\varepsilon}}^D_t$ and $\underline{\bar{\varepsilon}}^d_t$ are

$$\bar{\varepsilon}^s_{pit} = \alpha^s_{pi}\varepsilon^s_{pit}, \quad \bar{\varepsilon}^D_{pit} = \alpha^d_{pi} b_{1pi} \varepsilon^D_{pit}$$

and

$$\bar{\varepsilon}^d_{pit} = \alpha^d_{pi}\varepsilon^d_{pit}.$$

The elements of the vector of constants $\underline{\lambda}$ and the matrix π are functions of the parameters in the equations for each of the Y_{pit} and the weights defined above. If the economy is subject to no shocks, the equilibrium values of the employment change variables are determined by equation (8–8). The solution for the steady state value of $\underline{Y}$ is

$$\underline{Y} = [I - \pi]^{-1}\underline{\lambda}. \qquad (8-9)$$

Equation (8–8) and the variances and serial correlation properties of the various shocks determine the steady state variance of employment growth in the various sectors. The variance of the aggregate employment change Y_{ct} is a weighted sum of the variances and covariances of employment changes in the individual sectors. Consequently fluctuations in sector-specific shocks contribute to fluctuations in aggregate employment growth. This is the collective impact hypothesis.

Fifth, the parameters of the product demand, labor demand, and labor supply equations must be consistent with the long-run equilibrium of wages across sectors, taking account of compensating wage differentials. If the compensating wage differentials are stable as a percentage of the wage, then equilibrium wage growth in all of the sectors should be the same. We omit a discussion of the nature of these restrictions since we do not examine them in the empirical work below.

Employment Determination: The Nonmarket Clearing Case. It is useful to explore the implications of the behavior of the labor market in the case in which wages do not instantaneously adjust to equate the short-run supply of and demand for labor in each sector. We work with a variant of the contract wage models of Fischer [1977] and Phelps and Taylor [1977] that have formed the basis for a number of theoretical and empirical studies of wage behavior. The basic idea of these models is that the wage is set in period $t-1$ to the value that would clear the market in period t in the absence of unanticipated shocks to the economy or the sector. Ex post, the wage does not clear the market if unanticipated shocks shift the labor demand and supply schedules. We assume that in the event of a discrepancy between supply and demand at the preset wage, the actual employment level is a weighted average of the two.

The implied equation for the growth in the wage is

$$\begin{aligned}\omega_{pit} = {} & \alpha_{pi}[b_{opi} + b_{1pi}a_{opi} - q_{opi}] + \alpha_{pi}[b_{1pi}a_{1pi} \\ & - q_{1pi}]Y_{ct-1} + \alpha_{pi}[b_{1pi}a_{2pi} - q_{2pi}]Y_{p\cdot t-1} \\ & - \alpha_{pi}q_{3pi}Y_{\cdot it-1} + \alpha_{pi}[b_{2pi} - q_{4pi}]Y_{pit-1} \\ & + \alpha_{pi}b_{1pi}\varepsilon^D_{pit-1} + \alpha_{pi}\varepsilon^d_{pit-1} - \alpha_{pi}\varepsilon^s_{pit-1}.\end{aligned} \qquad (8-10)$$

In equation (8–10) we have temporarily assumed that the various shocks in the model follow random walks in levels to avoid having to introduce additional notation, so that c^D_t, etc., are the innovations in the shocks. Let μ^s_{pi} denote the weight of labor supply and μ^d_{pi} denote the weight of labor demand in employment ($\mu^d_{pi} + \mu^s_{pi} = 1$) so that the employment growth equation may be written as[5]

$$Y_{pit} = \mu^s_{pi} Y^s_{pit} + \mu^d_{pi} Y^d_{pit}. \qquad (8-11)$$

Using equation (8–10) to eliminate ω_{pit} from equations (8–3) and (8–4) for Y^d_{pit} and Y^s_{pit} and substituting into equation (8–11) leads to the nonmarket clearing employment equation

$$\begin{aligned} Y_{pit} = {} & \alpha^s_{pi} q_{opi} + \alpha^d_{pi} b_{1pi} a_{opi} + [\alpha^s_{pi} q_{1pi} + \alpha^d_{pi} b_{1pi} a_{1pi}] Y_{ct-1} \\ & + [\alpha^s_{pi} q_{2pi} + \alpha^d_{pi} b_{1pi} a_{2pi}] Y_{p\cdot t-1} + \alpha^s_{pi} q_{3pi} Y_{\cdot it-1} \\ & + [\alpha^s_{pi} q_{4pi} + \alpha^d_{pi} b_{2pi}] Y_{pit-1} + \mu^d_{pi} b_{1pi} \varepsilon^D_{pit} + \mu^d_{pi} \varepsilon^d_{pit} \\ & + \mu^s_{pi} \varepsilon^s_{pit} + \alpha_{pi} b_{1pi} (\mu^d_{pi} b_{3pi} + \mu^s_{pi} q_{5pi}) \varepsilon^D_{pit-1} \\ & + \alpha_{pi} (\mu^d_{pi} b_{3pi} + \mu^s_{pi} q_{5pi}) \varepsilon^d_{pit-1} - \alpha_{pi} (\mu^d_{pi} b_{3pi} \\ & + \mu^s_{pi} q_{5pi}) \varepsilon^s_{pit-1} + \alpha^d_{pi} b_{opi} \end{aligned} \qquad (8-12)$$

The coefficients on the lagged employment terms in equation (8–12) are identical to the market clearing employment equation (8–6). However, the coefficients on the shocks ε^D_{pit}, ε^d_{pit}, and ε^s_{pit} are different unless the weights (μ^s_{pi}, μ^d_{pi}) happen to equal (α^s_{pi}, α^d_{pi}). Furthermore, in the nonmarket clearing case the first lag of each shock affects employment. This occurs since one period is required for wages to adjust to the shocks. Consequently, the econometric specification discussed below, in which we assume that the lagged shocks have a coefficient of zero in the model, is inconsistent, in general, with the nonmarket clearing model. However, in the special case where (μ^s_{pi}, μ^d_{pi}) equal (α^s_{pi}, α^d_{pi}), the lagged shocks do not affect employment in the nonmarket clearing case, and equations (8–6) and (8–12) are equivalent.

Extensions. In this section, we discuss extensions of the basic model. First, we discuss the role of unemployment. Second, we consider the possibility that labor supply responds (with a lag) to permanent changes in the demand for labor in a given sector.

A straightforward means of incorporating unemployment into the model is to assume that the change in unemployment in a given sector is a negative function of the change in employment in that sector. Such a relationship is implied by the nonmarket clearing model discussed above, especially if labor demand receives a larger weight in employment determination than labor supply. A negative relationship is also consistent with a market clearing model where some workers respond to a reduction in current wages by increasing consumption of leisure or by searching more intensely for alternate employment opportunities. Specifically, we assume that U_{pit}, the change in the unemployment rate in pi, is determined by

$$U_{pit} = \theta Y_{pit}, \qquad (8-13)$$

where θ is negative. The specific value of θ depends upon the extent to which reductions in the number and quality of job opportunities in equations (8–6) or (8–12) translate into changes in unemployment or changes in labor force participation. Let U_{ct} denote the change in the aggregate unemployment rate, where U_{ct} is a weighted average of the U_{pit}. If the weights are similar to the weights of Y_{pit} in Y_{ct}, then one may use equation (8–13) to approximate U_{ct} as

$$U_{ct} = \theta Y_{ct}. \qquad (8-14)$$

We assume that, with a one period lag, an increase in the unemployment rate increases the supply of workers to all sectors of the economy with a positive coefficient q_{8pi}. In this case the supply equation (8–4a) becomes

$$\begin{aligned} Y^s_{pit} = {} & q_{opi} + (q_{1pi} + q_{8pi}\theta) Y_{ct-1} + q_{2pi} Y_{p\cdot t-1} \\ & + q_{3pi} Y_{\cdot it-1} + q_{4pi} Y_{pit-1} + q_{5pi} \omega_{pit} + \varepsilon^s_{pit}. \end{aligned} \qquad (8-15)$$

In the market clearing case the employment equation becomes

$$\begin{aligned} Y_{pit} = {} & [\alpha^d_{pi}(b_{opi} + b_{1pi} a_{opi}) + \alpha^s_{pi} q_{opi}] + [\alpha^d_{pi} b_{1pi} a_{1pi} \\ & + \alpha^s_{pi} q_{1pi} + \alpha^s_{pi} q_{8pi} \theta] Y_{ct-1} \\ & + [\alpha^s_{pi} q_{2pi} + \alpha^d_{pi} b_{1pi} a_{2pi}] Y_{p\cdot t-1} + \alpha^s_{pi} q_{3pi} Y_{\cdot it-1} \\ & + [\alpha^s_{pi} q_{4pi} + \alpha^d_{pi} b_{2pi}] Y_{pit-1} + \alpha^s_{pi} \varepsilon^s_{pit} + \alpha^d_{pi} b_{1pi} \varepsilon^D_{pit} \\ & + \alpha^d_{pi} \varepsilon^d_{pit}. \end{aligned} \qquad (8-16)$$

One obtains an equation for Y_{pit} that, after rearrangement of coefficients, is identical to equation (8–6) in a reduced-form sense. A similar result holds for equation (8–12). Thus, both the employment equations (8–6) and (8–12) are consistent with the above model of unemployment. It is easy to extend the model to allow for the possibility that unemployment in region p has a larger effect on the supply of labor to region p than to other regions (because of moving costs), and to allow for the possibility that unemployment in industry i has a larger effect on the supply of labor to industry i than to other industries. These modifications would result in further changes in the interpretation of the coefficients of the lagged employment terms in equations (8–6) and (8–12).

Nevertheless, the above view of unemployment is highly restrictive. It requires the assumption that the effect of shocks to labor supply and demand on unemployment are proportional to their effects on the level of employment. One might expect demographic shifts or changes in unemployment insurance provisions to have different impacts upon the effective supply of labor (Y^s_{pit}) and upon the decision to participate in the labor force. In this case, it would be necessary to add an error term to equations (8–14) and (8–15). The reader may verify that in this case an additional source of shocks (dated $t-1$) are added to the employment equations (8–6) and (8–12).

Differential Responses to Temporary and Permanent Shocks. Discussions of structural unemployment and reallocation across sectors of the labor market frequently make a distinction between the effects of transitory demand shocks and permanent demand shocks. A transitory demand reduction (resulting from either a product demand shift or a technology shock) is likely to have a smaller effect on the supply of labor to a particular sector than a demand change which is perceived to be permanent. Workers are less likely to incur the fixed costs of moving between industries or between regions in response to a transitory sectoral shock than to a permanent one. (See, for example, the discussion in Topel [1986].) Lilien [1982b] assumes explicitly that the supply of workers to a given sector responds only to permanent shifts in the sectoral composition of demand. The extent to which structural unemployment is a problem depends in part on the amount of time required for workers to recognize that the shifts in demand are permanent, the size of the supply response to these shocks, and the speed with which decreases in employment in a given sector induce individuals to increase their supply of labor to other sectors.

Let ξ_{pit} denote a *permanent* sector-specific shift in labor demand, which may arise either from a shift in product demand or a shock to technology or the prices of nonlabor inputs. To avoid having to define a completely new set of notation, we assume momentarily that all other demand disturbances defined previously are transitory and simply add ξ_{pit} to the labor demand equation (8–3). This leads to

$$\begin{aligned} Y^d_{pit} = {} & (b_{opi} + b_{1pi}a_{opi}) + b_{1pi}a_{1pi}Y_{ct-1} \\ & + b_{1pi}a_{2pi}Y_{p\cdot t-1} + b_{2pi}Y_{pit-1} \\ & + b_{3pi}\omega_{pit} + b_{1pi}\varepsilon^D_{pit} + \varepsilon^d_{pit} + \xi_{pit}. \end{aligned} \qquad (8\text{–}17)$$

Further, we assume that workers learn with a one period lag that the shock is permanent, and that Y^s_{pit} is a positive function of ξ_{pit-1}. This leads to the supply equation

$$\begin{aligned} Y^s_{pit} = {} & q_{opi} + q_{1pi}Y_{ct-1} + q_{2pi}Y_{p\cdot t-1} + q_{3pi}Y_{\cdot it-1} \\ & + q_{4pi}Y_{pit-1} + q_{5qi}\omega_{pit} + \varepsilon^s_{pit} + q_{9pi}\xi_{pit-1}. \end{aligned} \qquad (8\text{–}18)$$

Following through on the earlier substitutions leads to the employment equation for the market clearing case

$$\begin{aligned} Y_{pit} = {} & [\alpha^d_{pi}(b_{opi} + b_{1pi}a_{opi}) + \alpha^s_{pi}q_{opi}] + [\alpha^d_{pi}b_{1pi}a_{1pi} \\ & + \alpha^s_{pi}q_{1pi}]Y_{ct-1} + [\alpha^s_{pi}q_{2pi} + \alpha^d_{pi}b_{1pi}a_{2pi}]Y_{p\cdot t-1} \\ & + \alpha^s_{pi}q_{3pi}Y_{\cdot it-1} + [\alpha^s_{pi}q_{4pi} + \alpha^d_{pi}b_{2pi}]Y_{pit-1} \\ & + \alpha^s_{qi}\varepsilon^s_{pit} + \alpha^d_{pi}b_{1pi}\varepsilon^D_{pit} + \alpha^d_{pi}\xi_{pit} + \alpha^d_{pi}\varepsilon^d_{pit} \\ & + \alpha^s_{pi}q_{9pi}\xi_{pit-1}. \end{aligned} \qquad (8\text{–}19)$$

This modification to the model also introduces lagged values of shocks into the employment growth equation.

Note that policies intended to retrain or assist in the relocation of workers (e.g., the Manpower Development and Training Act of 1962 or the current Job Training Partnership Act of 1982 in the United States) should increase the response of labor supply to a permanent shock and also presumably increase the responsiveness of supply for a given sector to unemployment in other sectors. An increase in the level and duration of unemployment benefits could reduce these responses.

In this section we have considered several theoretical models of employment determination in a given sector. We now turn to the issue of moving from a theoretical model to an equation which can be estimated from available data. We focus on reduced-form models which are compatible with the market clearing model (8–6), although the same approach could be used to consider other models.

IV An Econometric Model of the Analysis of Employment Variation

B. Estimating Equations

In the market-clearing model outlined above, and in particular equation (8–6), the basic unit of an analysis is employment growth in a specific province-industry pair. In this model, employment growth depends on a set of observable variables and a set of unobservable shocks. The observable variables consist of: (1) the growth in Canadian employment in the previous year; (2) the growth in employment in the own industry in the previous year; (3) the growth in employment in the own province in the previous year; and (4), the growth in employment in industry i-province p. The unobservable shocks to province p-industry i consist of: (1) a national (Canadian) shock; (2) a shock to industry i; (3) a shock to province p; and (4), an idiosyncratic shock to province p-industry i.

As it stands, equation (8–6) is too general to be used for empirical estimation. Thus we consider a model that implicitly imposes a number of restrictions on the theoretical equation (8–6). First, we assume that all coefficients (including those on the shocks) have only an i subscript, and do not differ across provinces for the same industry. Imposing this restriction results in an equation of the form

$$Y_{pit} = \lambda_i + \gamma_i Y_{ct-1} + \delta_i Y_{p\cdot t-1} + \theta_i Y_{\cdot it-1} + \phi_i Y_{pit-1} + \alpha_i^d \varepsilon_{pit}^d + \alpha_i^d b_{1i} \varepsilon_{pit}^D + \alpha_i^s \varepsilon_{pit}^s, \qquad (8\text{–}20)$$

where

$$\gamma_i = \alpha_i^s q_{1i} + \alpha_i^d b_{1i} a_{1i} \qquad (8\text{–}21a)$$

$$\delta_i = \alpha_i^s q_{2i} + \alpha_i^d b_{1i} a_{2i} \qquad (8\text{–}21b)$$

$$\theta_i = \alpha_i^s q_{3i} \qquad (8\text{–}21c)$$

$$\phi_i = \alpha_i^s q_{4i} + \alpha_i^d b_{2i}. \qquad (8\text{–}21d)$$

It should be emphasized that γ_i, δ_i, θ_i, and ϕ_i are reduced form parameters that combine a number of structural effects as given in equations (8–21a) through (8–21d). Next, we further restrict the theoretical model by simplifying the error structure in equation (8–20). To clarify this simplification, we first write each of the errors in equation (8–20) in terms of reduced-form coefficients on the respective national, industrial, provincial, and idiosyncratic shocks

$$\alpha_i^s \varepsilon_{pit}^s = \alpha_i^s g_{6i} c_t^s + \alpha_i^s g_{7i} v_{pt}^s = f_i^s c_t^s + g_i^s v_{pt}^s, \qquad (8\text{–}22a)$$

$$\alpha_i^d \varepsilon_{pit}^d = \alpha_i^d b_{4i} c_t^d + \alpha_i^d b_{5i} \eta_{it}^d + \alpha_i^d b_{6i} v_{pt}^d + \alpha_i^d u_{pit}^d = f_i^d c_t^d + h_i^d \eta_{it}^d + g_i^d v_{pt}^d + k_i^d u_{pit}^d, \qquad (8\text{–}22b)$$

and

$$\alpha_i^d b_{1i} \varepsilon_{pit}^D = \alpha_i^d b_{1i} a_{4i} c_t^D + \alpha_i^d b_{1i} a_{5i} \eta_{it}^D + \alpha_i^d b_{1i} a_{6i} v_{pt}^D + \alpha_i^d b_{1i} u_{pit}^D = f_i^D c_t^D + h_i^D \eta_{it}^D + g_i^D v_{pt}^D + k_i^D u_{pit}^D \qquad (8\text{–}22c)$$

The coefficients h_i^d, h_i^D, k_i^d, and k_i^D are not identified, and we normalize them to 1.0.[6] To simplify the model for empirical implementation, we make the following approximation[7]:

$$f_i c_t \approx f_i^s c_t^s + f_i^d c_t^d + f_i^D c_t^D \qquad (8\text{–}23a)$$

and

$$g_i v_{pt} \approx g_i^s v_{pt}^s + g_i^d v_{pt}^d + g_i^D v_{pt}^D. \qquad (8\text{–}23b)$$

We also use the following definitions:

$$\eta_{it} = \eta_{it}^d + \eta_{it}^D \qquad (8\text{–}23c)$$

and

$$u_{pit} = u_{pit}^d + u_{pit}^D. \qquad (8\text{–}23d)$$

Given these simplifications, our equation for employment growth in *pi* becomes

$$Y_{pit} = \lambda_i + \gamma_i Y_{ct-1} + \delta_i Y_{p\cdot t-1} + \theta_i Y_{\cdot it-1} + \phi_i Y_{pit-1} + \varepsilon_{pit}, \qquad (8\text{–}24a)$$

where

$$\varepsilon_{pit} = f_i c_t + g_i v_{pt} + \eta_{it} + u_{pit}. \qquad (8\text{–}24b)$$

These approximations represent strong restrictions on the error structure that are unlikely to hold in practice. For example, in terms of the national shock, equation (8–23a) will only be strictly valid if $f_i^s = f_i^d = f_i^D$ or $c_t^s = m_1 c_t^d = m_2 c_t^D$ in each period. Indeed, one may argue that using only one index of national shocks is too restrictive, given the many plausible sources of shocks at this level. Our response to this objection is threefold. First, in the empirical work below we use the growth in U.S. GNP as a second index of aggregate shocks. Second, even the restricted model is quite complex, so it seems sensible to begin by determining whether the data are rich enough to support the restricted model before proceeding to more general specifications. Third, the restricted model gives the sectoral shocks their best chance to play a role in the variation of aggregate employment growth. If sectoral shocks do not appear to play a major role using the restricted model, for our purposes there is little point in moving to more complex models.

Two further modifications to equation (8–24a) are useful. For simplicity, the theoretical models discussed above ignored any impact of external shocks. However, it is important in the empirical work to allow external shocks (particularly those arising from the United States) to influence employment growth in the Canadian sectors. To do so, we assume that the current and lagged growth rate in real U.S. GNP, US_t and US_{t-1}, affect employment growth in *pi* with an industry-specific coefficient. Second, we found that including the own lag Y_{pit-1} had no effect on the empirical results, and thus for clarity we set $\phi_i = 0$ for all *i* in the discussion that follows. Thus our empirical equation takes the form[8]

$$Y_{pit} = \lambda_i + \gamma_i Y_{ct-1} + \delta_i Y_{p\cdot t-1} + \theta_i Y_{\cdot it-1} + B_{1i} US_t + B_{2i} US_{t-1} + \varepsilon_{pit}, \qquad (8\text{–}25)$$

where ε_{pit} is given by (8–24b).

Since Y_{ct-1}, $Y_{p\cdot t-1}$, and $Y_{\cdot it-1}$ (taken together) depend on the $PI \times 1$ vector $\underline{Y}_{t-1}$ (through the weights defined in (8–7a), (8–7b), and (8–7c)), we can write this modified system as

$$\underline{Y}_t = \underline{\lambda} + \pi \underline{Y}_{t-1} + \underline{B}_1^* US_t + \underline{B}^*_2 US_{t-1} + \underline{\varepsilon}_t,$$

where

$$\underline{B}_1 = [B_{11}, \ldots, B_{1I}]', \ \underline{B}_2 = [B_{21}, \ldots, B_{2I}]'$$
$$\underline{B}_1^{*\prime} = [\underline{B}_1', \underline{B}_1', \ldots, \underline{B}_1'] \text{ and } \underline{B}_2^{*\prime} = [\underline{B}_2', \ldots, \underline{B}_2']. \quad (8-26)$$

Thus, equation (8–26) can be viewed as a restricted autoregressive model, where the matrix π depends on the national, industry, and province weights and the regression parameters[9]

$$\underline{\gamma}' = [\gamma_1, \ldots, \gamma_I], \ \underline{\delta}' = [\delta_1, \ldots \delta_I] \text{ and}$$
$$\underline{\theta}' = [\theta_1, \ldots, \theta_I].$$

As noted above, ε_{pit} is assumed to follow a factor structure of the form

$$\varepsilon_{pit} = f_i c_t + \eta_{it} + g_i v_{pt} + u_{ipt}, \quad (8-24b)$$

where c_t = Canadian shock affecting all province-industry pairs with industry-specific coefficient f_i; $\mathrm{Var}(c_t) = \sigma_c^2$.
η_{it} = industry-specific shock affecting industry i; $\mathrm{Var}(\eta_{it}) = \sigma_{\eta i}^2$.
v_{pt} = province-specific shock affecting all industries in province p with industry specific weight g_i; $\mathrm{Var}(v_{pt}) = \sigma_{vp}^2$.
u_{pit} = idiosyncratic disturbance relecting special conditions affecting only pi; $\mathrm{Var}(u_{pit}) = \sigma_{upi}^2$.

We assume that the national shock c_t, the vector $\underline{\eta}_t = (\eta_{1t}, \ldots, \eta_{It})'$ of industry disturbances, the vector $\underline{v}_t = (v_{1t}, \ldots v_{pt})'$ of province disturbances, and the vector $\underline{u}_t = (u_{11t}, \ldots, u_{PIt})'$ of province-industry shocks, are mutually uncorrelated at all leads and lags. For example, c_t is assumed uncorrelated with the shock that is specific to manufacturing. It is natural to decompose the variance of the employment disturbances in this way. However, in our empirical work we also make the much 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 combined province-industry shocks u_{pit} are uncorrelated across provinces and industry pairs. In any error components model of this type, restrictions are necessary for identification, and the interpretation of results are conditional on these identifying restrictions. In our model the independence assumptions *within* the vector of industry errors $\underline{\eta}_t$, provincial errors $\underline{v}_t$ and idiosyncratic errors $\underline{u}_t$ represent identifying restrictions. Intuitively our procedure can be viewed as asking whether we gain anything by starting from a baseline model with a national shock and then adding sets of independent industry shocks and independent provincial shocks. The justification for this approach is that empirically it will be extremely difficult to distinguish between models with only national shocks and models with correlated provincial and industry shocks. Moreover, even if this empirical

distinction could be made, it would not be an interesting distinction for interpreting theoretical models.

From the error structure shown in equation (8–24b) and the identifying independence assumptions, we can calculate the model's prediction for the correlation between ε_{pit} and $\varepsilon_{p'i't}$. For the case of different industries ($i \neq i'$) in different provinces ($p \neq p'$), only the national shock c_t makes a contribution and

$$\mathrm{cov}(\varepsilon_{pit}, \varepsilon_{p'i't}) = f_i f_{i'} \sigma_c^2. \quad (8-27a)$$

If the industries differ, but are located in the same province, v_{pt} also makes a contribution and

$$\mathrm{cov}(\varepsilon_{pit}, \varepsilon_{pi't}) = f_i f_{i'} \sigma_c^2 + g_i g_{i'} \sigma_{vp}^2. \quad (8-27b)$$

On the other hand, if the provinces differ ($p \neq p'$) but the industries are the same, η_{it} makes a contribution and

$$\mathrm{cov}(\varepsilon_{pit}, \varepsilon_{p'it}) = f_i^2 \sigma_c^2 + \sigma_{\eta i}^2 \quad (8-27c)$$

Finally, if both the provinces and the industries are the same, then η_{it}, v_{pt}, and u_{it} all make a contribution and

$$\mathrm{Var}\ (\varepsilon_{pit}) = f_i^2 \sigma_c^2 + \sigma_{\eta i}^2 + g_i^2 \sigma_{vp}^2 + \sigma_{upi}^2. \quad (8-27d)$$

Equation (8–25) summarizes the effect of current Canadian shocks, lagged and current growth in U.S. GNP, and the lagged employment growth across Canadian sectors, on the current employment growth across Canadian sectors. Equations (8–27a) through (8–27d) present the covariance structure between errors. Before we can obtain an expression for the impact of U.S. and Canadian shocks on fluctuations in steady state growth in Canadian employment, it is necessary to specify the form of the processes determining US_t and the Canadian shocks c_t, $\underline{v}_t$, $\underline{\eta}_t$, and $\underline{u}_t$. We assume that US_t follows a second order autoregressive process

$$US_t = \rho_1 US_{t-1} + \rho_2 US_{t-2} + \varepsilon_{ust}, \quad (8-28)$$

where ε_{ust} is a white noise error (i.e., uncorrelated over time) with variance σ_{US}^2. In terms of the Canadian shocks, a priori we rule out autocorrelation in $\underline{u}_t$. Empirically, we found no evidence of autocorrelation in c_t and $\underline{\eta}_t$, and evidence of only a small degree of autocorrelation in $\underline{v}_t$. Moreover, allowing for this autocorrelation had no impact on the empirical results. Thus in the interests of clarity, we proceed as if c_t, $\underline{\eta}_t$, and $\underline{v}_t$ can all be treated as white noise.

Recalling that national employment growth takes the form

$$Y_{ct} = \underline{w}'\underline{Y}_t, \qquad (8\text{–}7a)$$

where $\underline{w}$ is the vector of national weights (for ease of notation we have dropped the c subscript), it is straightforward to show that the steady state variance in national employment growth $V(Y_{ct})$ takes the form

$$V(Y_{ct}) = \underline{w}'H_{US}\underline{w} + \underline{w}'H_c\underline{w} + \underline{w}'H_\eta\underline{w} + \underline{w}'H_v\underline{w} + \underline{w}'H_u\underline{w}. \qquad (8\text{–}29)$$

The first term in equation (8–29) is the contribution of the *US* shock to $V(Y_{ct})$ where H_{US} is a $PI \times PI$ matrix depending on π, $\underline{B}_1$, $\underline{B}_2$. σ^2_{us}, ρ_1 and ρ_2.[10] (Recall that π, in turn, is a function of $\underline{\theta}$, $\underline{\delta}$, $\underline{\gamma}$, and the national, provincial, and industrial weights.) The contribution of the Canadian shock c_t to the steady state variance in national employment growth is given by the second term in this equation, where H_c depends on π, $\underline{f}$ and σ^2_c. The contributin of the $I \times 1$ vector of industrial shocks $\underline{\eta}_t$ is represented by the third term in (8–29), where H_η is a function of π and the vector of industry variances. The fourth term in equation (8–29) indicates the contribution of the $P \times 1$ vector of provincial shocks $\underline{v}_t$, where H_v depends on π, $\underline{g}$, and the vector of provincial variances. Finally the contribution of the *PI* vector of idiosyncratic shocks $\underline{u}_t$ is given by the fifth term, where H_u depends on π and the vector of idiosyncratic variances. The fraction of the variance in national employment growth due to any one of these shocks (or set of shocks) is given by the ratio of the respective term in equation (8–29) to the sum of all of the terms.

B. Estimation Methods

The above model provides a straightforward method of comparing the role of sectoral shocks relative to the role of national and external shocks in fluctuations of national employment growth. Of course, before the model can be implemented, one must estimate the parameters in equations (8–25) and (8–27a–d).[11] Estimation of the regression parameters $\underline{\theta}$, $\underline{\delta}$, $\underline{\gamma}$, $\underline{B}_1$, and $\underline{B}_2$ is straightforward. The appropriate estimation method is either OLS or TSLS, depending on the degree of autocorrelation in c_t, $\underline{\eta}_t$, $\underline{v}_t$, and $\underline{u}_t$ and how one wants to interprete equation (8–25). In practice the variance decomposition of equation (8–29) is insensitive to the method used to estimate equation (8–25).

The method used to estimate the parameters defined in equations (8–27a–d) will be less familiar to some readers and thus deserves a more detailed discussion. To carry out this estimation, one first takes the $PI \times 1$ vectors of residuals from equation (8–25) for each time period and forms the empirical covariance matrix of the residuals

$$S = \Sigma_t \underline{\hat{\varepsilon}}_t \underline{\hat{\varepsilon}}_t'/T. \qquad (8\text{–}30a)$$

A typical element of S takes the form

$$S_{pip'i'} = \Sigma_t \hat{\varepsilon}_{pit} \hat{\varepsilon}_{p'i't}/T. \qquad (8\text{–}30b)$$

If $p \neq p'$ and $i \neq i'$, the error structure shown in equation (8–24b) predicts that this empirical covariance in equation (8–30) should take the form given by equation (8–27a). Alternatively, if $p = p'$ but $i \neq i'$ the model predicts this empirical covariance will be given by equation (8–27b), and a similar argument can be made concerning equations (8–27c) and (8–27d). Of course, even a correct model will not predict perfectly, but on average it should predict correctly. Analogous to least squares estimation, one can obtain "minimum distance" estimates of the $\underline{f}$ and $\underline{g}$ terms, as well as the variances of the national, provincial, industrial, and idiosyncratic shocks, by choosing the values of these parameters which minimize the sum of squared differences between the sample covariances given in equation (8–30) and the predicted covariances chosen from the appropriate expression in equations (8–27a–d).

C. An Overview of the Empirical Results

In estimating the model described in section IV, we faced a number of difficult technical econometric problems that we could not fully resolve. We also considered several further modifications of the model. In general our results were not sensitive to these modifications, but some specific parameter estimates were affected. A full discussion of these technical problems and our sensitivity analysis is inappropriate in the present context; however, it is important to emphasize that we view our empirical work as a significant first step but not, in any way, as the final word on these issues. Moreover, even ignoring these technical issues, the basic model contains almost 100 parameters, and their interpretation is complicated by the dynamic nature of the model. Here we provide a basic summary of the results in the hope that this will enable readers to gain the flavor of the results without incurring the cost of carefully reviewing each set of parameter estimates and simulation results.

The basic data for the study are annual observations on employment growth for the period 1961–82 disaggregated by one digit industry and province.[12] In our analysis we (separately) aggregate the Nova Scotia and New Brunswick data and the Manitoba and Saskatchewan data. Observa-

Table 8–6. Average Percentage Share in Canadian Employment[a] by Province and Industry: 1961–1982

	Newfoundland	Nova Scotia/ New Brunswick	Quebec	Ontario	Saskatchewan/ Manitoba	Alberta	British Columbia	Row Totals
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 8–7. Means and Standard Deviations of the Log First Differences in Industry and Provincial Employment

A. Industry

	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. Province/Region

	Newfoundland	Nova Scotia/ New Brunswick	Quebec	Ontario	Saskatchewan/ Manitoba	Alberta	British Columbia
Mean	.0293	.0214	.0241	.0295	.0244	.0525	.0395
Standard Deviation	(.0287)	(.0206)	(.0241)	(.0182)	(.0175)	(.0213)	(.0290)

tions for Prince Edward Island, the Yukon, and the North West Territories are not used in the analysis. Summary statistics for the data are given in tables 8–6 and 8–7.

In addition to the variance decomposition given in equation (8–29), the results of our estimation can be summarized in terms of: (1) the feedback effects of Y_{ct}, $Y_{p\cdot t}$, and $Y_{\cdot it}$ on current employment growth in *pi*; (2) the effects of the current shocks ε_{ust}, c_t, $\underline{\eta}_t$, and $\underline{v}_t$ on current employment growth; and (3) impact of the shocks on the time pattern of employment growth.

In terms of the feedback effects our results can be summarized as follows:

1. Lagged Canadian employment growth has a negative impact on all industries except construction, government, and services. The largest feedback effects occur in forestry, mining, manufacturing, and construction.

2. The lagged change in own provincial employment growth has a substantial positive impact on current employment growth in most industries. The largest effects of this variable are found in mining, manufacturing, construction, transport, and finance.

3. The effects of lagged own industry employment are mixed in sign and relatively small.

The effects of the current shocks on current employment growth may be summarized as follows:

1. U.S. GNP has a positive impact effect on all industries except government. It has a strong effect on forestry, manufacturing, and construction, a moderate effect on trade and finance, and a relatively weak effect on mining.

2. The current Canadian shock has its largest impact on forestry, mining, and construction. It has an intermediate effect in manufacturing and transportation. Government employment growth reacts negatively to the national shock.

3. The own industry shock is more important than the national shock in finance, service, and trade. The national shock is more important than the own industry shock in mining, manufacturing, forestry, and construction.

The province shocks, somewhat surprisingly, have their largest impact on forestry and mining and somewhat smaller effects on transportation and manufacturing. An anomolous result is that the construction response to the province shock is often estimated to be negative. The provincial variances, except for Newfoundland, are relatively small. It should be noted that the estimates of industry and province variances are imprecise, and some point estimates are less than zero.[13]

The impact of provincial and industry shocks on the time pattern of employment growth is quite complex. Thus we limit ourselves to summarizing the dynamic response to one-time U.S. and national shocks. The industries' response to the national shock is similar to their response to the U.S. shock. In response to a U.S. shock, the growth rate of national employment rises above its initial level for three periods and then returns to zero. In most industries the impact of the shock is always positive. However, in forestry, manufacturing, and finance the growth rate first rises in response to a U.S. shock and then falls before returning to its initial value. In government, the U.S. shock first lowers and then raises employment growth.

The most interesting result of our empirical work concerns the decomposition of the steady state variance in the national employment growth. We find that the changes in U.S. GNP dominate the variance of Canadian national employment growth, accounting for 62% to 67% of this variation. The next most important source of variation is the Canadian national shock, which accounts for 24% to 28% of the variance in national employment growth. The contribution of the industry shock ranges from approximately 5% to 9%. The contribution of the province shocks range from less than 1% to 2.5%. The idiosyncratic shocks account for 1.5% to 2% of the variance. The combination of industry-specific, province-specific, and the combined province-industry-specific shocks account for 7% to 12% of the steady-state variance in Canadian employment growth. Thus while the sectoral shocks account for only a small portion of the variation in national employment growth, they account for a significantly higher fraction of the variation due to Canadian sources.

V. Structural Shift in the Variance of Aggregate Employment Growth

Most economists would agree that the aggregate economy demonstrated greater instability in the 1970s and the early 1980s than in the 1960s. An important issue is the source of this greater instability. In this section we present the results of a preliminary investigation of the causes of structural shift in the variance of aggregate economic activity.

We focus on the variance of aggregate Canadian employment growth over this period. We examine the contribution of the U.S. shocks, the national shock, industrial shocks, provincial shocks, and the combined province-industry specific (idiosyncratic) shocks to the steady-state variance of employment growth in the subperiods 1963–70 and 1972–82. We assume that the regression coefficients in equation (8–25), the U.S. autoregressive parameters in equation (8–28), and the response coefficients $\underline{f}$ and $\underline{g}$ in equations (8–27a–d) are constant across the subperiods, but allow the

Table 8–8. Investigating Structural Shift in the Steady-State Variance of Aggregate Employment Growth (Full Model Estimates)

Sample Period	$V(Y_{ct})$	*Percentage Contribution of*					
		U.S. Shocks	*National Shocks*	*Industry Shocks*	*Province Shocks*	*Idiosyncratic Shocks*	*All Sectoral Shocks*[e]
1.[a]							
1963–1970	0.557×10^{-3}	68.2	22.6	1.2	3.0	4.9	9.1
1972–1982	1.2023×10^{-3}	61.2	26.7	8.5	2.2	1.1	11.8
2.[b]							
1963–1970	0.568×10^{-3}	68.8	23.3	1.3	1.8	4.7	7.8
1972–1982	1.224×10^{-3}	60.1	30.0	7.2	1.4	1.2	9.8
3.[c]							
1963–1970	0.529×10^{-3}	74.0	24.5	−2.1	−1.6	5.2	1.5
1972–1982	1.158×10^{-3}	63.5	27.8	8.6	−0.9	0.9	8.6
4.[d]							
1963–1970	0.532×10^{-3}	73.6	24.8	−2.1	−1.4	5.0	1.5
1972–1980	1.193×10^{-3}	61.7	80.8	7.4	−0.5	0.7	7.2

[a]Full sample estimates of $\underline{f}$ and $\underline{g}$ used. Negative variance estimates set to 0.
[b]Parameters $\underline{f}$ and $\underline{g}$ reestimated. Negative variance estimates set to 0.
[c]Full sample estimates of $\underline{f}$ and $\underline{g}$ used. Negative variance estimates *not* set to 0.
[d]Parameters $\underline{f}$ and $\underline{g}$ reestimated. Negative variance estimates *not* set to 0.
[e]Sum of the contribution of industry, province, and idiosyncratic shocks.

variance terms σ^2_{US}, σ^2_c, as well as the industry, province, and idiosyncratic variances, to differ across the periods. We use two approaches in re-estimating the model. In each approach we use the full sample regression coefficients and the full sample estimates of the U.S. autoregressive parameters, and estimate σ^2_{US} for the two sample periods. In the first approach we fix $\underline{f}$ and $\underline{g}$ at the full sample parameter estimates and then calculate separate estimates of the (non-U.S.) variance parameters for the subperiods. In the second approach, we re-estimate $\underline{f}$ and $\underline{g}$ and the period-specific variance parameters jointly. Here we allow the variances to differ in the subperiods but constrain the response coefficients $\underline{f}$ and $\underline{g}$ to be constant over the subperiods. Given parameter estimates from each of these approaches, we calculate an estimate of the steady-state variance in national employment growth for the two subperiods, and the percentage contribution to this variance of U.S. shocks, a national Canadian shock, provincial shocks, industrial shocks, and idiosyncratic province-industry specific shocks.

It is important to note that each of these approaches places stringent demands on the available data. For example, in the 1963–70 period we estimate a fairly rich factor model from covariances based on eight annual observations. As we note below, there is evidence that this model is, in fact, too rich for the available data. Thus we also consider a simpler model.

In panel 1 of table 8–8 we report the results of the variance decomposition when the loading factors $\underline{f}$ and $\underline{g}$ take on their full sample point estimates.[14] As in our earlier work, in calculating the variance decompositions we have set negative point estimates of the variances to zero. In panel 2 of the table we present the variance decomposition results when $\underline{f}$ and $\underline{g}$ are re-estimated under the assumption that each vector is constant over the two periods. There is remarkably little difference in the results produced by the two procedures, and thus we focus on the results in panel 1.

These results indicate that the variance in national employment growth doubled in the second period. Further, the relative contribution of the U.S. shock, the idiosyncratic shocks, and perhaps the provincial shock appear to have diminished in the 1970s while the relative contribution of the national and industrial shocks appear to have increased during this period. However, it is important to note that the absolute level of the contribution to steady-state variance increased substantially for all of the sources of variance except the idiosyncratic shocks.

There are two reasons for exercising considerable caution when examining the results in panels 1 and 2 of the table. First, standard errors are not available for the contributions to the steady-state variance, and the changes in the respective contributions in the two periods may not be large relative to

Table 8–9. Investigating Structural Shift in the Steady-State Variance of Aggregate Employment Growth (No Provincial Shocks)

Sample Period	$V(Y_{ct})$	*Percentage Contribution of*					
		U.S. Shocks	*National Shocks*	*Industry Shocks*	*Province Shocks*	*Idiosyncratic Shocks*	*All Sectoral Shocks*[e]
1.[a]							
1963–1970	0.545×10^{-3}	71.7	22.3	1.4	---	4.5	5.9
1972–1982	1.197×10^{-3}	61.5	28.5	8.4	---	1.5	9.9
2.[b]							
1963–1970	$.544 \times 10^{-3}$	71.8	22.2	1.5	---	4.5	6.0
1972–1982	1.213×10^{-3}	60.7	32.2	6.7	---	0.4	7.1
3.[c]							
1963–1970	0.531×10^{-3}	73.7	23.0	−1.2	---	4.6	3.4
1972–1982	1.182×10^{-3}	62.3	28.9	8.3	---	0.4	8.7
4.[d]							
1963–1970	0.529×10^{-3}	73.9	22.8	−1.3	---	4.6	3.3
1972–1982	1.213×10^{-3}	60.7	32.2	6.7	---	0.4	7.1

[a]Full sample estimates of $\underline{f}$ used. Negative variance estimates set to 0.
[b]Parameters $\underline{f}$ reestimated. Negative variance estimates set to 0.
[c]Full sample estimates of $\underline{f}$ used. Negative variance estimates *not* set to 0.
[d]Parameters $\underline{f}$ reestimated. Negative variance estimates *not* set to 0.
[e]Sum of the contribution of industry and idiosyncratic shocks.

sampling error. Second, in each approach approximately 30% of the point estimates of the (non-idiosyncratic) variance parameters are negative. Moreover, in contrast to the variance decompositions over the full sample, we find that *not* setting these variables to zero in the variance decompositions can affect somewhat the interpretation of the contributions, particularly the total contribution of sectoral shocks reported in the last column of the table (see panels 3 and 4).

Since these problems may indicate that a model with national, industry, and provincial shocks is too complex for estimation on the subperiods, we repeated our calculations for a model that excludes provincial shocks. Thus, the provincial variances equal zero and g drops out of the model. These results are reported in table 8–9, where each panel corresponds to the respective panel in table 8–8.[15] The results in table 8–9 are very similar to those in table 8–8 discussed above. However, we must note that again approximately 30% of our point estimates of the variance parameters were negative.

Thus the results in tables 8–8 and 8–9 must be considered preliminary.[16] However, these results indicate that increases in the variances of all shocks except the idiosyncratic ones lead to the greater instability of aggregate Canadian employment growth in the 1970s and 1980s.

VI. A Review of Evidence on Sectoral Shifts and the Reallocation Hypothesis

The above analysis indicates that sectoral shocks play only a modest role in fluctuations in employment growth in Canada via what we have called the collective impact mechanism. However, we wish to emphasize that our results do not rule out the possibility that sectoral shocks play a substantial role in employment fluctuations through the reallocation mechanism. Our findings, while preliminary, indicate that the direct effect of the average value of the sectoral shocks (weighted by the size of the specific sectors) has only a modest variance relative to the variance in aggregate employment growth. However, in the reallocation hypothesis, Lilien is concerned with the effect of fluctuations in the *variance* of sectoral shocks rather than fluctuations in the *average* of the sectoral shocks that occur in a particular time period. In fact, Lilien assumes explicitly that the average of the sectoral shocks is zero in every period. In our analysis the variance of the average of the sectoral shocks is not zero and is an increasing function of the variances of the individual shocks.

Several recent studies have examined the reallocation hypothesis, with mixed results. We briefly summarize the main methods and results rather than attempt a comprehensive survey, since research on the reallocation hypothesis is very active and appears to be in a state of flux. Readers are also referred to the survey in Lilien and Hall [1984, pp. 61–71].

Lilien [1982a] proxies the variance in sectoral shifts by constructing the employment growth dispersion measure σ_t. This dispersion index is defined as the square root of the weighted sum of squared deviations of industry growth in employment from aggregate employment growth. The reallocation hypothesis suggests that an increase in the dispersion in employment demand should increase layoffs, holding total accessions constant. Lilien finds that a measure of σ_t constructed from data for 21 manufacturing industries has a strong positive effect on the layoff rate in manufacturing even after one controls for the quit rate and the aggregate change in manufacturing employment.

Lilien [1982a] also finds that current and lagged values of a measure of σ_t, constructed from employment growth in 11 one-digit industries, has a positive relationship to the unemployment rate even after one controls for aggregate demand fluctuations as proxied by a distributed lag on Barro's unanticipated money growth variable. Taken at face value, Lilien's results are impressive in that they indicate that shifts in the natural rate associated with σ_t account for 36% of the variance in the detrended unemployment rate. The relationship is much stronger during the 1970s than during the '60s. This is consistent with casual evidence that structural shifts were more important during the 1970s, although our findings for Canada indicate that the variability in sectoral shocks rose by only a modest amount *relative* to the variance in aggregate and external shocks.

However, Lilien [1982b] noted that the dispersion measure σ_t will be correlated with *aggregate* shocks affecting all industries if the responses to such shocks are industry specific, as in the model we present above. Although Lilien [1982b, p. 22] does not take a stand on the impact that this would have on his earlier findings, Abraham and Katz [1985] show that under plausible assumptions aggregate shocks (not controlled for by unanticipated money growth) will induce a positive correlation between σ_t and the unemployment rate. This calls Lilien's initial findings into question.

The subsequent evidence in Lilien [1982b] and Abraham and Katz [1985] is mixed on whether Lilien's initial results are due to a spurious correlation between σ_t and some aggregate shock. Lilien approaches the issue directly by repeating his earlier analysis but with an alternative dispersion level, SIG_t. This variable is based upon the residuals of a model for industry employment growth that controls for the effects of aggregate shocks with time effects for each year and a distributed lag of unanticipated money

growth. (Lilien disaggregates by industry, and the time effects are equivalent to the national shock c_t with coefficient vector $\underline{f}$ in (8–24b).) He finds that a distributed lag of SIG_t has a strong positive effect on the unemployment rate in a regression that also includes a trend and a distributed lag of unanticipated money shocks. These results basically confirm the findings of his first study. It is worth noting, however, that Lilien's model (see his equation 24) implies that he should have also included the estimates (that depend on his estimated time effects as well as unanticipated money) of the aggregate shock (D_t in his notation) and its square as additional regressors in the unemployment equation. It is possible that (1) unanticipated money growth, and the other controls that Lilien reported trying, do not adequately control for D_t, and that (2) the level and/or square of D_t happens to be correlated with the estimates of SIG_t. In this case, some bias might remain, although we do not have any evidence that this problem is important. Note, however, that our results in section V suggest that in Canada, *both* aggregate shocks and sectoral shocks had higher variance during the 1970s and early 1980s than during the 1960s.

Abraham and Katz argue that an increase in sectoral shifts should be accompanied by higher vacancy levels (an outward shift in the Beverage curve), while aggregate demand shocks would have a negative effect on vacancy rates. They find that Lilien's σ_t is negatively related to the Help Wanted index for the United States (controlling for unanticipated money growth). They also obtain a negative relationship between a measure of σ_t for the British economy and a British series on job vacancies that is less subject to criticism than the Help Wanted index. Finally, they find that the sectoral dispersion measure SIG_t constructed by Lilien [1982b] is also negatively related to the Help Wanted index. Abraham and Katz provide some speculation on why SIG_t might be correlated with aggregate demand, and conclude that neither Lilien's analysis using σ_t nor the analysis using SIG_t provide "... a firm basis for establishing that sectoral shifts have been an important source of cyclical fluctuations in unemployment" (p. 19). Lilien and Hall [1984] are more positive in their assessment of the evidence.

Two additional studies deserve mention. Medoff [1983] identifies sectoral shifts with geographical changes in labor demand. He presents evidence that is loosely consistent with Lilien's [1982a] analysis of industry shifts. He also presents evidence suggesting that the Beverage curve has shifted out over time. This finding would be consistent with the reallocation hypothesis, but may also be related to other factors which have caused the short-run Phillips curve to shift. Medoff also finds that a weighted sum of squared *state* employment growth rates (not the squared deviations from the national employment growth rate) has a positive association with the Help Wanted index. He also finds that the weighted sum of squared *industry* employment growth rates has a positive association with the Help Wanted index. However, these results are not necessarily inconsistent with Abraham and Katz's finding of a negative association between the Help Wanted index and both σ_t and SIG_t, since Medoff's dispersion measure is different from the ones used by Lilien and Abraham and Katz. Moreover, Medoff controls for the prime age male unemployment rate while these other studies do not. Medoff also finds a negative link between dispersion in growth rates and labor productivity. This result is consistent with the reallocation hypothesis. Overall, his research supports a role for reallocation in an outward shift of the short run Phillips curve during the 1970s.

Finally, Neelin [1985] has recently analyzed the reallocation hypothesis for Canada. First, she finds an insignificant relationship between the Help Wanted index and measures of σ_t for Canada calculated on an industry, region, and combined industry-region basis. Thus, she obtains ambiguous results when using Abraham and Katz' check on Lilien's [1982a] procedure. Second, Neelin decomposes the variance in sectoral shifts into a component induced by past deviations of GNP from trend and a component induced by shocks to employment in each sector that are orthogonal to the lagged GNP variable. She finds that after controlling for eight lags of the unemployment rate and the current and lagged values of various proxies for aggregate demand shifts, all of the link between σ_t and unemployment is due to the component of σ_t induced by GNP rather than the dispersion component induced by sectoral shocks, when σ_t is computed on an industry or combined industry-region basis. When σ_t is computed by regions, the component of σ which is exogenous with respect to GNP has a small effect. Overall Neelin's results for Canada point to a much smaller role for the reallocation hypothesis in unemployment fluctuations than that suggested by Lilien's results for the United States.

Clearly, the current evidence on the reallocation mechanism is mixed. As is the case with the collective impact hypothesis, further research is required before any firm conclusions may be drawn.

VII. Concluding Remarks

In this chapter we analyze two mechanisms through which disaggregate shocks affecting specific sectors of the economy may induce aggregate fluctuations. The first, which we call the collective impact hypothesis, simply acknowledges that aggregate employment may reflect fluctuations in an appropriately weighted average of the disaggregate shocks. We develop a disaggregate model of employment in which sectoral shocks enter through product demand, labor demand, and labor supply. The theoretical model provides a foundation for the econometric time series model that we have used in our research on the contribution of disaggregate shocks to aggregate fluctuations. However, it is oversimplified in a number of respects and hopefully can be improved upon in future research. An interesting avenue for future research would be to introduce nonlinearities into the model that would permit shifts in the variance parameters of the sectoral shocks to affect the expected value of the growth in the log of aggregate employment, as suggested by the reallocation hypothesis. In our model the variances in the sectoral shocks affect only the variance of aggregate employment. Unfortunately, this represents a difficult task, and such a nonlinear model will raise further econometric problems.

The empirical analysis of the collective impact hypothesis indicates that industry-specific and province-industry specific shocks account for 7% to 12% of the variation in Canadian employment growth over the period 1961–82. U.S. shocks and aggregate Canadian shocks account for 62% to 67% and 24% to 28% of the variance, respectively. Thus, our results suggest that sectoral shocks play only a modest role in aggregate fluctuations in employment, although they play a more important role in terms of variation due to Canadian sources.

We also find a large increase between the 1960s and the 1970s in the contribution of sectoral shocks to aggregate employment fluctuations, although in absolute terms the contributions of the United States and the national Canadian shock also more than double. While the relative importance of sectoral shocks appears to have increased, the greater variability of output during the 1970s and early 1980s appears to be due primarily to aggregate sources. However, these estimates should be treated very cautiously, since the model estimates used to compute the variance decompositions for the subperiods are far from satisfactory.

Although the collective impact hypothesis has received little attention in the literature, a number of recent studies have examined the importance of the hypothesis that changes in the variance of sectoral shocks induce changes in employment because of the time and resources lost as labor adjusts in response to the changing composition of demand. This "reallocation" mechanism and the collective impact mechanism are not mutually exclusive, although no existing study (including our own) allows for both in a single model. The results of existing studies of the reallocation mechanism are mixed, and it is too early for strong conclusions to be drawn about it.

Notes

1. We learned of Tobin's paper from Lilien [1982b], who also uses this quote. Note that Tobin, in his American Economic Association presidential address, states, "The myth of macroeconomics is that relations among aggregates are enlarged analogues of relations among corresponding variables for individuals, households, firms, industries, markets. The myth is a harmless and useful simplification in many contexts, but sometimes it misses the essence of the phenomenon." [Tobin, 1972, p. 9]. Tobin presents a view of the natural rate of unemployment that is similar to Lilien's, aside from an assumption that sectoral wages adjust more slowly to excess supply than to excess demand. However, Tobin does not emphasize fluctuations in the natural rate that might result from changes in the variance of sectoral shocks.

2. The recent study by Blanchard and Watson [1984] is one of a number of studies that suggests that *aggregate* shocks arise from a number of sources.

3. In aggregating various determinants of aggregate demand into one index that enters the equation for D_{pit} with a sector-specific coefficient, we are implicitly assuming that differences across sectors in the response of D_{pit} to the components of aggregate demand are the same for all components. For example, the assumption implies that the ratio of the response of the demand for manufacturing products from a given region to a change in the money supply and to a change in military expenditure changes is the same for all regions. This is a strong assumption.

4. The product price does not appear in equation (8–1a) because D_{pit} indexes changes in the position of the product demand curve rather than product demand itself. We substitute D_{pit} directly into the condition which determines labor demand, so that the product price does not appear there either.

5. Fischer assumes that employment is demand determined, in which case the parameters $\mu^{s}_{pi} = 0$ for all p, i.

6. We allow the variance of industry shocks η_{it} to differ by industry and the variance of idiosyncratic shocks μ_{pit} to differ by industry-province pair.

7. It is also necessary to normalize the $\underline{f}$ and $\underline{g}$ vectors. One possible normalization is $f_1 = 1$ and $g_1 = 1$.

8. We also experimented with a province specific constant in equation (8–25), but this did not change the results.

9. Given that $PI = 63$ in our work and $T = 20$, it is not possible to leave π as an unrestricted matrix to be determined by the data.

10. The explicit expressions are quite lengthy and are omitted to save space. These expressions are given in Altonji and Ham [1985].

11. The model that we estimate falls into the general class of index models discussed in Engle and Watson [1981]. Models in this class incorporate direct feedback from past values of the observed variables to the current values as well as serial correlation in the unobserved variables that drive the system. See Altonji and Ham [1985] for a discussion of other possible approaches to assessing the importance of sectoral shocks, including the use of multiregional structural econometric models of the type surveyed in Bolton [1980], and vector autoregressive models.

12. It is not possible to obtain a finer industrial classification when also disaggregating by region.

13. For the sample used in section V, 3 of the 17 point estimates of the variances were negative, although none of these was significantly different from zero.

14. All of the estimates in tables 8–8 and 8–9 are based on the residuals when OLS is used to estimate equation (8–25) and data on Newfoundland are excluded. We carried out some limited experiments with other sets of residuals, and our results did not change.

15. The model excluding provincial shocks was estimated on the full sample period 1963–82. The resulting parameter estimates for $\underline{f}$ were used to calculate the results in panels 1 and 3 of table 8–9.

16. In future work it would be interesting to investigate the structural shift issue using parameter estimates based on quarterly or monthly data. Using a finer degree of time aggregation would allow the data to be more informative in each of the subperiods, although it would also complicate the estimation considerably.

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