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REGIONAL INCOME FLUCTUATIONS:
COMMON TRENDS AND COMMON CYCLES

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ABSTRACT

This paper investigates trend and cycle dynamics in per capita income for the major U.S. regions during the 1956-95 period. Cointegration and serial correlation common features information are used in jointly decomposing the series into trend and cycle components. We find considerable differences in the volatility of regional cycles. Controlling for differences in volatility, we find a great deal of comovement in the cyclical response for all regions but the Far West. Possible sources underlying differences in regional cycles are explored, such as the share of a region's income accounted for by manufacturing, defense spending as a proportion of a region's income, oil price shocks, and the stance of monetary policy. Somewhat surprisingly, we find that the share of manufacturing in a region seems to account for little of the variation in regional cycles relative to national cycles, but manufacturing's share differentially affects trend growth for four of the seven regions studied.

I. Introduction

The United States is made up of diverse regions that, although linked, may respond differently to changing economic circumstances. Some regions may react more strongly than others to nationwide forces, such as changes in monetary and fiscal policies, changes in relative prices, and technological innovations. For example, Carlino and DeFina (1998) showed that regions respond quite differently to unexpected changes in monetary policy. There is evidence that changes in the relative price of energy affect energy-producing states differently from energy-consuming states. Recent cutbacks in defense spending and downsizing in financial industries have been noted as the main reasons for continuing weakness in much of the northeastern part of the country.

Differences in a region's industrial structure may also contribute to differences in regional business-cycle behavior. Since regions have different mixes of industries, they experience different shocks to output, resulting in region-specific business cycles. For example, the Great Lakes region contains a much larger share of the cyclically sensitive manufactured durables sector, while the share of manufactured durables in the Southwest region is much smaller.

Despite long-standing interest in and concern about this issue, there is little empirical evidence on whether and to what extent regional business cycles differ. In this paper we investigate trend and cycle dynamics in regional incomes using recently developed time-series techniques that exploit common features in the regional series.

We look for common trends and common cycles in real per capita personal income for the major regions of the United States using quarterly data for the 1956:1-95:2 period. There are five main findings of this research.

First, the levels of real per capita incomes for the regions are cointegrated.

Second, our analysis reveals considerable differences in the volatility of regional cycles. The standard deviation of the cyclical component in the most volatile region (Southeast) is almost five times as great as that in the least volatile region (Far West). The cyclical component in the New England, Mideast, Southeast, and Southwest regions tends to be more volatile than the national average. Cycles in the Far West region tend to be less volatile than the national average, while per capita income in the Great Lakes and Plains regions is about as volatile as the national average.

Third, controlling for differences in volatility, we find a great deal of comovement in the cyclical response of all but the Far West region. Although the Far West region tends to comove with the other regions and the nation, the extent of that correlation is much weaker than it is for all other regions.

Fourth, we find that cyclical innovations are relatively more important than trend innovations in explaining the total variation in regional per capita incomes. This finding highlights an important feature of our methodology. The technique we use allows for variability in both trend and cycle components of regional per capita incomes. This is significant because a deterministic trend model could attribute too much importance to transitory fluctuations.

Finally, we explore some possible sources underlying the differences in regional cycles, such as the share of a region's income accounted for by manufacturing; defense spending as a proportion of a region's income; oil price shocks; and the stance of monetary policy. Somewhat surprisingly, we find that the share of manufacturing in a region seems to account for little of the variation in regional cycles relative to national cycles, but manufacturing's share differentially affects trend growth in four of the seven regions studied.

II. Literature Review

Studies on regional business-cycle theory and measurement date from the early work of McLaughlin (1930), Vining (1949), Borts (1960) and Syron (1978). Recently, interest in regional fluctuations has been renewed, and the authors of new studies have employed systems methods of estimation--vector autoregression (VAR) techniques. Recent papers by Sherwood-Call (1988), Cromwell (1992), Carlino and DeFina (1995), and Coulson (1999) have focused on differential regional growth instead of differences in regional business cycles.[1] One exception is a recent paper by Quah (1996). Quah looks at comovement among aggregate and regional disaggregated data by modeling the dynamics as a cross-sectional distribution. While Quah's work is related to ours, his goal is to consider how leading regions contribute to national cycles, whereas ours is a comparison of cycles among regions.

III. The Empirical Model

Our study uses quarterly data on real per capita personal income (in logs) by major BEA region for the 1956:1 to 1995:2 period. One issue is how to deflate nominal regional incomes, since regional price deflators do not exist. However, consumer price indexes (CPIs) do exist for many of the metropolitan areas in the various regions. To form the regional CPIs, we grouped the available metropolitan-area CPIs by region and weighted them by their relative importance. Unfortunately, Denver is the only metropolitan area in the Rocky Mountain region where the BLS calculated a CPI, and this index is available only for 1964-86. Given the absence of a deflator that covers our entire sample period, we elected to drop the Rocky Mountain region from our analysis. This is not a major concern, since the Rocky Mountain region accounts for only 3 percent of national income and population. This leaves seven regions in the analysis that follows.[2] Cointegration tests revealed that the seven regional price indexes share a single cointegrating relationship. We also found a fairly high degree of correlation among the regional inflation measures (correlation coefficients were, in general, around .75).

Not surprisingly, we found that average quarterly real per capita income growth varied widely across regions, ranging from a low of less than two-tenths of a percent in the Far West region to a high of over six-tenths of a percent in the Southeast region. The simple correlations of growth in regional real per capita incomes are reported in Table 1, along with the sample standard deviations (final column). The standard deviation of real per capita income growth varies widely across regions: the standard deviation of real per capita income growth in the most volatile region (Plains) is almost twice that of the least volatile region (Mideast).

Our analysis of the regional data proceeds by examining whether the series are cointegrated, the presence of cointegrating relationships indicating that the series share stochastic trends. Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests were used to check for stationarity in the level and growth rate of regional real per capita incomes. We find that the unit root null cannot be rejected for the level of regional real per capita income using either test, although stationarity is achieved by first differencing. Thus, the levels of the series appear to be I(1) while first differences are I(0).

The likelihood-based cointegration tests of Johansen (1988, 1991) and Johansen and Juselius (1990) were used to test for cointegration under the restriction of a single lag in the vector error correction model (VECM) representation of a system with seven variables. This lag length was chosen based on Akaike and Schwarz information criteria. A constant term was included in the

VECM. The results of a likelihood ratio test for cointegration are presented in Table 2. The lambda-max test statistics indicate a single cointegrating relationship among the seven regions, while the trace test statistic supports two cointegrating relationships. We proceeded under the assumption that the data are adequately characterized by two cointegrating relations. The presence of such common long-run trends in the regional data could arise from factors such as national economic policy or perhaps common productivity movements.

The regional income series appear to have common trends, but do they have common cycles? We examined this possibility using the common features framework described in Engle and Kozicki (1993) and Vahid and Engle (1993). Let y_t denote an n-vector of I(1) variables whose first difference is autoregressive. The elements of Δy_t are said to have a serial correlation common feature if there exists a linear combination $\beta\Delta y_t$ such that $E_{t-1}(\beta\Delta y_t) = 0$. Vahid and Engle (1993) show that if a set of I(1) variables share a serial correlation common feature, the levels of the variables share a common cycle in their Beveridge-Nelson decompositions. Engle and Kozicki (1993) use the common features framework to examine international business cycles, interpreting serial correlation common features as common business cycles.

We tested for the presence of serial correlation common features in the regional income series using the canonical correlation-based tests described in Vahid and Engle (1997). The test examines canonical correlations between Δy_t and its relevant history, determined as the dependent variables in the VECM representation of the system. The canonical correlations that are insignificantly different from zero represent linear combinations of Δy_t that are uncorrelated with the past information set and thus give the number of independent cofeature vectors. The results of the tests are given in Table 3. The test statistic is based on the scalar components model framework of Tiao and Tsay (1989). Ordering the squared canonical correlations (λ_j^2) from low to high, the null hypothesis for the test is that the first j correlations are zero but the (j+1)th is nonzero. The tests are consistent with a finding that the system is characterized by four canonical correlations that are insignificantly different from zero, suggesting that the system has four independent cofeature vectors.

We conclude that the seven regions do share common, synchronous cycles. To further analyze the dynamics of regional income we decompose the series into trend and cycle components. We do so making use of the information on the number of cointegrating vectors and cofeature vectors. Consider first the VECM representation of the *n*-dimensional regional income system where, for ease of exposition, we drop constant terms:

$$\Delta y_t = \Pi_1 \Delta y_{t-1} + \ldots + \Pi_p \Delta y_{t-p} + \beta\alpha' y_{t-1} + \varepsilon_t \qquad (1)$$

with γ and α full rank matrices of order $n \times r$, and r is the rank of the cointegration space.

Following Vahid and Engle (1993) we estimate the following restricted reduced form system by two stage least squares:

$$\begin{bmatrix} I_s & \tilde{\alpha}^{*\prime} \\ 0_{(n-s)\times s} & I_{n-s} \end{bmatrix} \Delta y_t = \begin{bmatrix} 0_{s\times(np+r)} \\ \Pi_1^* \ldots \Pi_p^* \beta^* \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \vdots \\ \Delta y_{t-p} \\ \hat{\alpha}' y_{t-1} \end{bmatrix} + v_t \qquad (2)$$

where Π_i^* and β^* represent the partitions of Π_i and β corresponding to the bottom *n-s* reduced form VECM equations and *s* is the number of linearly independent cofeature vectors. The error term v_t in equation (2) is given by:

$$v_t = \begin{bmatrix} I_s & \tilde{\alpha}^{*\,\prime} \\ 0_{(n-s)\times s} & I_{n-s} \end{bmatrix} \varepsilon_t$$

Inverting the coefficient matrix on Δy_t in equation (2) and multiplying through the right-hand side of equation (2) yields a reduced form VECM model that contains the common feature and cointegration information:

$$\Delta y_t = \Pi_1^{**}\Delta y_{t-1} + \ldots + \Pi_p^{**}\Delta y_{t-p} + \beta^{**}\alpha' y_{t-1} + \varepsilon_t^* \qquad (3)$$

This reduced form representation allows then for the efficiency gains due to common cycles.

Representation (3) can be used in a multivariate decomposition of the series into trend and cycle components. We examined two such decompositions: the Beveridge-Nelson (1982) decomposition and the Gonzalo-Granger (1995) decomposition. Under certain circumstances these two decompositions are equivalent, but in general the common-factor-based approach of Gonzalo-Granger is such that the permanent component of the decomposition, although an I(1) process, is not representable as a multivariate random walk.[3] The cyclical component from both decompositions are plotted in Figure 1.[4] The cycles are quite similar region-by-region, with the possible exception of the Far West, where the Beveridge-Nelson decomposition gives a somewhat more volatile cycle. Given the similarity of the cyclical components derived from the two decompositions and the wide familiarity with the Beveridge-Nelson decomposition, all the results that follow are based on the cyclical and trend components given by the multivariate Beveridge-Nelson decomposition.

A. Trend-Cycle Decompositions The percent change in the actual levels of per capita incomes for the seven BEA regions and the U.S. for the past seven recessions is reported in the top panel of Table 4. The table also reports the Beveridge-Nelson trend components in the middle panel and the Beveridge-Nelson cyclical components in the bottom panel for each recession.[5] The table shows, for example, that the 5.6 percent annualized decline in real per capita income in the Great Lakes region during the 1957-58 recession consists of a 0.8 percent increase in the trend term and a 6.3 percent decline in the cyclical component.[6]

The 1973-75 recession and the 1980 recession are of interest for several reasons.[7] First, these were among the most severe recessions of the postwar period for most regions. Declines in real per capita income were in general larger in the 1973-75 and 1980 recessions than in those of other postwar recessions. At the national level, real per capita income fell more than 6 percent on an annualized basis during the 1980 recession, compared with the 4 percent annualized drop in the 1973-75 recession, the prior largest downturn of the postwar period. Second, Table 4 shows that the effects of the 1973-75 and 1980 recessions led to declines in trend growth for all regions. That is, real per capita personal incomes at the regional level never return to the earlier trends following the 1973-75 recession and 1980 recessions.

With the exception of the Far West region, prior to the 1973-75 recession, the trend component generally increased during recessions, mitigating transitory declines in *total* real per capita income. However, beginning with the 1973-75 recession, the trend component has generally declined in all recessions and in all regions. Thus, our findings for the U.S. regions are in accord with the Nelson and Plosser (1982) view that business cycles are not entirely temporary events.

We now turn our attention to the transitory components of regional incomes. In the Southwest and Far West regions, the Beveridge-Nelson cyclical component was negative in six of the seven recessions shown in Table 4, while it was negative in five recessions in the Great Lakes region. On the other hand, the Beveridge-Nelson cyclical component was negative in only two of the past seven recessions in the Southeast region, and it was negative in three recessions in the New England region. To approximately control for differences in amplitude of the series and help clarify the common timing and duration of regional cyclical components, we standardize the regional cyclical components by dividing each series by their respective standard deviations. Figure 2 presents the standardized cyclical component for each region. The graph includes the NBER recession bars for reference, shaded from peak to trough.[8] The standardized cyclical component for the nation has been included in each graph. The graph shows that the cyclical component exhibits a cyclical pattern similar to NBER reference cycles in all regions.[9] Typically, the cyclical component declines during recessions and increases during expansions. This cyclical pattern shows up in all regions but is much more pronounced in the Far West region, especially during the first half of the sample. The graph shows that six of the seven regions have highly correlated cycles. The Far West region tends to differ from the other regions mostly in terms of the amplitude of its cycles. In addition, the amplitude of the cycle for the Plains region tends to be more pronounced than the other regions during the last ten years of the sample. There also appear to be more high-frequency fluctuations in the transitory component since the early 1980s than before that time. Similarly, prior to the 1980s, there was much more low-frequency fluctuation in the cyclical component than after that date.

Table 5 reports the simple correlation coefficients among the regional and national cyclical components. With the exception of the Far West region, the correlation coefficients among regions in every instance are equal to 0.88 or more. Hence, the transitory components in regions other than the Far West are highly correlated with the national cyclical component. With the exception of the Far West region, the correlation coefficient is at least 0.92 between any of these regions and the nation. The Far West region shares a much weaker correlation with the nation and all other regions. The correlation between the Far West and the other regions is 0.33 or less.

The last column of Table 5 reports the standard deviation of the regional cyclical components for our entire sample period. Despite the comovement of the regional cyclical components, the data reveal considerable cross-regional differences in volatility. The cyclical component in the most volatile region (Southeast) is almost five times as great as in the least volatile region (Far West). The cyclical component in the New England, Mideast, Southeast, and Southwest regions tends to be more volatile than the national average. Per capita income in the Far West region tends to be less volatile than the national average. Per capita income in the Great Lakes and Plains regions is about as volatile as the national average.

<u>B. Variance Decomposition of Regional Per Capita Income Innovations</u> The relative importance of innovations to the transitory and permanent components for the total variation of regional per capita income is investigated via a variance decomposition. The decompositions are based on bivariate VARs of the log first differences of the permanent and transitory components.

Each VAR contains three lags of each variable (based on the Schwarz information criterion) and a constant term. The findings of the trend/cycle decomposition are reported in Table 6 for selected horizons (h) between 1 and 16 quarters. The decompositions reported in Table 6 are based on seven separate variance decompositions (one for each region). In Table 6, each cell contains two numbers: the first number represents the relative importance of a shock to that component when the trend is ordered first in the orthogonalization procedure, and the number in parentheses represents the same measure when the cyclical component is ordered first. Engle and Issler (1995), and others, suggest putting trend innovations first in the orthogonalization procedure, since in real business cycle models innovations in productivity cause both trend and cycle movements.

When the trend component is ordered first in the decomposition, the greatest contribution to the long-run or 16-step ahead forecast variance comes from the cyclical component for five (Mideast, Great Lakes, Plains, Southeast, and Southwest) of the seven regions. Alternatively, when the cyclical component is ordered first in the decomposition, the greatest contribution to the 16-step ahead forecast variance also comes from the cyclical component for all regions with the exception of the Southeast and Southwest regions, which are too close to call. By and large, these results suggest that the cyclical component makes the greatest contribution to regional income forecast variances.

IV. What Causes These Differential Responses?

In this section we look at the effects of a number of variables commonly thought to affect both cycle as well as trend growth. Differing industrial structures is perhaps the most often cited reason to account for regional differences in both business cycle responses and trend growth. At the national level, Lilien (1982), Long and Plosser (1987), and Horvath and Verbrugge (1995), among others, find that a significant part of aggregate fluctuations is due to sectoral shocks. The combination of regional differences in industrial structure and the different responses of various industries to shocks could make some regions more vulnerable to innovations than others. In addition, Shea (1996) has found evidence that industries that comove over time also tend to agglomerate spatially. Shea posits several hypotheses regarding the possible reasons for this phenomenon, including local activity spillovers, or external economies of scale. The optimal level of activity of an industry in a given region depends on the aggregate level of activity in all other industries. Thus, when one local industry declines, for example, the decline tends to spillover to all other industries in the region. One of Shea's goals was to show that the correspondence between spatial and temporal comovement is important for fluctuations in the national economy. But for our purposes it is important to note that the effect of local activity spillovers will differ across regions since the degree of synergy, or links, among industries will differ across regions because of differences in industrial structure and the strength of external economies of scale. Browne (1978) found that industry mix was an important factor responsible for regional differences in cyclical behavior during the period 1958-76. More recently, Clark (1998) and Clark and Shin (1998) found that 20 to 30 percent of the forecast error variance in regional employment fluctuations was related to differences in regional industrial structure. We use the percent of a region's total output accounted for by manufacturing to measure the importance of industry mix on regional cycles and trend growth.

While industry mix is one factor that may be responsible for regional differences in cyclical behavior, other factors are likely to play a role as well. Carlino and DeFina (1998) found that monetary policy has differential effects on regional per capita incomes. The interest rate channel associated with monetary policy may interact with industry mix differences and cause different regional responses to Fed tightening and easing of policy. While this channel for monetary policy would be captured by our industry mix variable, other possibilities include differing regional responses due to credit channel influences. For example, regional differences in the proportion of large and small borrowers, and the sources of credit available to each, could also lead to different regional responses to monetary policy. We use the Boschen and Mills (1995), hereafter BM, "narrative measure" that ranks monetary policy on a numerical scale from -2 (large emphasis on inflation control) to +2 (large emphasis on promoting real growth).[10]

Researchers have argued that spatial variations in defense spending may be an important source of regional differences in income growth [Mehay and Solnick (1990), and Hooker and Knetter (1997)] and employment cycles [Davis, Loungani, and Mahidhara (1997)]. For our seven regions, average military spending in the postwar period ran from a high of $13.3 billion in both the New England and Far West regions to a low of $3.8 billion in the Plains region.[11] We include the percent of a region's income accounted for by military spending as an explanatory variable in the model that follows. Finally, the relative price of oil is included in our empirical model as a proxy for exogenous supply shocks.

How important are these factors in accounting for differential regional responses in cyclical and trend growth? To answer this question, we used the estimated cyclical and trend components for each region and the nation to form relative (to the nation) regional cyclical variables and relative trend variables. The relative regional cycle and trend variables are alternatively used as dependent variables in a region-by-region regression model (i.e., a separate regression for each region) to see what relationship exists among oil price shocks, innovations in monetary policy, shocks to defense spending, manufacturing share, and regional economic activity. Our regression equations are given by:

$$y_{i,t} = \alpha_0 + \sum_{j=1}^{6} \beta_j \Delta oil_{t-j} + \sum_{j=1}^{6} \delta_{t-j} BM_{t-j} + \sum_{j=1}^{6} \phi_j \Delta pmfg_{i,t-j} + \sum_{j=1}^{6} \eta_j \Delta pmilt_{i,t-j} + \sum_{j=1}^{6} \nu_j y_{i,t-j} + \varepsilon_{i,j}$$

Where:

y = either the estimated relative (to the nation) cyclical component (levels) or estimated relative trend variable (first difference);

oil = implicit price deflator for fuels and related products relative to the PPI ;

BM = Boschen and Mills narrative index of monetary policy;

pmfg = the proportion of a region's total income accounted for by its manufacturing industry;

pmilt = defense spending as a proportion of a region's total income;

ε = random error term;

Δ = first difference of variable; and

i indexes region, and t indexes time

Six lags of each variable are included to account for lagged adjustment, and six lags of the dependent variable are included as regressors to control for serial correlation. With the exception of the cyclical components and the BM index, first differencing is required to make the variables stationary. We used the heteroskedasticity-consistent estimator of the variance-covariance matrix, due to White, in the regressions that follow. The sample period is 1956:1 to 1992:4, providing 146 observations in each regression. The findings are reported in Table 7.

Table 7 reports two sets of findings for each region: the response to the various shocks of the region's cycle relative to the national cycle, and the response to the various shocks of a region's trend growth relative to national trend growth. Each cell reports the sum of the coefficients of that variable. An acceleration in the relative price of oil causes regional cycles in the New England and Great Lakes regions to increase significantly more than the national average cyclical response and to increase relatively less than average in the Far West region. An acceleration in the relative price of oil had a significantly negative impact on trend growth in the New England and Mideast regions relative to national trend growth, while having a positive and significant impact on relative trend growth in the Plains region. Surprisingly, the relative cycle and relative trend growth components in the Southeast region were not differentially impacted relative to average cycle and trend growth components for the nation from an acceleration in the relative price of oil. Although both the relative cycle and relative trend growth variables are positive in the Southeast region, neither variable is significant.

We found that positive shocks to the BM index, which indicates an expansionary monetary policy stance, had a significantly positive impact on the relative cyclical component in the New England region, while having a significantly negative impact in the Far West regions. We also find in the relative trend growth regressions that expansionary monetary policy has a positive and significant impact on relative trend growth in three regions (Plains, Southeast, and Far West) while having a negative and significant relationship in the Southwest region. Although the coefficients on the monetary policy variable is significant for these four regions, in general, the estimated coefficients are quite small.

Similar to Browne (1978), Clark (1998), and Clark and Shin (1998), we find evidence that differential regional growth is tied to industry mix. An acceleration in the share of a region's income originating in manufacturing significantly increased the relative cyclical component in the New England region while lowering it in the Mideast region. More important, perhaps, is the finding that trend growth in three cases (New England, Plains and Far West) is significantly increased relative to U.S. average trend growth, while relative trend growth in one region (Southeast) is significantly lower.

An acceleration in the growth of defense spending relative to total income appears to have significantly increased the relative cyclical component in the Mideast region, while lowering it in the Plains region. Interestingly, relative trend growth appears to be negatively impacted by an acceleration in the growth of defense spending relative to total regional income. The relative trend component in four regions (New England, Great Lakes, Southeast, and Southwest) is negative and significant. Thus, increased reliance on defense spending lowers trend growth. This finding may be of some consolation to regions that recently experienced cuts in defense spending. However, Hooker and Knetter (1997) find that cuts in military spending had a sizable negative impact on those states with a large exposure to the military sector and a modest impact on most other states.

V. Conclusion

The national economy is a composite of diverse regional sub-economies. Similarly, national business cycles are amalgams of regional cycles. When we consider only national aggregates, such as GDP, national income, employment, and industrial production, a large amount of detail about regional cycles is lost. This loss of regional detail may be unimportant if the divergence of regional cycles from national cycles is small. However, we find evidence of considerable divergence of regional business cycles from national cycles. The cyclical component in the most volatile region

(Southeast) is almost five times as great as in the least volatile region (Far West). Controlling for differences in volatility, we find a great deal of comovement in the cyclical response of all but the Far West region. Large differences in business cycles across regions can make it difficult for national policymakers to bring about satisfactory outcomes in all parts of the country. Attempts at stimulating the economy, for example, may lead to tight labor markets in some regions while others lag behind.

We also investigated possible sources of the observed differences in regional business cycles relative to national average cycles and in regional trend growth relative to trend growth nationally. While it is often claimed that cyclical differences in regional per capita incomes result largely from differences in regional industrial structure, we find little evidence to support this claim. A relatively high share of manufacturing appears to have increased the cyclical response in the New England region relative to the national average response while lowering the cyclical response in the Mideast region. However, having a relatively high share of a region's employment in manufacturing appears to increase trend growth relative to average national trend growth in the New England, Plains, and Far West region, while lowering it only in the Southeast region. In a study that is closely related to ours, Engle and Issler (1995) look at the degree of trend and cyclical comovement in U.S. sectoral output during the postwar period. Similar to the findings in this paper, they find very different behavior for trends, but they find quite similar cyclical behavior among the one-digit industries. These findings underscore the importance of trend-cycle decomposition for understanding the sources of change in regional and national variables. Studies that narrowly look at growth in regional or national activity may wrongly classify shocks to growth as temporary events.

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Table 1: Simple Correlations of Real Regional Per Capita Personal Income Growth, 1956:1-95:2

	US	NE	ME	GL	PL	SE	SW	StDev*
NE	0.75							0.12
ME	0.75	0.70						0.10
GL	0.81	0.53	0.63					0.12
PL	0.62	0.24	0.33	0.59				0.19
SE	0.82	0.57	0.54	0.66	0.49			0.11
SW	0.74	0.48	0.48	0.52	0.46	0.69		0.13
FW	0.78	0.54	0.48	0.49	0.27	0.57	0.42	0.12

NE = New England, ME = Mideast, GL = Great Lakes, PL = Plains, SE = Southeast, SW = Southwest, and FW = Far West

*Standard Deviation

Table 2: Cointegrating Test Results				
Test Statistic		Critical Value at 95%		Null Hyp.
λ_{max}	Trace	λ_{max}	Trace	
4.45*	4.45*	3.76	3.76	$r \leq 6$
9.44	13.89	14.07	15.41	$r \leq 5$
12.78	26.67	20.97	29.68	$r \leq 4$
16.23	42.90	27.07	47.21	$r \leq 3$
22.72	65.62	33.46	68.52	$r \leq 2$
28.64	94.26*	39.37	94.15	$r \leq 1$
55.42*	149.68*	45.28	124.24	$r \leq 0$

*denotes significant at 5% level.

.

Table 3: Cofeatures Test			
Canonical Correlations λ	χ^2 Statistic C(S)[a]	Degrees of Freedom[b]	Significance Level
0.587	173.28	63	0.0000
0.473	107.36	48	0.0000
0.447	67.86	35	0.0007
0.339	33.10	29	0.1018
0.246	14.07	15	0.5202
0.152	4.35	8	0.8240
0.068	0.73	3	0.8656

[a]The χ^2 Test is:

$$C(S) = -(T - h)\sum_{i=1}^{s}\log(1-\lambda_i^2)$$

[b]Degrees of freedom are given by s*(h*k+r+s)
where s = number of canonical correlations,
k = dimension of y(t)
r = number of cointegrating vectors
h = number of lags-1 in VECM

Table 4: Annualized Perrcent Change in Per Capita Income for Postwar Recession*

RECESSIONS	NE	ME	GL	PL	SE	SW	FW	US
ACTUAL INCOME								
3Q 57-2Q 58	-3.23	-3.83	-5.59	0.13	-1.28	-0.47	-4.11	-3.28
2Q 60-1Q 61	1.30	0.26	0.19	4.02	-0.20	-1.31	-5.45	-1.27
4Q 69-4Q 70	-0.66	-1.11	-2.80	-0.19	2.03	3.26	-1.79	-0.55
4Q 73-1Q 75	-2.93	-3.69	-4.37	-8.95	-3.68	-4.10	-2.37	-4.02
1Q 80-3Q 80	-4.48	-4.06	-9.29	-7.62	-6.85	-5.48	-6.81	-6.32
3Q 81-4Q 82	0.57	-0.02	-4.09	-1.34	-2.74	-0.61	-0.93	-1.16
3Q 90-2Q 91	-2.78	-1.53	-1.54	1.01	-0.12	-0.38	-1.57	-1.08
1Q 80-4Q 82	-0.29	-0.34	-2.85	-0.03	-1.42	1.15	-1.06	-0.62
BN-TREND COMPONENT								
3Q 57-2Q 58	3.12	3.29	0.75	5.02	5.02	5.97	-1.03	2.18
2Q 60-1Q 61	0.12	1.46	1.65	5.05	-1.45	0.74	-3.45	-0.39
4Q 69-4Q 70	2.62	2.15	-0.53	2.63	4.48	5.18	-0.24	1.87
4Q 73-1Q 75	-5.23	-5.35	-5.03	-6.65	-4.80	-3.82	-1.49	-4.26
1Q 80-3Q 80	-6.02	-6.60	-8.66	-8.34	-8.50	-4.32	-3.95	-6.41
3Q 81-4Q 82	-0.78	-2.03	-5.92	-4.15	-5.65	-1.19	-2.44	-2.93
3Q 90-2Q 91	-1.32	0.66	0.32	0.87	-0.27	-0.26	-1.50	-0.35
1Q 80-4Q 82	-0.81	-1.19	-3.73	-1.53	-1.93	0.66	-2.13	-1.41
BN-CYCLICAL COMPONENT								
3Q 57-2Q 58	-6.30	-7.06	-6.32	-4.83	-6.22	-6.35	-3.08	-5.46
2Q 60-1Q 61	1.18	-1.20	-1.46	-1.02	1.25	-2.04	-2.02	-0.89
4Q 69-4Q 70	-3.28	-3.27	-2.27	-2.82	-2.45	-1.92	-1.56	-2.43
4Q 73-1Q 75	2.27	1.64	0.66	-2.26	1.10	-0.28	-0.88	0.24
1Q 80-3Q 80	1.59	2.63	-0.66	0.75	1.73	-1.19	-2.91	0.09
3Q 81-4Q 82	1.35	2.00	1.80	2.78	2.87	0.57	1.50	1.77
3Q 90-2Q 91	-1.46	-2.18	-1.85	0.14	0.15	-0.12	-0.07	-0.73
1Q 80-4Q 82	0.51	0.83	0.79	1.44	0.48	0.50	1.00	0.79

*Trend and cyclical components may not sum to actual due to rounding error.

TABLE 5: Simple Correlations Among the Regional Cyclical Components and the Standard Deviation of a Region's Cyclical Component,1956:1-95:2

	US	NE	ME	GL	PL	SE	SW	StDev*
US								0.0378
NE	0.99							0.0530
ME	0.99	0.99						0.0479
GL	0.99	0.97	0.98					0.0398
PL	0.92	0.88	0.89	0.92				0.0340
SE	0.97	0.96	0.96	0.96	0.90			0.0648
SW	0.98	0.97	0.98	0.96	0.89	0.95		0.0441
FW	0.36	0.32	0.31	0.33	0.26	0.20	0.32	0.0133

NE = New England, ME = Mideast, GL = Great Lakes, PL = Plains,
SE = Southeast, SW = Southwest, and FW = Far West

*Standard Deviation

Table 6: Proportion of the Variation of Per Capita Income Innovations Attributed to Trend and Cyclical Shocks at Horizon (h)*

	h = 1		h = 5		h = 9		h = 16	
	Cycle	Trend	Cycle	Trend	Cycle	Trend	Cycle	Trend
New England	0.99 (0.54)	0.01 (0.46)	0.02 (0.69)	0.98 (0.31)	0.03 (.71)	0.97 (0.29)	0.04 (0.71)	0.96 (0.29)
Mideast	0.95 (0.46)	0.05 (0.59)	0.95 (0.60)	0.05 (0.40)	0.94 (0.61)	0.06 (0.39)	0.94 (0.61)	0.06 (0.39)
Great Lakes	0.91 (0.63)	0.09 (0.37)	0.93 (0.70)	0.07 (0.30)	0.92 (0.71)	0.08 (0.29)	0.92 (0.71)	0.08 (0.29)
Plains	0.31 (0.94)	0.69 (0.06)	0.40 (0.95)	0.60 (0.05)	0.40 (0.94)	0.60 (0.06)	0.90 (0.94)	0.60 (0.06)
Southeast	0.89 (0.34)	0.11 (0.66)	0.93 (0.42)	0.07 (0.58)	0.91 (0.44)	0.06 (0.56)	0.94 (0.44)	0.06 (0.56)
Southwest	0.94 (0.55)	0.06 (0.45)	0.92 (0.51)	0.08 (0.49)	0.91 (0.51)	0.09 (0.49)	0.91 (0.51)	0.09 (0.49)
Far West	0.49 (0.95)	0.51 (0.05)	0.39 (0.88)	0.61 (0.12)	0.38 (0.88)	0.62 (0.12)	0.38 (0.88)	0.62 (0.12)

* Numbers in parenthesis are for cycle component ordered first in variance decomposition.

Table 7: Estimated Equations Explaining Variations in Trend and Cycle Components.

		OIL	BM	PMFG	PMILT	$\bar{R}^2$
New England	Cycle	0.0313***	0.0021**	0.7427*	-0.0112	0.79
	Trend	-0.0575***	-0.0042	0.1816**	-0.0058**	0.57
Mideast	Cycle	0.0086	-0.0002	-0.1225**	0.9687***	0.66
	Trend	-0.0385**	-0.0005	0.4862	-0.0573	0.41
Great Lakes	Cycle	0.0021***	0.0012	-0.1534	0.0701	0.39
	Trend	-0.0036	0.0005	0.1422	- 0.0299**	0.72
Plains	Cycle	0.0474	0.0018	0.7780	-1.2424***	0.25
	Trend	0.0403**	0.0015***	0.7397**	-0.4153	0.56
Southeast	Cycle	0.0157	0.0006	0.7772	0.4614	0.93
	Trend	-0.0001	0.0001*	-0.5494**	-0.2999***	0.48
Southwest	Cycle	0.0376	-0.0013	-0.0389	0.0626	0.49
	Trend	0.0212	-0.0007***	0.1321	-0.2050*	0.71
Far West	Cycle	-0.0632***	-0.0016***	-1.3154	0.6356	0.93
	Trend	0.0058	0.0001***	0.7390***	-0.4128	0.49

*, **, *** denotes significant at the 10 percent, 5 percent, and 1 percent levels respectively. H_0: Coefficients are jointly zero. OIL = relative price of fuels and related products; BM = narrative index of monetary policy; PMAN = manufacturing share of total regional income; PMILT = defense spending as a share of total regional income; and the dependent variable is either the relative (to the nation) " cycle" or relative "trend" components.

Figure 1.- Beveridge-Nelson and Gonzalo-Granger Cycles

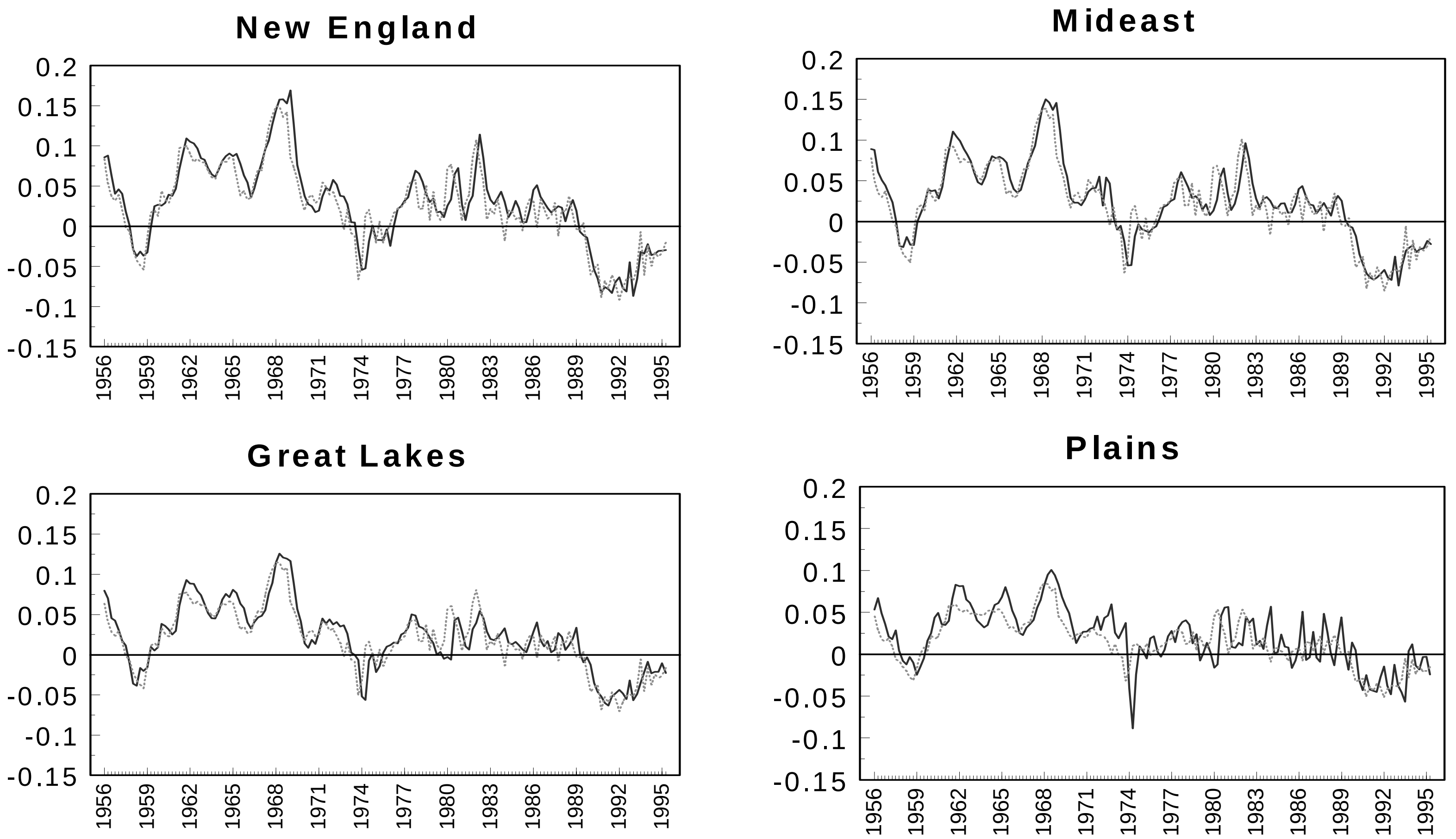
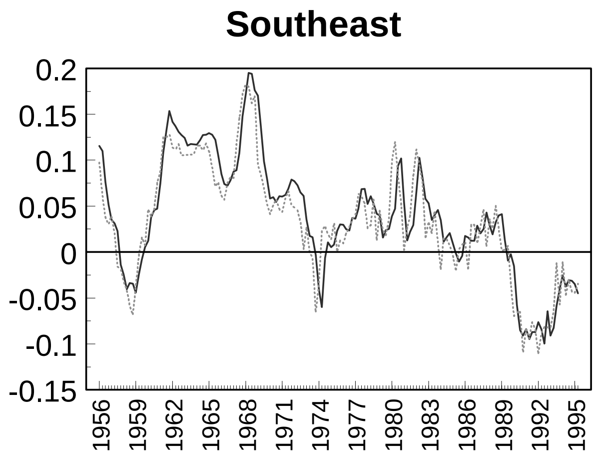
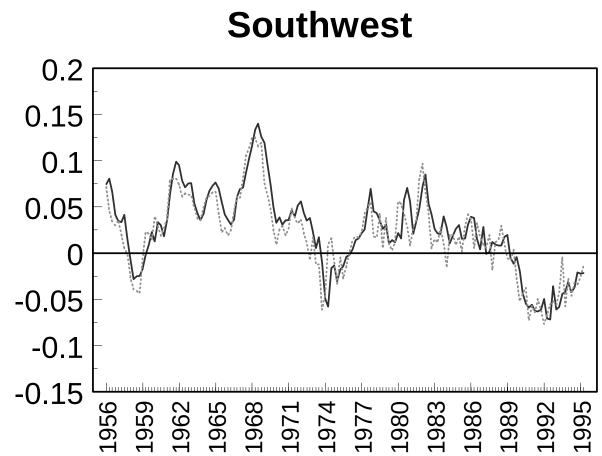
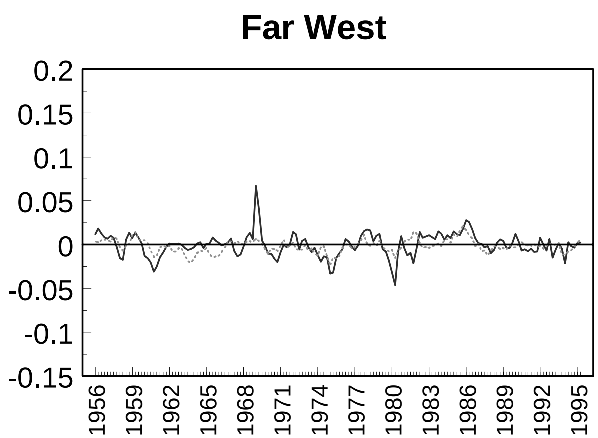


Figure 1a- Beveridge-Nelson and Gonzalo-Granger Cycles

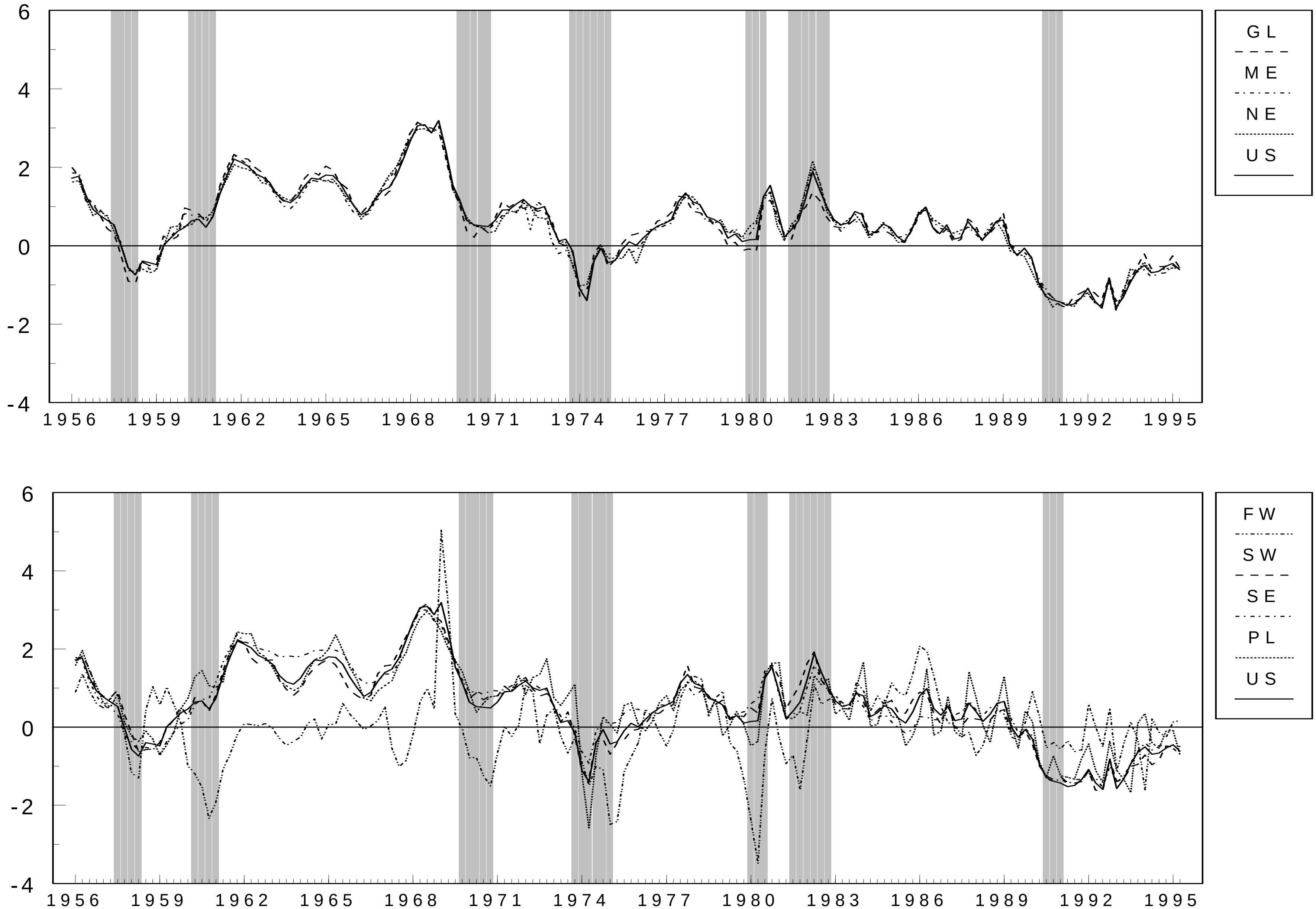






Note: The graphs show the cyclical component of log real regional per capita personal income. The solid line shows the Beveridge-Nelson cycle, and the dashed line shows the Gonzalo-Granger cycle.

Figure 2.- Standardized Cyclical Components of Regional Personal Income



Note: Each line represents the Beveridge-Nelson cyclical component of the log of real regional per capita personal income divided by its own standard deviation. The US represents the income weighted average of the regional cycles. The shaded bars correspond to the NBER reference dates.
NE = New England. ME = Mideast, GL = Great Lakes, PL = Plains, SE = Southeast, SW = Southwest, and FW = Far West.

Endnotes

1. Some studies have focused more narrowly on specific metropolitan areas. Studies by Coulson (1993) and Coulson and Rushen (1995) use VAR models of the economies of the Philadelphia (Coulson) and Boston (Coulson and Rushen) metropolitan areas to quantify national, industry-specific, and local influences. A number of other recent papers have looked at regional labor market dynamics [Blanchard and Katz (1992) and Davis, Loungani and Mahidhara (1997)].

2. See Appendix A for definitions of the regions.

3. The Beveridge-Nelson decomposition and Gonzalo-Granger decomposition are equivalent when the number of common cycles is equal to the cointegration rank of the system. See Proietti (1997) for details.

4. Both decompositions were calculated using Gauss code that implements the algorithm in Proietti (1997).

5. The trend and cycle components for the nation are weighted averages of trend and cycle estimates at the regional level. Each region's share of national real personal income is used as weights. The trend and cyclical components for the nation were also computed as unweighted averages of the regional trend and cyclical estimates. We found very little difference between the weighted and unweighted versions. We used the weighted average versions in this article.

6. The data in Table 4 were annualized to facilitate comparisons across recessions of different lengths.

7. Since it is debatable whether the 1980 and the 1981-82 recessions were one long recession, as opposed to two separate ones, we combined the 1980-82 period and report this as one recession at the bottom of each panel in Table 4.

8. The peaks and troughs of business cycles are dated by the National Bureau of Economic Research (NBER) by considering the comovement in many different economic indicators, such as gross

domestic product, industrial production, personal income, sales, employment, and unemployment. By looking at changes in a variety of economic variables, the NBER minimizes the chance of reaching an erroneous conclusion based on mismeasurement. Unfortunately, many of these indicators are not available on a monthly basis at the regional level. Therefore, it is not possible to date the peaks and troughs of business cycles at the regional level.

9. Beveridge and Nelson (1981), using national data, show that the Beveridge-Nelson cyclical component corresponds with the traditional NBER dating.

10. We elected to use the BM index instead of the fed funds rate since funds rate changes can have different interpretations depending on the operating procedure in place. Narrative approaches, such as the BM index, minimize these difficulties by attempting to identify monetary policy shocks by looking at evidence derived from the Federal Open Market Committee's policy directives. Another advantage of the BM index is that inflation expectation series, which are not available quarterly for 1956-95 and must be estimated, are not required to generate real interest rates.

11. Defense expenditure consists of prime contracts awarded by the Department of Defense and by the National Aeronautics and Space Administration. We thank Prakash Loungani for providing these data.

APPENDIX A
DEFINITIONS OF REGIONS

New England
- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island
- Vermont

Mideast
- Delaware
- District of Columbia
- Maryland
- New Jersey
- New York
- Pennsylvania

Great Lakes
- Illinois
- Indiana
- Michigan
- Ohio
- Wisconsin

Plains
- Iowa
- Kansas
- Minnesota
- Missouri
- Nebraska
- North Dakota
- South Dakota

Southeast
- Alabama
- Arkansas
- Florida
- Georgia
- Kentucky
- Louisiana
- Mississippi
- North Carolina
- South Carolina
- Tennessee
- Virginia
- West Virginia

Southwest
- Arizona
- New Mexico
- Oklahoma
- Texas

Far West
- California
- Nevada
- Oregon
- Washington

Rocky Mountain (Omitted)
- Colorado
- Idaho
- Montana
- Utah
- Wyoming