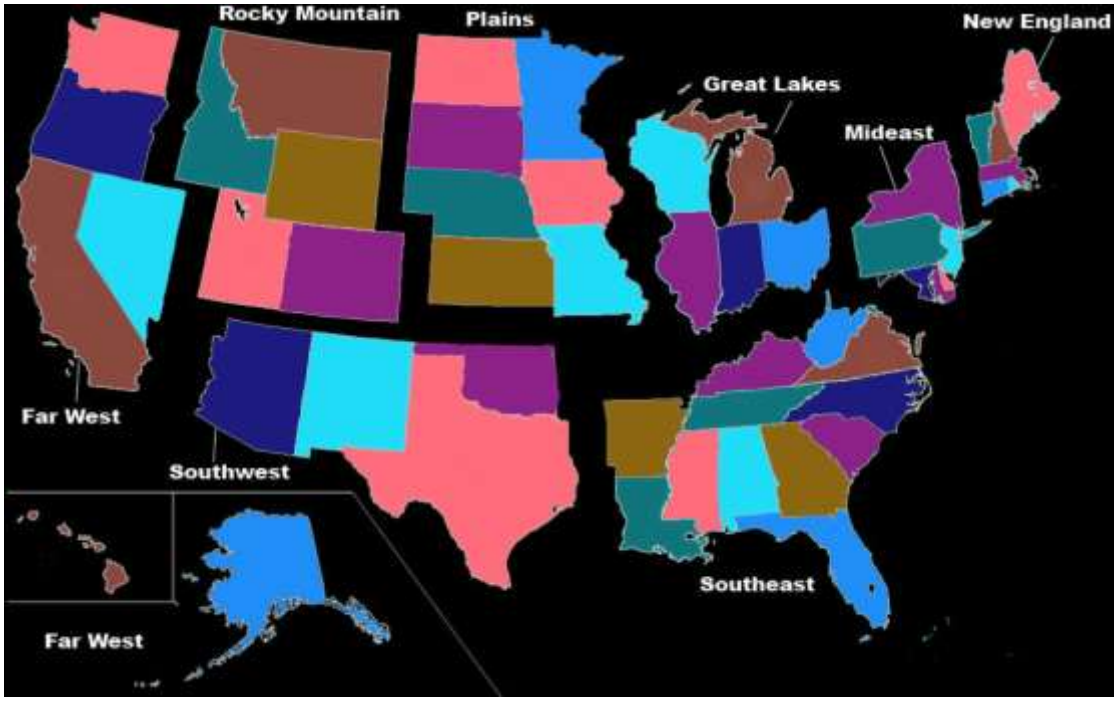


Regional Business Cycles In the United States

By Gary L. Shelley

Peer Reviewed

Dr. Gary L. Shelley (shelley@etsu.edu) is an Associate Professor of Economics, Department of Economics and Finance, East Tennessee State University.

Abstract

This paper uses a band-pass filter to identify business cycles falling into a frequency band of 6 to 32 quarters in the annualized growth rate of quarterly real personal

income in the United States and in each of the eight regions of the country as defined by the Bureau of Economic Analysis (BEA). Results for a time span from the third quarter of 1967 through the first quarter of 2017 indicate that the business cycle is well captured by the band-pass filter. Estimates also indicate that in general the business cycle within each geographical region is similar to the aggregate cycle. The strong similarity across regions of the 2007-2008 recession is consistent with a downturn caused by an aggregate shock. However, there are noticeable regional differences in the severity of the 1991 and 2001 recessions. The regional differences suggest that sectoral shocks also played a role in these recessions.

Introduction

Since the work of Burns and Mitchell (1946), the "business cycle" traditionally is defined as the cycle in real economic series falling into a frequency band of 1.5 to 8 years (6 to 32 quarters). This study uses the band-pass filter of Christiano and Fitzgerald (2003) to estimate the business cycle in quarterly real personal income growth in the United States and in each of the eight regions defined by the Bureau of Economic Analysis. Correlations between estimates of the aggregate cycle and each of the regional cycles are examined. In addition, the experiences of each region in the 1991, 2001, and 2008 recessions are examined to explore the degree to which these experiences were shared nationally.

One purpose of this study is to evaluate how well the band pass filter estimates the business cycle in national and regional real personal income growth. A second purpose is to compare regional business cycles to each other and to the national cycle. The band pass filter simplifies this comparison by removing both short term (high frequency) "noise" and long term (low frequency) cycles, leaving only the estimated business cycle for each series. If an estimated regional cycle substantially differs from the national and other regional cycles, then future research is needed to explore why the specific region was either more or less susceptible to cyclical shocks. In addition, comparison of the regional and national experiences may suggest whether each recession was caused by aggregate or by sectoral shocks. Similarity of the aggregate and regional downturns is consistent with an aggregate shock. However, difference in the severity of a recession across regions suggests that sectoral shock were a contributing factor.

Previous research, including Lilien (1982), and Long and Plosser (1987), found that a large part of aggregate fluctuations are due to sectoral shocks. Browne (1978), and Clark (1998) found that industry mix is an important determinant of cyclical performance. Shea (1996) provides evidence that industries sharing similar cyclical movements tend to aggregate spatially. For example, if similar industries tend to cluster with the southeast region, then the states within the region may share similar business cycles that differ substantially from those in other regions. The finding by Carlino and DeFina (1995) that the effects of monetary policy tend to vary by region also suggests that business cycles may differ across regions of the country.

Relatively few papers have estimated and compared business cycles for the regions of the United States. Carlino and Sill (2001) used the Beveridge-Nelson decomposition to estimate cycles for seven of the eight NBER regions with quarterly data from the first quarter of 1956 through the second quarter of 1995. At the time of their work, regional CPI's were not available. Therefore, they deflated the regional nominal personal income series using a weighted average of CPI's for the major metropolitan areas within a given region. They found a high degree of comovement between the regional cycles. The correlations of their estimated regional cycles with the aggregate US cycle were above 90% with the sole exception of the far western region (which had a correlation of only 35%).

The study by Carvalho and Harvey (2005) was mainly concerned with possible convergence of regional growth. However, they used unobserved components estimation to obtain estimates of the cycles in real per capita income for the eight NBER regions with annual data spanning the years 1950 to 1999. Recessions for all regions were highly coherent with the national cycle and closely approximated the NBER recession reference dates. However, a model imposing a single cycle across all regions was found to be too restrictive. In addition they found considerable differences in the volatility of the regional cycles.

This study differs in several ways from earlier papers in this line of research. First, estimates are based on quarterly data from the third quarter of 1967 through the first quarter of 2017. Secondly, personal income in each region is deflated using the regional CPI corresponding most closely to that region provided by the Bureau of Labor Statistics. Third, estimates of the business cycle are obtained using the band-pass filter of Christiano and Fitzgerald (2003).

Methodology

The band-pass filter of Christiano and Fitzgerald (CF filter) provides one way of estimating the cycle in a time series that falls into a frequency band of interest. Suppose that a researcher desires to examine the standard business cycle of 1.5-8 year frequency in a time series $\{x_t\}$. Christiano and Fitzgerald show that there exists an orthogonal decomposition:

$$x_t = y_t + \tilde{x}_t \ .$$

The y_t component is the series of interest and has power only in the business cycle frequencies while the $\tilde{x}_t$ component has no power in these frequencies. The finite-length CF filter minimizes the mean squared error (MSE) between the filtered series and the series filtered by an ideal band pass filter. That is, the CF band pass perfectly separates out components (y_t) driven by stochastic cycles at the specified periodicities.

The CF filter offers several advantages over alternative measures. Everts (2006) finds that the CF filter produces more accurate estimates of low frequency cycles than

does the competing BK filter of Baxter and King (1999). In addition, unlike the BK filter, the CF filter estimates cycles for the full data sample. The HP filter, by Hodrick and Prescott (1997), is not as useful for this study because it is strictly a high-pass filter, intended to remove low frequency components of a time series leaving only a high frequency component. If the HP filter were used, then short term noise with a frequency of less than 1.5 years would remain in the "filtered" series. Thus, the HP filtered series would not be an estimate of the "business cycle" as defined above.

In this paper, a business cycle of 6-32 quarters is estimated for the annualized growth rate of real personal income in the United States and in each of the eight regions. The RATS (Regression Analysis of Tme Series) software package is used to obtain the CF filtered series. A researcher can obtain the same results using the asymmetric version of the CF filter available in EVIEWS.

Both the augmented Dickey-Fuller (ADF) test of Dickey and Fuller (1979) as well as the KPSS test of Kwiatkowski, Phillips, Schmidt, and Shin (1992) are applied to each series prior to estimation. An intercept is included in the ADF test equations, and the augmenting lag length is selected using the Schwarz Information Criterion (SIC). The KPSS test equations includes an intercept and Newey-West estimated standard errors. As can be seen in Table One below, the ADF tests reject the null hypothesis of a unit root and the KPSS tests failed to reject stationarity for each series. These results allow implementation of the version of the CF filter that assumes stationary series.

Table One
Real Personal Income Growth
ADF and KPSS Test Results

Series	ADF Test Statistic	ADF p-value	KPSS Test Statistic	KPSS 5% Critical Value
United States	-7.34	0.0000	0.1663	0.4630
New England	-7.43	0.0000	0.1076	0.4630
Mideast	-14.06	0.0000	0.0534	0.4630
Great Lakes	-12.50	0.0000	0.0916	0.4630
Southeast	-5.57	0.0000	0.4519	.0.4630
Plains	-13.03	0.0000	0.0829	0.4630
Southwest	-11.82	0.0000	0.4217	0.4630
Rocky Mountain	-12.39	0.0000	0.2667	0.4630
Far West	-12.51	0.0000	0.2038	0.4630

Comparison of National and Regional Cycles

Personal income data for the US and its eight regions are available from the Bureau of Economic Analysis. These series are listed as part of the SQ1 data set at BEA.gov. The eight regions are: New England, Mideast, Great Lakes, Southeast, Plains, Southwest, Rocky Mountain, and Far West. Aggregate personal income is deflated by

the CPI for all urban consumers. The regional nominal personal income figures are deflated by regional CPI's calculated by the Bureau of Labor Statistics (BLS). The BLS provides four regional CPI's: the Northeast, Midwest, South, and West. Personal income for New England and Mideast are deflated using the Northeast CPI. Great Lakes and Plains incomes are deflated by the Midwest CPI. Southeast personal income is deflated by the South CPI. Southwest, Rocky Mountain, and Far West incomes are deflated by the West CPI. This study obtained the four regional CPI series from the FRED database of the Federal Reserve Bank of Saint Louis (fred.stlouisfed.org). The inputs in the CF filter are the annualized growth rates (4 times the percentage change from the previous quarter) of the real personal income series. All growth rate series are quarterly and span the period from the third quarter of 1967 through the first quarter of 2017.

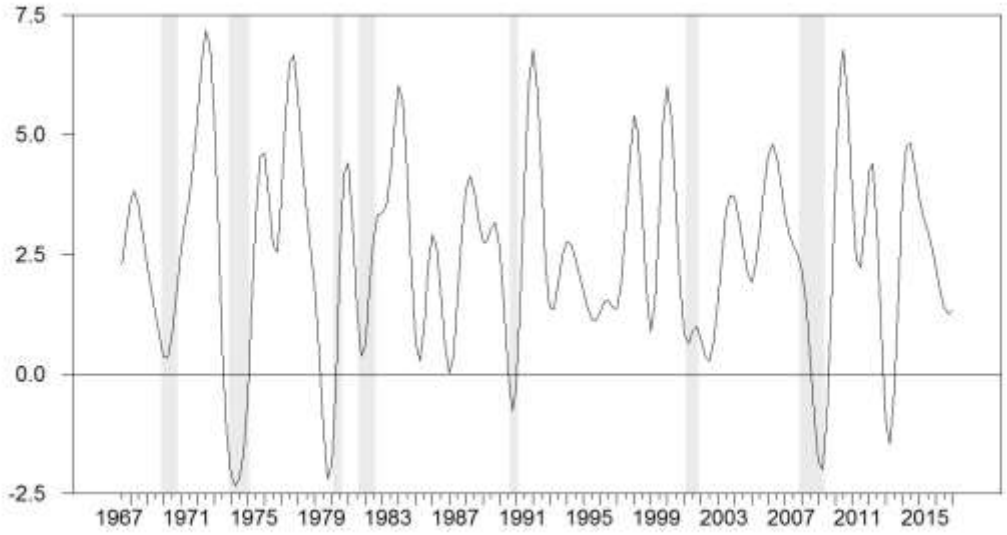
As shown in Table Two below, the mean of annualized quarterly growth in U.S. real personal income was 2.49% with a standard deviation of 3.44% over this sample period. Average annualized regional real personal income growth ranged from a low of 1.80% in the Great Lakes region to a high of 3.50% in the Southwest. Annualized growth was lower than the national average in the New England, Mideast, Great Lakes, and Plains regions. Annualized growth was greater than the national average in the Southeast, Southwest, Rocky Mountain, and Far West regions. The standard deviation of real personal income growth ranged from a low of 3.80% in the MidEast region to a high of 5.39% in the Plains region. The standard deviation of real personal income growth was lower for the national economy than for any of the individual regions.

Table Two
Real Personal Income Growth
Means and Standard Deviations

	United States	New England	MidEast	Great Lakes	Southeast
Mean	2.49	2.21	1.83	1.80	3.09
Std. Dev.	3.44	3.94	3.80	4.26	3.99
		Plains	Southwest	Rocky Mountain	Far West
Mean		2.30	3.50	3.36	2.88
Std. Dev.		5.39	4.41	4.71	4.08

The 6-32 quarter CF filtered cycle in U.S. real GDP growth is shown in Figure 1 below. Shaded areas correspond to NBER business cycle reference dates. Note the close correspondence between negative values of the CF filtered business cycle and the reference dates. It appears that the business cycle in U.S. real personal income is captured well by the CF filter with cycles in the frequency band of 6 to 32 quarters. One exception is that there is a very noticeable downturn in national real personal income growth in 2013. This downturn also appears in the eight regional cycles. However, there was no national recession in 2013.

Figure One
Estimated Business Cycle in
United States Real Personal Income Growth



New England real personal income grew at an annualized quarterly rate of 2.21%, slightly less than that for the country as a whole. Volatility of real income growth was higher than that for the nation as indicated by a standard deviation of 3.94%. The estimated business cycle in New England real personal income is displayed (together with the national cycle) in Figure Two below. In Figure Two and in following Figures Three through Nine, the estimated regional business cycle in real personal income growth is displayed as a solid line, and for comparison the estimated national cycle is included as a dashed line. The correlation between the New England and U.S. cycle, presented in Table Three shown below Figure Two is 0.84. Although the New England business cycle appears similar to the national cycle, there are some noticeable differences. New England appears to have experienced more severe cyclical downturns in the recessions of 1991 and 2001 than the nation. However, New England real personal income appears to have experienced a less severe downturn than the aggregate U.S. during the 2008 recession. Unlike the aggregate U.S., New England experienced negative growth in its income cycle in both 1985 and in 1996.

Figure Two
Estimated Business Cycle in
New England Real Personal Income Growth

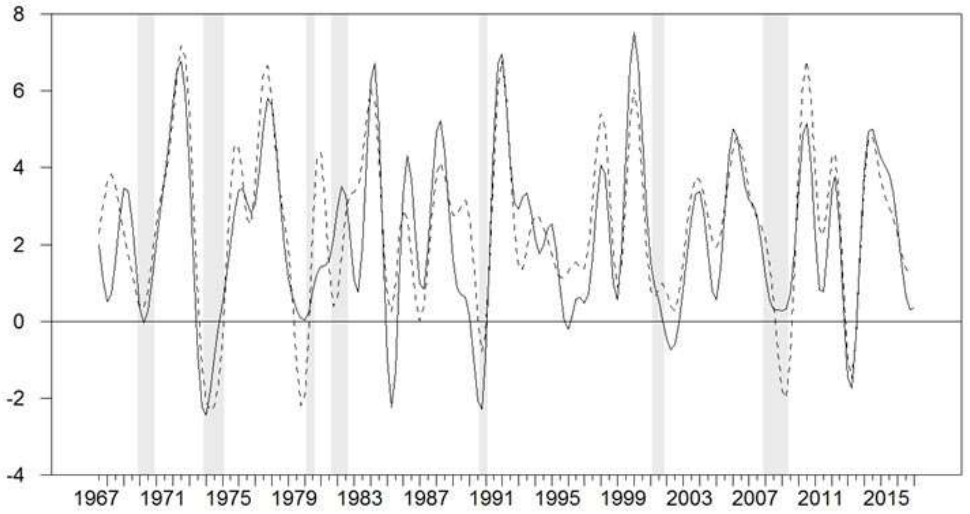
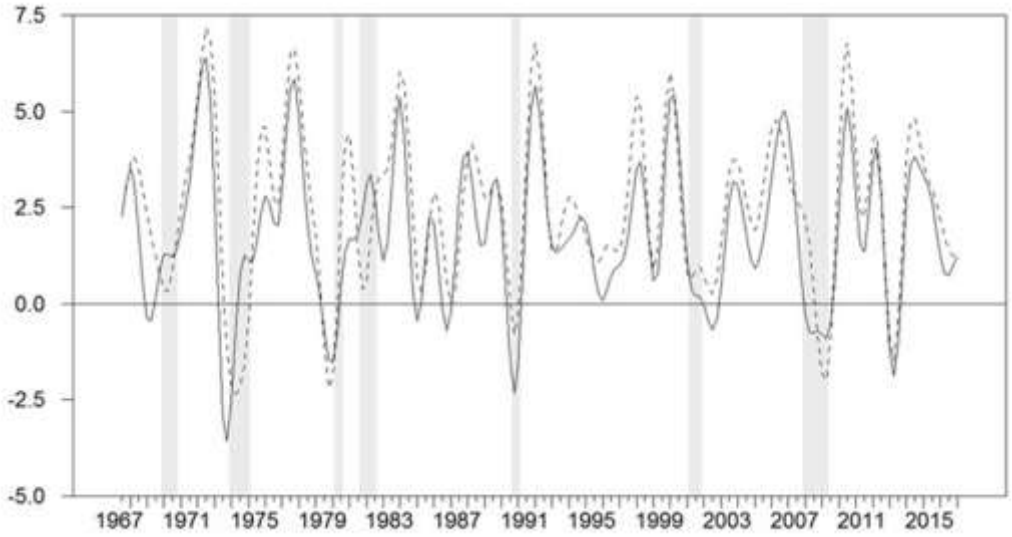


Table Three
Correlations between Estimated Aggregate
and Regional Business Cycles

	New England	Mideast	Great Lakes	Southeast	Plains	Southwest	Rocky Mountain	Far West
United States	0.84	0.87	0.94	0.96	0.82	0.82	0.87	0.88

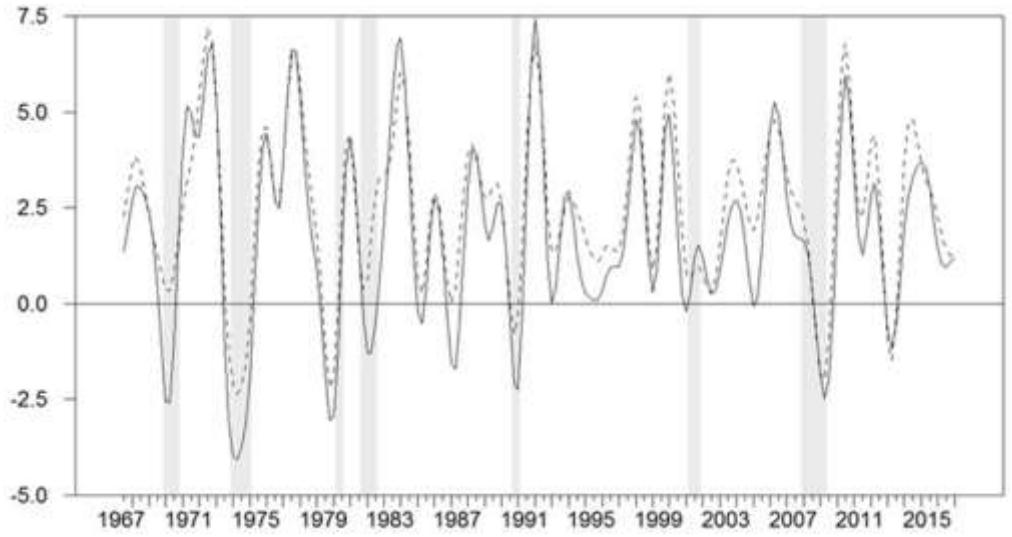
Real personal income growth in the Mideast region averaged 1.83% with a standard deviation of 3.80%. This was the second lowest average growth among the eight regions. Examination of the plotted business cycle for the Mideast and the U.S. in Figure Three below shows that the region experienced similar cycles. This is reflected by a correlation of 0.87 between the Mideast and national cycles. Examination of the plotted cycles shows that the Mideast, similar to New England, suffered more severe downturns than the nation in both the 1991 and 2001 recessions. The downturn in the Mideast cycle in 2008 is similar to the national cycle. Like New England, the Mideast experienced negative downturns in its cycle in the mid-1980's that did not reach negative values in the national cycle.

Figure Three
Estimated Business Cycle in
Mideast Real Personal Income Growth



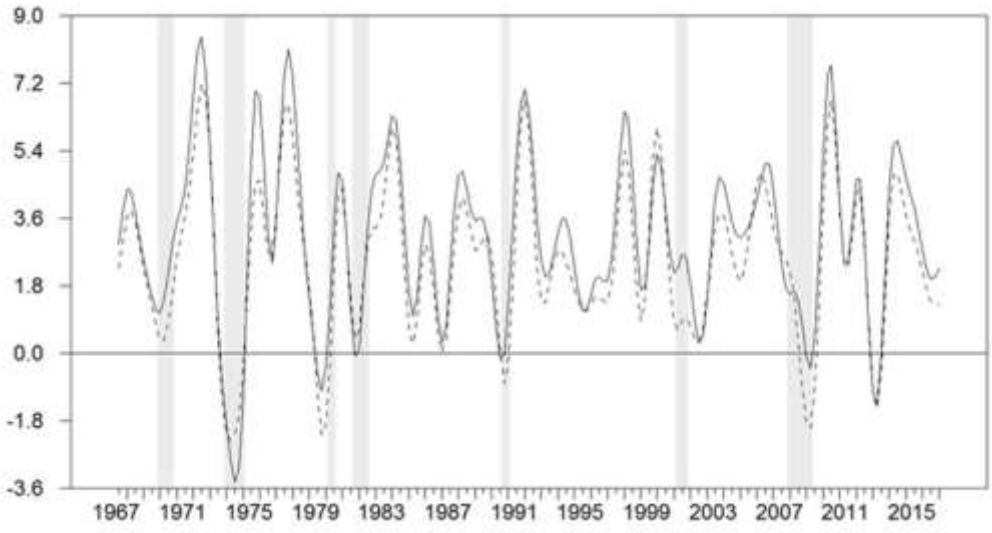
The Great Lakes region experienced average growth in real personal income of 1.80% with a standard deviation of 4.26%. This is the lowest average regional growth rate. As demonstrated in Figure Four below, the cyclical pattern is very similar to the aggregate U.S. The correlation between real person income growth cycles in the Great Lakes region and the U.S. is 0.94. The cyclical downturn in Great Lakes real personal income is similar to that of the U.S. in the 2001 and 2008 recessions. However, like New England, the Great Lakes experienced a more severe downturn in the 1991 recession. Also similar to New England and the Mideast, the cycle in Great Lakes real personal income growth reached negative values in the mid-1980's.

Figure 4
Estimated Business Cycle in
Great Lakes Real Personal Income Growth



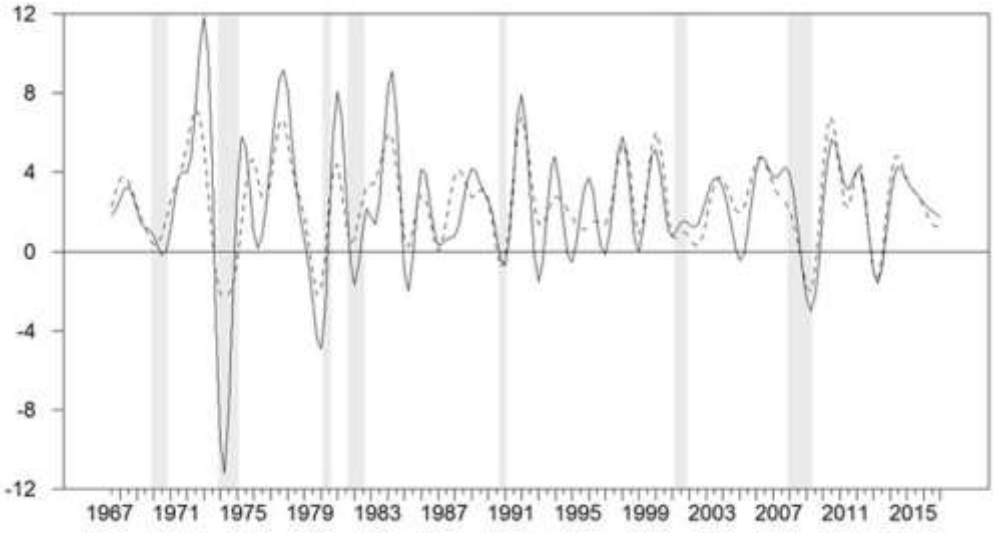
Southeastern average growth in real personal income exceeded that of the U.S. with a rate of 3.09% and was somewhat more volatile with a standard deviation of 3.99%. The correlation between the two cycles is 0.96. Figure Five below shows that the region experienced cyclical downturns at approximately the same time as the U.S. However, the Southeast appears to have experienced a slightly more moderate downturn than the aggregate U.S. in 1991 and a much less severe downturn in 2008. In addition, the cycle in Southeast personal income growth turns down, but does not reach negative values in the 2001 recession.

Figure Five
Estimated Business Cycle in
Southeast Real Personal Income Growth



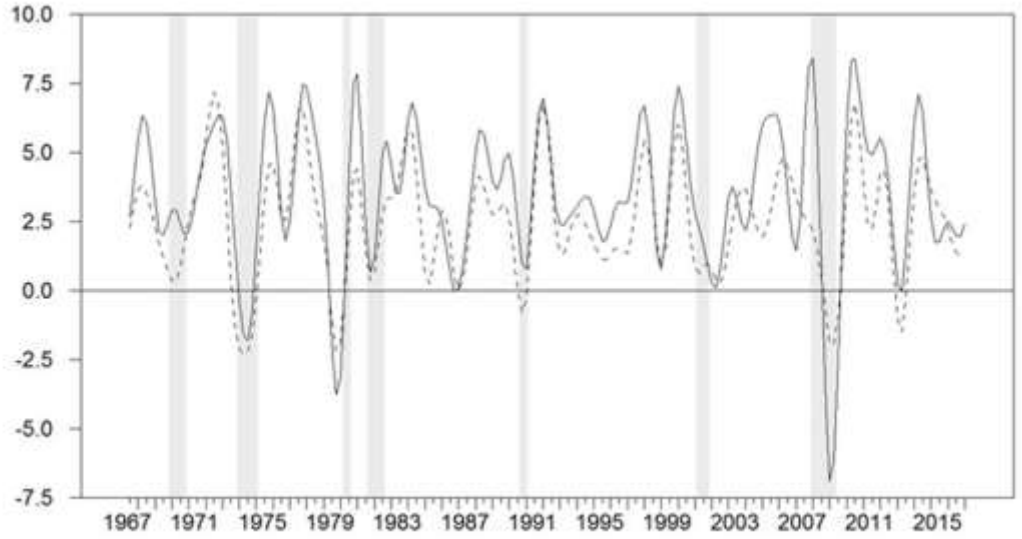
The Plains region averaged 2.30% growth in real personal income over this sample. Real income growth in the Plains was the most volatile of all the regions with a standard deviation of 5.39%. The correlation between the Plains and national cycles is 0.82. The Plains and US cycles are displayed in Figure Six below. The Plains appears to have suffered more severe drops in real income during the 1974, 1980, and 1982 recessions than the overall US. The downturns in the Plains cycle in 1991, 2001, and 2008 appear similar to the national cycle. There are cyclical downturns in Plains real income growth around 1985 and in 2005 that do not appear in the national cycle. In addition, the estimated Plains business cycle is noticeably more volatile than the national cycle in the 1990's.

Figure Six
Estimated Business Cycle in
Plains Real Personal Income Growth



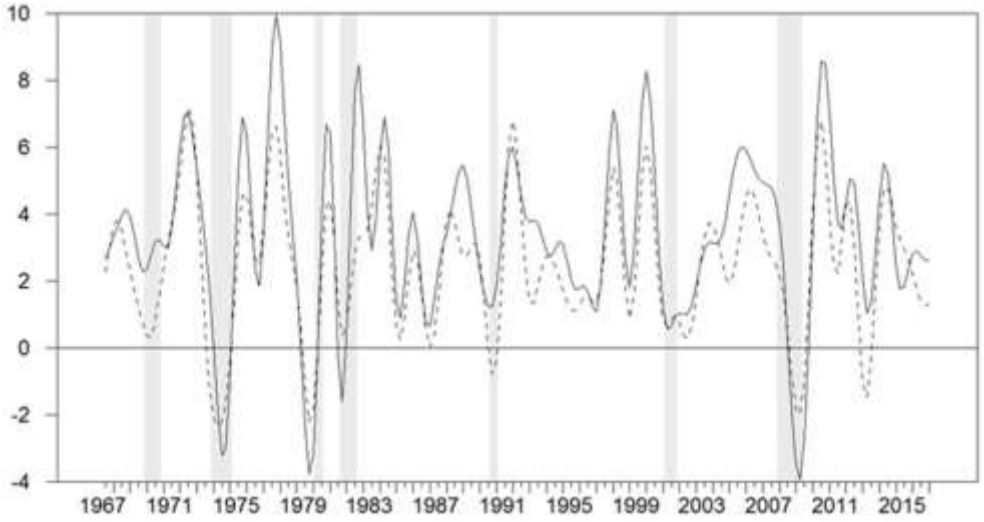
Average growth in real personal income in the Southwest was 3.50%, the highest among the eight regions. The standard deviation was 4.41%. The correlation between the Southwest and US business cycles is 0.82. The plotted business cycles, shown in Figure Seven below, display a similar overall pattern. However, there are differences in the severity of the Southwest and national cycles in specific recessions. Although the Southwest and nation experienced similar downturns in the 2001 recession, the Southwest cycle displays a more severe downturn during the 2008 recession. In contrast, the Southwest cycle does not turn negative during the 1991 recession.

Figure Seven
Estimated Business Cycle in
Southwest Real Personal Income Growth



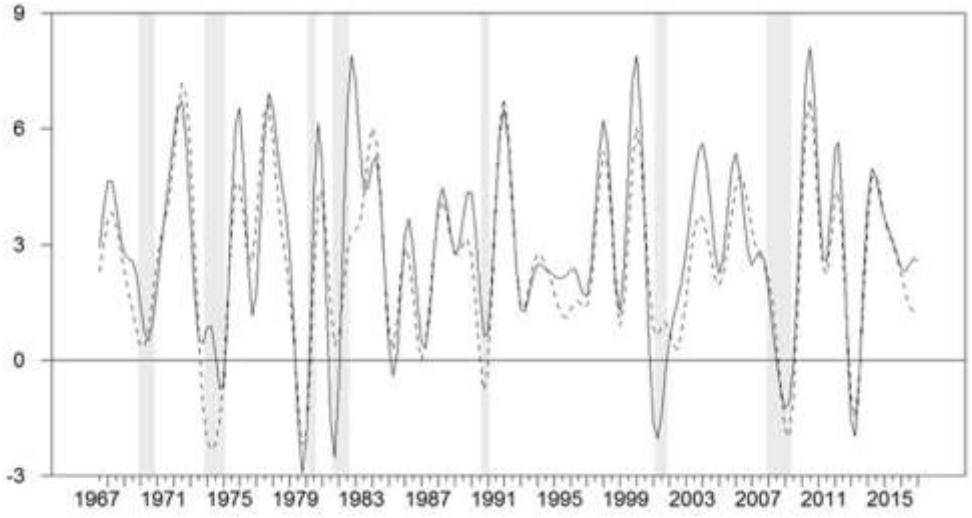
The Rocky Mountain region realized an average growth rate of real personal income of 3.36%, the second highest among the eight regions. The standard deviation of real income growth was 4.71%, also the second highest among the regions. The estimated business cycle in Rocky Mountain real personal income growth is shown with the national cycle in Figure Eight below. The correlation between the Rocky Mountain and national cycles is 0.87. The Rocky Mountain region experienced a downturn in 2001 that was very similar that that in the aggregate series. Unlike the national cycle, the Rocky Mountain downturn in 1991 did not turn negative. However, the Rocky Mountain region experienced a downturn in 2008 that was more severe than that in national real personal income growth.

Figure Eight
Estimated Business Cycle in
Rocky Mountain Real Personal Income Growth



Real personal income in the Far West region grew at an average rate of 2.88% with a standard deviation of 4.08%. The estimated Far West and US business cycles are presented in Figure Nine below. The correlation between these two cycles is 0.88. The decline in the Far West cycle is very similar to that for the nation in 2008. The downturn in the Far West cycle did not become negative in the 1991 recession. However, the Far West experienced a more severe downturn in its cycle during the 2001 recession than the US as a whole. Similar to New England, the Mideast, and the Great Lakes, the Far West experienced a negative cyclical downturn in the mid-1980's that was not experienced nationally.

Figure Nine
Estimated Business Cycle in
Far West Real Personal Income Growth



The Three Most Recent Recessions

The national economy experienced a downturn in real personal income growth that slightly reached negative values in the 1991 recession. A comparison of the eight regions shows that this recession was accompanied by downturns and resulting negative values in the estimated real personal income cycles of the New England, Mideast, Great Lakes, and Plains regions. This suggests that this recession was most severely experienced in these regions. The estimated cycles for the other four regions experienced downturns, but did not reach negative values during this recession. This suggests that regional or sectoral shocks may have been important in this recession.

The estimated aggregate business cycle in real personal income growth turned down but did not reach negative values in the 2001 recession. Only the estimated business cycles for the New England, Mideast, and Far West regions became negative. Estimated cycles for the Great Lakes, Plains, Southwest, and Rocky Mountain regions experience downturns similar to that in the national cycle. The downturn in the Southeast cycle did not approach that of the national cycle. This suggests that regional characteristics, particularly those of the New England, Mideast, and Far West economies may have been strong influences on this recession.

Estimated business cycles in real personal income growth have downturns reaching negative values for the US and for seven regions in the 2008 recession. There was a large downturn in the New England cycle but it did not become negative. This is

consistent with effects of an aggregate shock. The downturns were most severe, surpassing the national downturn, in the Southwest and Rocky Mountain regions. Downturns reached negative values in the New England and Southeast regions but were less severe than in the nation as a whole.

Conclusion

This study estimated and analyzed band-pass filtered business cycles in real personal income for the United States and the eight regions defined by the Bureau of Economic Analysis. Results demonstrate that filtered national and regional cycles falling into the traditional 6-32 quarter business cycle range correspond well to NBER business cycle reference points. Thus, it appears that the CF band pass filter performs well in identifying the business cycle in these series.

High correlations between the estimated national and regional cycles suggest that no region is either overly susceptible to or insulated from the national cycle. With exception of New England, all regions experienced cyclical downturns in real personal income growth reaching negative values in the 2008 recession. This finding is consistent with an aggregate shock during this recession. However, there are noticeable differences in the cyclical experience of the regions during the 1991 and 2001 recessions. The cyclical downturn in the 1991 recession reached negative values only in the estimated cycles of the New England, Mideast, Great Lakes, and Plains regions. Similarly, only the estimated cycles for the New England, Mideast, and Far West regions became negative during the 2001 recession. These observations suggest that regional economic characteristics may have played important roles in both 1991 and 2001. In addition, there are regional negative downturns not observed nationally in the mid-1980's (New England, the Mideast, the Great Lakes, and the Far West), in 1996 (New England), and in 2005 (the Plains) that should be explored further. Finally, the Plains region experienced more cyclical volatility during the 1990's than was experienced either nationally or in the other regions.

References

Baxter, M., and King, R. (1999), Measuring business cycles: approximate band-pass filters for economic time series, *The Review of Economics and Statistics* 81, 575-593.

Browne, L. (1978), Regional industry mix and the business cycle, *New England Economic Review* (November-December), 35-53.

Burns, A.F., and Mitchell, W.C. (1946), *Measuring Business Cycles***,** National Bureau of Economic Research, New York.

Carlino, G. and DeFina, R. (1995), Regional income dynamics, *Journal of Urban Economics* 37(1), 88-106.

Carlino, C. and Sill, K (2001), Regional income fluctuations: common trends and common cycles, *The Review of Economics and Statistics* 83(3), 446-456.

Carvalho, V. and Harvey, A (2005), Growth, cycles and convergence in US regional time series, *International Journal of Forecasting* 21, 667-686.
Christiano, J., and Fitzgerald, T. (2003), The band pass filter, *International Economic Review* 44(2), 435-465.
Clark, T. (1998), Employment fluctuations in the US regions and industries: the roles of national, region-specific, and industry-specific shocks, *Journal of Labor Economics* 16(1), 202-229.
Dickey, A., and Fuller, W. (1979), Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association* 74, 427-431.
Everts, M (2006), Band-pass filters, unpublished working paper, Munich Personal RePEc Archive, paper #2049.
Hodrick, R., and Prescott, E. (1997), Postwar business cycles: an empirical investigation, *Journal of Money, Credit, and Banking* 29, 1-16.
Kwiatkowski, D., Phillips, P., Schmidt, P., and Shin, Y. (1992), Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economics time series have a unit root?, *Journal of Econometrics* 54, 159-178.
Lilien, D. (1982), Sectoral shifts and cyclical unemployment, *Journal of Political Economy* 90(4), 777-793.
Long, J. and Plosser, C. (1987), Sectoral versus aggregate shocks in the business cycle, *American Economic Review* 77(2), 333-336.
Shea, J. (1996), Comovement in cities, *Carnegie-Rochester Conference on Public Policy* 44, 169-206.