# Are U.S. and Seventh District business cycles alike?

**Michael A. Kouparitsas and Daisuke J. Nakajima**

## Introduction and summary

When academic economists talk about business cycles, they have something more general in mind than persistent fluctuations of gross domestic product (GDP) about its trend, which is the definition typically used by business economists. For an academic economist, the business cycle describes the way that cyclical fluctuations of GDP typically relate to cyclical fluctuations of other economic time series (such as consumption and investment) from the same economy. One of the most striking findings of the vast academic business cycle literature is that irrespective of the time period or particular country, business cycles are all alike. This means that the typical relationship between cyclical fluctuations of GDP and cyclical fluctuations of other economic time series of the U.S. economy is similar to the typical relationship between cyclical fluctuations of the same time series in all other market-based economies. As Lucas (1977) notes, this finding is both important and challenging for the study of business cycles, since it suggests the possibility of a unified explanation of business cycles based on general laws governing market economies.

So, we know that national business cycles are alike in important ways. What do we know about subnational business cycles? Given that subnational economies, such as those of U.S. states, are as large as some national economies, one would expect their business cycles to have been well studied. In contrast to national business cycles, little is known about subnational business cycles. The goal of this article is to expand our knowledge of subnational business cycles by testing whether the proposition that all business cycles are alike extends to U.S. states. We limit our analysis to the business cycles of the U.S. and the five states (Iowa, Illinois, Indiana, Michigan, and Wisconsin) of the U.S. Federal Reserve's Seventh District, home of the Federal Reserve Bank of Chicago.[1]

Our approach follows that of international business cycle studies, such as Backus and Kehoe (1992), by conducting a detailed analysis of the way in which activities within a regional economy relate to the region's aggregate business cycle and the way in which regional aggregate business cycles relate to one another. The main limitation on subnational business cycle research stems from a deficiency of state-level data analogous to the national income and product accounts data that are typically used in the analysis of national business cycles. We overcome this problem by finding suitable state-level proxies for national account aggregates (please see the appendix for further details). Consumption expenditure is proxied by real retail sales taxes, investment is proxied by the number of residential home sales and housing permits, while output is proxied by real personal income, various measures of labor input (including nonfarm payroll employment and average manufacturing hours) and capital utilization. One of the byproducts of this analysis is that we uncover new leading variables that could serve as useful indicators of the future direction of District state business cycles.

We find that District state business cycles are like the national business cycle along a number of dimensions. Turning to the within-region analysis, which explores the way activities within a regional economy relate to the region's aggregate business cycle, we find that state-level analogues of consumption and

*Michael A. Kouparitsas is an economist and Daisuke J. Nakajima is an associate economist in the Economic Research Department at the Federal Reserve Bank of Chicago.* *The authors thank Richard Kaglic for the suggestion of this topic and many useful discussions in the early stages of this article; Craig Furfine, François Velde, and Jonas Fisher for their comments and suggestions on an earlier draft; and, above all, Alexei Zelenev for his insightful comments and perseverance in assembling the data used in this article.*

residential investment have similar business cycle characteristics to their national counterparts. Moreover, they tend to be strong leading indicators of the national and state business cycles. Our labor market analysis yields much stronger results. Here, we find that the business cycle characteristics of national and state-level measures of labor market activity are virtually identical, especially with regard to whether they are procyclical or countercyclical, as well as leading or lagging.

A similar conclusion emerges from the across-region analysis, which explores the way in which regional aggregate business cycles relate to one another. We find that irrespective of the data source for measuring aggregate business cycles (we consider real personal income and nonfarm payroll employment), national and state-level business cycles are highly correlated at zero leads and lags. For Michigan and Indiana, there is weak evidence that the business cycles of these states lead the national business cycle by one quarter. It is fair to say based on these statistics that the District state business cycles are well described by the national business cycle. We conjecture that the high correlations are the result of important common shocks that affect both the national and regional business cycles.

These results are important not only for the study of business cycles, but also for the conduct of monetary policy. Mundell (1961) and others have argued that under certain conditions two or more economies may be better off if they abandon their individual monetary policies and pursue a common monetary policy with a common currency. The key provision governing which economies should form a single so-called optimal currency area (OCA) is the extent to which they have similar business cycles. If two or more economies have similar business cycles, then a common monetary policy for them is optimal. Our results suggest that the U.S. and the Seventh District clearly fit Mundell's notion of a single OCA, which suggests that optimal monetary policy for the U.S. is also the optimal monetary policy for the Seventh District and the District states.

## Brief literature review

Researchers have pursued a number of different avenues to overcome the apparent lack of an aggregate monthly or quarterly measure of state-level economic activity. A popular approach constructs composite indexes of regional activity from a set of disaggregate measures of state economies released on a monthly or quarterly basis. Crone and Clayton-Matthews (2005) use Stock and Watson's (1989) coincident indicator method to derive consistent coincident indexes for all 50 U.S. states. Their indexes rely exclusively on state-level labor market data, including total nonfarm payroll employment, average weekly hours in manufacturing, the unemployment rate, and real labor income. Crone and Clayton-Matthews do not explore the business cycle aspects of their coincident indicators. However, their approach follows earlier work by Orr, Rich, and Rosen (1999), which focuses on New Jersey and New York. One of the findings of this study is that while the amplitudes of the coincident index and nonfarm payroll employment differ, they have identical business cycle turning points. This suggests that one could rely solely on the nonfarm payroll employment series to identify the start and end dates of New Jersey and New York state business cycles. A similar picture emerges from the closely related study by Clayton-Matthews and Stock (1998–99), which constructs similar coincident indicators for Massachusetts. In this more ambitious study, the authors estimate a coincident index using data on state taxes and labor market indicators. As in the other study on New Jersey and New York state business cycles, dating the Massachusetts business cycle from the estimated coincident index yields the same turning points as using only the nonfarm payroll employment of the state. Based on these studies, we conclude that there are reliable high frequency indicators of aggregate state activity, such as nonfarm payroll employment, which can be used to identify state business cycles.

Other researchers have arrived at a similar conclusion about regional measures of economic activity and have gone on to explore the relationship between subnational and national business cycles in a variety of ways. Some examples of these business cycle analyses include Owyang, Piger, and Wall (2005), Kouparitsas (2002), and Hess and Shin (1998). Owyang, Piger, and Wall (2005) explore the synchronicity of business cycle phases for all 50 states. Their approach to identifying business cycles is fundamentally different to the method used in this article. They adopt a statistical method that identifies cyclical components of the state data, which is consistent with the approach used by the National Bureau of Economic Research (NBER) to date business cycles. The NBER rule-based approach to identifying expansions and contractions often yields different business cycle characteristics to the cyclical estimates identified using the statistical methods that we apply in this article. Despite these methodological differences, Owyang, Piger, and Wall find, as we do, that the business cycles of the five Seventh District states (Illinois, Indiana, Iowa, Michigan, and

Wisconsin) are closely related to the U.S. national business cycle.[2] Kouparitsas (2002) also explores the synchronicity of U.S. regional business cycles. The analysis is limited to the eight U.S. Bureau of Economic Analysis regions. Using an observed component technique, the study finds that while economic fluctuations of these economies are similar at business cycle frequencies, they are quite different at lower frequencies due to the different industry mix of each region. Hess and Shin (1998) is the most closely related study. They use a similar approach to the one used in this article for their study of the business cycles of nine U.S. Census regions and 13 U.S. states. Their results, however, are not directly comparable to ours, since they focus on annual data and report mean statistics across the 22 regions used in their study.

## Methodology

Our approach follows the macroeconomic business cycle literature by assuming that the data can be broken down into three distinct parts: a trend component, which captures permanent changes in the data series; a cyclical component, which captures persistent temporary deviations from the trend; and a high frequency component, typically referred to as noise, which is uninformative about the cyclical or trend components. Although it is possible that innovations to the trend and cyclical components are common, business cycle studies typically assume that these components are driven by independent innovations, which allow them to ignore the trend properties of the data.

A common misconception is that the cyclical component of any aggregate time series is a measure of the aggregate business cycle. This is only true for broad indicators of economic activity, such as GDP and gross national product (GNP). To see this we need to review Burns and Mitchell's (1946) classic definition of business cycles, which describes them as "expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals."[3] Although this definition is somewhat vague, Burns and Mitchell were quite specific about the data that should be used to measure the aggregate business cycle.[4] They recommended that the aggregate business cycle be measured as the cyclical component of the broadest measure of activity, in particular GNP. However, they were quick to add that estimates of GNP on a quarterly and monthly basis were at that time in the experimental stage, which led to their recommendation that aggregate business cycles be measured by isolating common cyclical components from a wide set of variables measured at monthly or quarterly intervals. We now have timely quarterly measures of aggregate economic activity, especially at the national level, so we can measure Burns and Mitchell's definition of the aggregate business cycle by extracting the cyclical component of a broad measure of activity, such as quarterly GNP.[5]

As discussed earlier, District states have a limited number of broad indicators of aggregate state-level activity. The most obvious choice is the state equivalent of GDP: gross state product (GSP). However, GSP arrives with a considerable lag of up to two years and is only available at an annual frequency. The alternatives are total personal income and total nonfarm payroll employment, which are published at quarterly and monthly intervals, respectively. Both measures have been used in the study of regional economic fluctuations. For brevity's sake and in keeping with the recommended approach of Burns and Mitchell (1946)—that is, to use the broadest measure of regional income to measure business cycles—we limit our discussion in this article to aggregate business cycles described by total personal income. However, we did explore the behavior of District state business cycles using both these measures of aggregate regional activity. After controlling for the fact that employment is a lagging indicator, we found that there was very little difference between aggregate business cycles described by personal income and nonfarm employment.[6]

### *Summarizing business cycles*

We follow the macroeconomic business cycle literature by summarizing regional business cycles along three dimensions: comovement, persistence, and volatility.

Comovement reflects the extent to which the cyclical component of an activity within a region, comprising several states, is correlated with the region's aggregate business cycle. If the correlation of a cyclical component of an activity with the region's aggregate business cycle is close to one, the activity is procyclical, which implies the within-region activity has similar cyclical peaks and troughs to the region's aggregate business cycle. It also means that the idiosyncratic component of the cyclical component of the within-state activity is small. Alternatively, if the correlation is close to minus one, this also implies the idiosyncratic component of the state activity is small, but now the activity is countercyclical, suggesting that a peak for one series is synchronized with a trough for the other.

Correlations can also be used to identify whether a within-region activity leads or lags the region's business cycle. We do this by plotting the cross-correlation function of the region's business cycle and the cycle of the within-region activity, which is the sequence of correlations of the region's aggregate business cycle at time $t$ with the cycle of the within-region activity at time $t - j$ over a range of $j$. We limit our analysis to leads and lags of up to two years. If the maximum absolute correlation occurs at time $k > 0$, this implies the within-region activity is a leading indicator of the region's aggregate business cycle. If the maximum occurs at $j = 0$, the activity is called a coincident indicator. Otherwise the activity is a lagging indicator. Most cases we explore have a U-shape or an inverted U-shape cross-correlation function, where the single trough or peak identifies the lead or lag. In some instances, the cross-correlation functions take on a horizontal S-shape or a horizontal Z-shape. We identify the lead or lag in those cases as the maximum of the absolute value of the peak and trough.

The persistence of the cyclical component of an activity within a region reflects the size of the correlation of the cyclical component with itself at time $t$ and time $t + 1$. If this first-order autocorrelation is close to one, the activity has a highly persistent cycle.

The volatility of the cyclical component of a time series is captured by its standard deviation. Researchers also study relative volatility, which is simply the ratio of the standard deviations of the cyclical component of a within-region activity and the region's aggregate business cycle. A relative volatility of one implies that the within-region activity has the same cyclical amplitude as the region's aggregate business cycle, while a relative volatility above one implies that the within-region activity has a larger cyclical amplitude than the region's aggregate business cycle.

### *Estimating cyclical components of time series*

There are several competing methods for performing univariate trend/cycle/noise decompositions. We use the most widely used approach, which is based on spectral analysis. This technique takes advantage of the fact that every time series can be thought of as the sum of components spanning different frequencies of oscillation. Business cycle studies typically assume that fluctuations with low frequency oscillations, lasting more than eight years, capture the trend, while high frequency oscillations, lasting less than 18 months, capture noise. Fluctuations that occur within the range of 18 months to eight years are referred to as business cycle frequencies. Some researchers have adopted slightly wider business cycle ranges by assuming the trend is captured by oscillations of ten or more years. We found that widening the interval affected the volatility and persistence of business cycles, but had little effect on business cycle comovement.

The easiest way to extract these business cycle frequencies is to use a band-pass filter, which essentially zeros out the frequencies of the data that the researcher is not interested in. Due to data limitations, researchers need to use approximate band-pass filters. The results reported in this article are based on data filtered by the widely used approximate band-pass filter developed by Christiano and Fitzgerald (2003), although we find that our main conclusions are not affected by the choice of approximate band-pass filter.

## Are subnational and national business cycles synchronized?

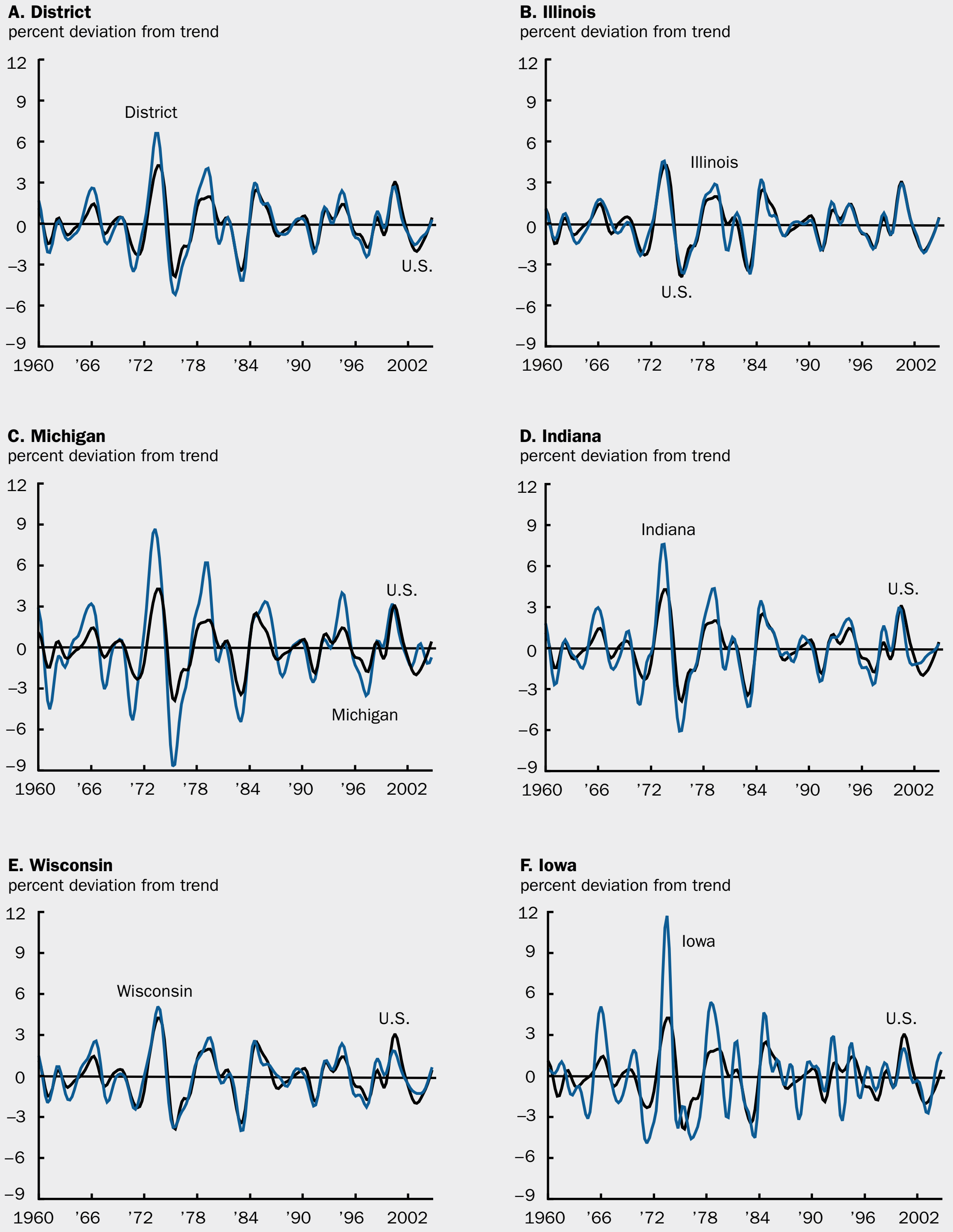
We begin our analysis by exploring the synchronicity of regional and national aggregate business cycles. Figure 1 plots the business cycles of U.S. national income (black line) with the business cycles of aggregate income for the Seventh District and aggregate income for the individual states (blue lines). It is obvious from this figure that there is a high degree of business cycle comovement. This observation is confirmed in figure 2, panel A, which plots the cross-correlation function of the national business cycle at time $t$ and the District and state cycles from time $t - 8$ to time $t + 8$. In most cases the peak correlation (ranging from 0.76 for Iowa to 0.94 for Illinois) occurs at a zero lead/lag. The exceptions are Michigan and Indiana, which lead the nation by one quarter. However, the point estimates of these correlations are marginally higher than those for their contemporaneous counterparts. These results suggest that state business cycles have relatively small idiosyncratic components, so to a very large extent, they reflect the national business cycle.

Figure 1 also implies that the persistence of the District state business cycles, with one exception, is roughly the same as the persistence of the national business cycle. Iowa appears to have a less persistent cycle. These observations are confirmed in table 1, panel A, which reports the first-order autocorrelations of the District state business cycles and the national business cycle. According to this table, while Iowa has a less persistent cycle with a first-order autocorrelation of 0.89, the persistence is roughly 0.93 for the business cycles of the other District states and the nation.

Variations in the volatility of the regional business cycles are also revealed in figure 1. The business cycles of Michigan, Indiana, and Iowa appear to be more volatile than the national business cycle, whereas the business cycles of Illinois and Wisconsin appear to be roughly similar to the national business cycle in terms of volatility. The extent of these differences is quantified in table 1, panel B, which reports

**FIGURE 1**

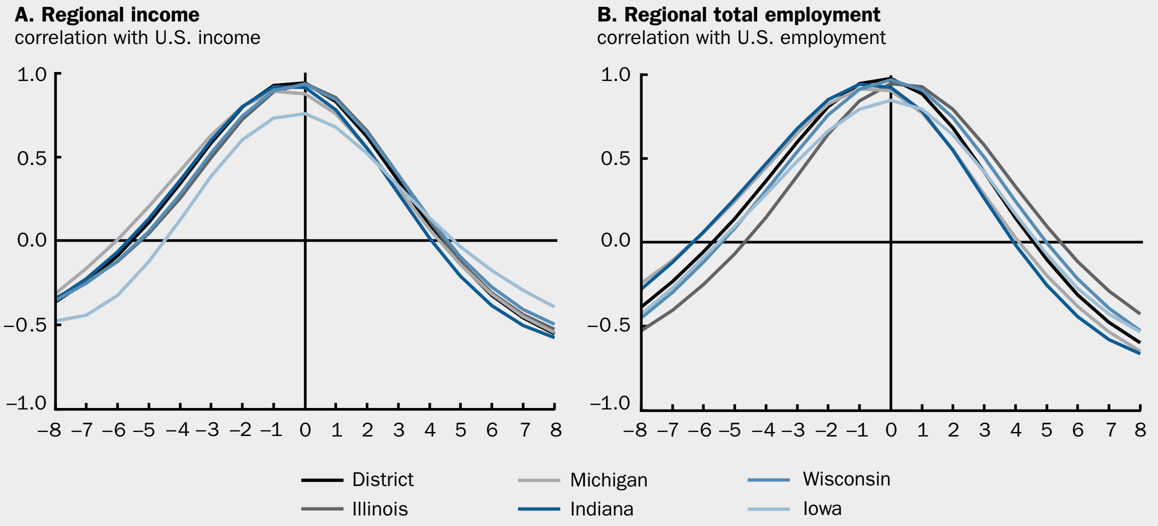
**Aggregate business cycles**




Source: Authors' calculations based on data from the U.S. Bureau of Economic Analysis from Haver Analytics.

**FIGURE 2**

**Across region: Income and total employment**




Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis and the U.S. Bureau of Labor Statistics from Haver Analytics.

the absolute volatility for the national business cycle in the first column and the volatility of the state business cycles relative to the national business cycle in the remaining columns. According to these estimates, Michigan and Iowa have business cycles with amplitudes that are twice as large as those of the national business cycle.

The most obvious explanation for differences in state business cycles is that each state has a different mix of industries. Table 2 explores this by reporting the share of gross state product accounted for by major industries in each of the state economies; it also shows this breakdown by industry for the District and national economies. Based on these data, Iowa differs significantly from the other states in the District in that it has an agriculture share that is more than three times as large as the share for the District. This suggests that Iowa's business cycle is more volatile and less persistent because Iowa is more sensitive to fluctuations in commodity prices, which are considerably more volatile than other prices. In contrast, Illinois is an outlier in that it has a manufacturing share (and general industry mix) that looks more like the national average than the District average, which explains why the Illinois business cycle is virtually identical to the national business cycle.

Because of the widespread use of state-level employment data for business cycle analysis, we repeated

**TABLE 1**

**Across region**

| | U.S. | District | Illinois | Michigan | Indiana | Wisconsin | Iowa |
|---|---|---|---|---|---|---|---|
| **A. Persistence** | | | | | | | |
| Income | 0.93 | 0.93 | 0.92 | 0.94 | 0.92 | 0.93 | 0.89 |
| Nonfarm payroll employment | 0.94 | 0.93 | 0.92 | 0.93 | 0.93 | 0.94 | 0.93 |
| **B. Volatility** | | | | | | | |
| | | **Relative volatility** | | | | | |
| Income | 1.49 | 1.35 | 1.04 | 1.95 | 1.48 | 1.10 | 1.79 |
| Nonfarm payroll employment | 1.17 | 1.20 | 0.96 | 1.75 | 1.48 | 1.12 | 1.04 |

Note: In panel B, income and nonfarm payroll employment are measured in absolute volatility for the U.S.
Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis and the U.S. Bureau of Labor Statistics from Haver Analytics.

**TABLE 2**

**Percent of regional gross state product accounted for by major industry**

| Region | Agriculture | Mining | Construction | Manufacturing | Transportation & public utilities | Trade | FIRE | Services | Government |
|---|---|---|---|---|---|---|---|---|---|
| Illinois | 0.45 | 0.23 | 4.51 | 14.86 | 5.95 | 13.05 | 22.15 | 29.32 | 9.48 |
| Michigan | 0.47 | 0.19 | 4.71 | 22.64 | 4.39 | 12.66 | 16.46 | 28.50 | 9.98 |
| Indiana | 0.62 | 0.32 | 4.62 | 29.73 | 5.69 | 11.76 | 15.56 | 21.95 | 9.74 |
| Wisconsin | 1.34 | 0.15 | 4.42 | 24.55 | 4.87 | 12.33 | 18.02 | 23.43 | 10.89 |
| Iowa | 2.70 | 0.20 | 3.90 | 21.93 | 5.67 | 13.03 | 19.18 | 21.62 | 11.77 |
| District | 0.77 | 0.22 | 4.53 | 21.09 | 5.32 | 12.65 | 18.82 | 26.59 | 10.02 |
| U.S. | 1.01 | 1.24 | 4.47 | 14.63 | 5.04 | 12.86 | 19.81 | 29.30 | 11.64 |

Note: FIRE is finance, insurance, and real estate.
Source: Authors' calculations based on data from the U.S. Bureau of Economic Analysis from Haver Analytics.

this exercise using total nonfarm payroll employment. Panel B of figure 2 reports the cross-correlation functions for national and state employment business cycles. These results are virtually identical to our findings for personal income. Just as in the income case, most states have peak correlations at a zero lead/lag, while Michigan and Indiana weakly lead the nation by one quarter. With the exception of Iowa, there is little difference in the relative persistence and volatility of District state business cycles measured using income and employment (see table 1 for details). In contrast, Iowa's employment business cycle is more persistent and less volatile than its income business cycle. This result reinforces our argument that differences in Iowa's income business cycle largely reflect differences in income due to price fluctuations, since fluctuations in employment reflect fluctuations in the volume rather than the value of production.

## Are national, District, and state business cycles alike?

The previous section established that there is a relatively high synchronization of national and District state aggregate business cycles. Does this mean that national and state business cycles are alike? The answer to this question is no. When Lucas (1977) and other business cycle researchers talk about business cycles being alike, they are referring to similarities in the way that cyclical fluctuations of activities within a region relate to the aggregate cycle of the region. The goal of this section is to compare national and subnational business cycles along as many within-region dimensions as we can.

Considerable effort has gone into understanding the dynamics of national income and various expenditure aggregates at the national and international levels. Therefore, any analysis of regional business cycles would be lacking if it did not provide analogues to these widely known facts about national business cycles. We begin with investment activity.

### *Investment*

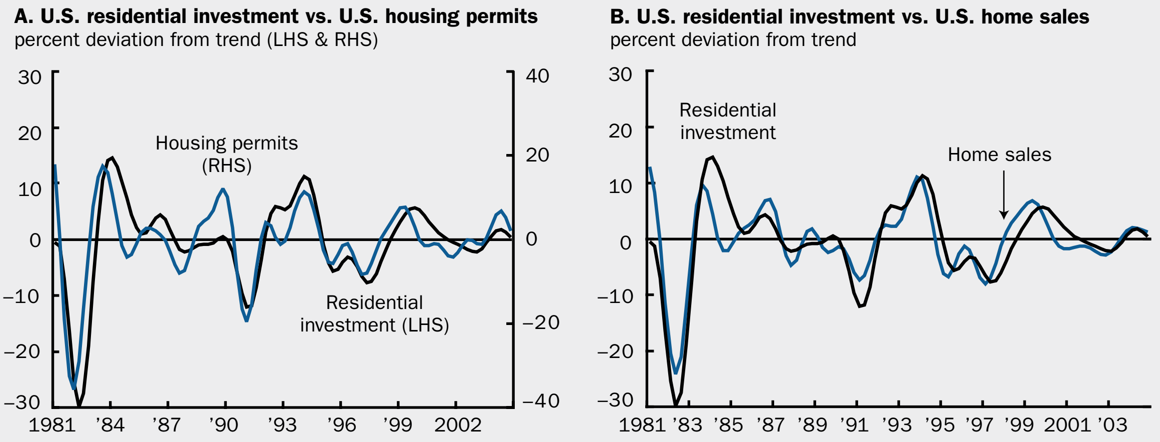
Investment expenditure is not available at the state level, so we must explore other indicators of investment activity. These data are limited to residential investment, since there are no state measures of business investment. Our residential investment indicators are the number of construction permits for housing and the number of home sales (new and existing). Figure 3 reveals that these indicators have similar cyclical properties to residential investment.

It is well known from the work of Fisher (2001) and others that residential investment tends to lead business investment over the business cycle. Turning to panel A of figure 4, we see the cross-correlation function of U.S. business investment from time $t - 8$ to $t + 8$ and national income has a peak correlation of 0.93 with the national income cycle at a zero lead/lag. The cross-correlation function for national residential investment and income, on the other hand, leads national income by three quarters with a peak correlation of 0.83. Panel B of figure 4 reveals that the cross-correlation functions for both of our indicators of residential investment with income have a similar shape to that of residential investment, with a peak correlation of 0.58 occurring at a lead of four quarters for housing permits and a peak correlation of 0.63 occurring at a lead of three quarters for home sales.

In figure 5, cross-correlation functions for District-level housing permits and income, as well as District home sales and income, are shown to have the same shape as the national level data, including peak correlations of 0.47 and 0.69, respectively, at a lead of three

**FIGURE 3**

**U.S. residential investment**



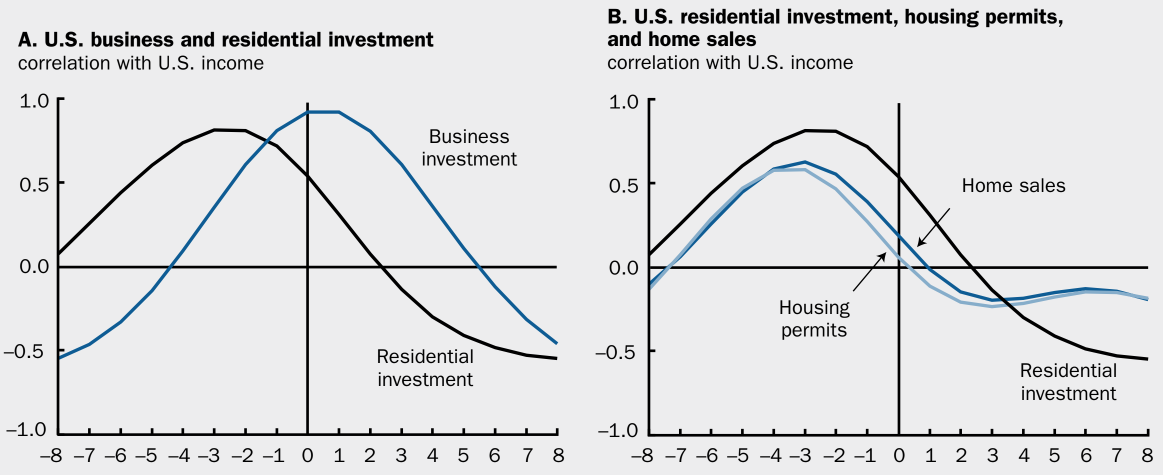

Notes: LHS means left-hand scale. RHS means right-hand scale.
Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis, U.S. Census Bureau, and National Association of Realtors from Haver Analytics.

quarters. Results for state-level data echo the national and District-level data, with statistically significant positive correlations for leading housing permits and home sales and insignificant correlations lagged of housing permits and home sales. The peak correlations between state-level income and housing permits and state-level income and home sales are similar in magnitude to the District-level results and vary from leads of two to four quarters. These findings suggest that housing permits and home sales are reliable leading indicators of regional cyclical income fluctuations.

The persistence of housing permits and home sales cycles is reported in table 3, panel A. These estimates suggest that there is very little variation across the region in terms of persistence. Panel B of table 3 reports the volatility of housing permits and home sales. The top row of this panel reports the absolute volatility of regional income, or the standard deviation of the

**FIGURE 4**

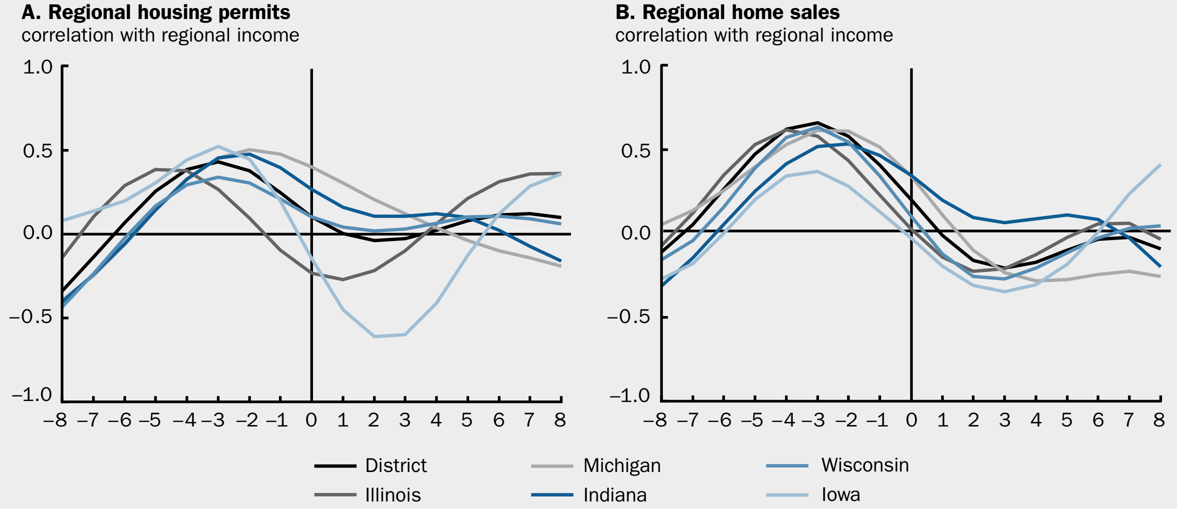
**Within region: Investment**




Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis, U.S. Census Bureau, and National Association of Realtors from Haver Analytics.

FIGURE 5

Within region: Housing permits and home sales




Sources: Authors' calculations based on data from the U.S. Census Bureau and the National Association of Realtors from Haver Analytics.

percentage deviation of the cycle from its trend. The following rows report the relative volatility of an activity, which is the ratio of the standard deviation of the cycle of the regional activity to the standard deviation of the region's income cycle. Values above one imply the activity is more volatile than the region's income cycle. The U.S. column reveals that housing permits have a relative volatility of 7.71, which is slightly higher than the relative volatility of residential investment, while home sales, with a relative volatility of 4.80, are less volatile than both residential investment and housing permits. Moving along the housing permits and home sales rows, we see that the District states have the same pattern.

### *Consumption*

Countless business cycle studies have documented that national consumption expenditure measured by personal consumption expenditure exhibits strong positive comovement with national income. Personal consumption expenditure is not available at the state level, so we use a measure of retail sales derived from retail sales tax revenue, which is available at the state level, as a proxy for consumption spending. We plot the cyclical components of these national time series in figure 6. National retail sales tax revenue is roughly twice as volatile as national consumption expenditure (see table 3, panel B). Along all other cyclical dimensions, these series appear to be very similar.

Panel A of figure 7 reveals that the cross-correlation function of U.S. retail sales tax revenue and income has an identical shape to that of U.S. consumption and income, including a peak correlation of 0.87, with a one quarter lead. This suggests that retail sales tax revenue is a reliable proxy for consumption.

Turning to the District-level data in panel B of figure 7, we find that although the relationship is weaker, there is a relatively strong positive relationship between retail sales tax revenue and District income, with the peak correlation of 0.66 occurring at a zero lag/lead. The cross-correlation functions of Michigan and Illinois display a similar pattern to the District. However, the peak correlation is somewhat lower for Illinois at 0.52. This suggests that retail sales tax data are a coincident indicator of business cycles of the larger District states. For the remaining states, Iowa, Indiana, and Wisconsin, the correlation between cyclical fluctuations in state income and state retail sales tax revenue is positive at a zero lead/lag, but it is close to zero and not statistically significant. Panel A of table 3 reveals that the persistence of the state retail sales tax revenue cycles is less than that of the national cycle, with a range of 0.81 for Indiana to 0.91 for Illinois. With the exception of Wisconsin, the state retail sales tax revenue cycles are roughly twice as volatile as the state income cycles, which are slightly more volatile than the national cycle (see table 3, panel B). Wisconsin's retail sales tax revenue cycle has a relative volatility of eight. Overall, these results suggest that over the business cycle, Michigan's and Illinois's consumption and income behave in a similar

**TABLE 3**

**Within region**

| | U.S. | District | Illinois | Michigan | Indiana | Wisconsin | Iowa |
|---|---|---|---|---|---|---|---|
| **A. Persistence** | | | | | | | |
| Income | 0.93 | 0.93 | 0.92 | 0.94 | 0.92 | 0.93 | 0.89 |
| Business investment | 0.94 | | | | | | |
| Residential investment | 0.94 | | | | | | |
| Existing home sales | 0.87 | 0.88 | 0.87 | 0.88 | 0.88 | 0.86 | 0.87 |
| Housing permits | 0.86 | 0.86 | 0.84 | 0.87 | 0.87 | 0.85 | 0.85 |
| Personal consumption | 0.94 | | | | | | |
| Retail sales tax revenue | 0.92 | 0.87 | 0.91 | 0.89 | 0.81 | 0.83 | 0.86 |
| Nonfarm payroll employment | 0.94 | 0.93 | 0.92 | 0.93 | 0.93 | 0.94 | 0.93 |
| Average hours in manufacturing | 0.89 | 0.88 | 0.86 | 0.89 | 0.90 | 0.90 | 0.86 |
| Initial unemployment claims | 0.91 | 0.91 | 0.92 | 0.90 | 0.91 | 0.91 | 0.86 |
| Unemployment rate | 0.92 | 0.90 | 0.90 | 0.92 | 0.89 | 0.90 | 0.90 |
| Real wage | 0.87 | 0.89 | 0.87 | 0.90 | 0.82 | 0.84 | 0.84 |
| Capital utilization (industrial sector) | 0.87 | 0.87 | | | | | |
| **B. Volatility** | | | | | | | |
| Income | 1.49 | 2.00 | 1.54 | 2.90 | 2.20 | 1.64 | 2.67 |
| | **Relative volatility** | | | | | | |
| Business investment | 3.21 | | | | | | |
| Residential investment | 6.79 | | | | | | |
| Existing home sales | 4.80 | 5.15 | 5.86 | 3.87 | 5.64 | 7.00 | 5.05 |
| Housing permits | 7.71 | 10.36 | 12.10 | 8.91 | 10.10 | 11.56 | 7.15 |
| Personal consumption | 0.79 | | | | | | |
| Retail sales tax revenue | 1.87 | 1.64 | 2.31 | 2.11 | 2.70 | 8.12 | 2.31 |
| Nonfarm payroll employment | 0.79 | 0.70 | 0.72 | 0.70 | 0.78 | 0.80 | 0.45 |
| Average hours in manufacturing | 0.56 | 0.53 | 0.57 | 0.77 | 0.69 | 0.47 | 0.43 |
| Initial unemployment claims | 7.43 | 7.58 | 7.83 | 6.76 | 8.24 | 9.09 | 5.04 |
| Unemployment rate | 0.43 | 0.38 | 0.45 | 0.40 | 0.36 | 0.48 | 0.14 |
| Real wage | 0.74 | 0.69 | 0.93 | 0.65 | 0.59 | 0.71 | 0.36 |
| Capital utilization (industrial sector) | 1.56 | 1.82 | | | | | |

Note: In panel B, income is measured in absolute volatility for the U.S., the District, and District states.
Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, U.S. Department of Labor, U.S. Census Bureau, and National Association of Realtors, all from Haver Analytics, and the Board of Governors of the Federal Reserve System.

way to their national counterparts; this also applies to the District as a whole. No clear conclusions can be reached for the other states. In light of these results, we are working on improving the quality of our retail sales tax data for these states by doing a more complete correction for tax rate changes and harmonizing the accounting rules, so we consider the findings of this section to be incomplete at this time.

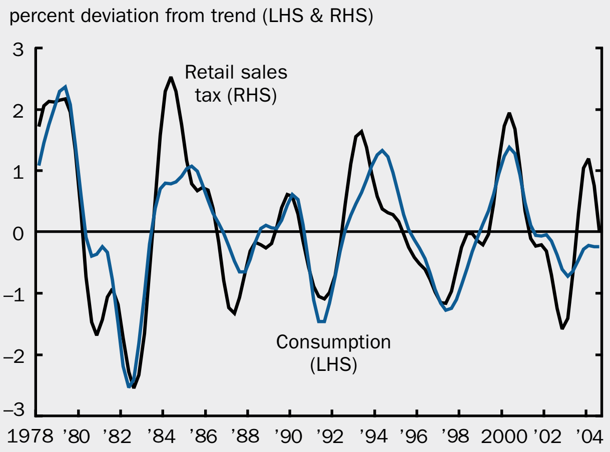
The remaining components of national expenditure are government spending and net exports. We are working on assembling data for state-level government spending, so we are unable to report those results at this time. Exports are the only component of net exports that are available at the state level, but our data samples are too small for any meaningful business cycle analysis, so we leave it to future research to explore the business cycle properties of exports at the state level.

### *Labor market*

The cyclical behavior of labor market data has been the focus of many business cycle studies (see the surveys of Cooley, 1995; King and Rebelo, 1999). There is considerable overlap in labor market data available at the national and state levels. We explore five measures of labor market activity: total nonfarm

**FIGURE 6**

**U.S. consumption vs. U.S. retail sales tax revenue**




Notes: LHS means left-hand scale. RHS means right-hand scale.
Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis from Haver Analytics and the U.S. Census Bureau.

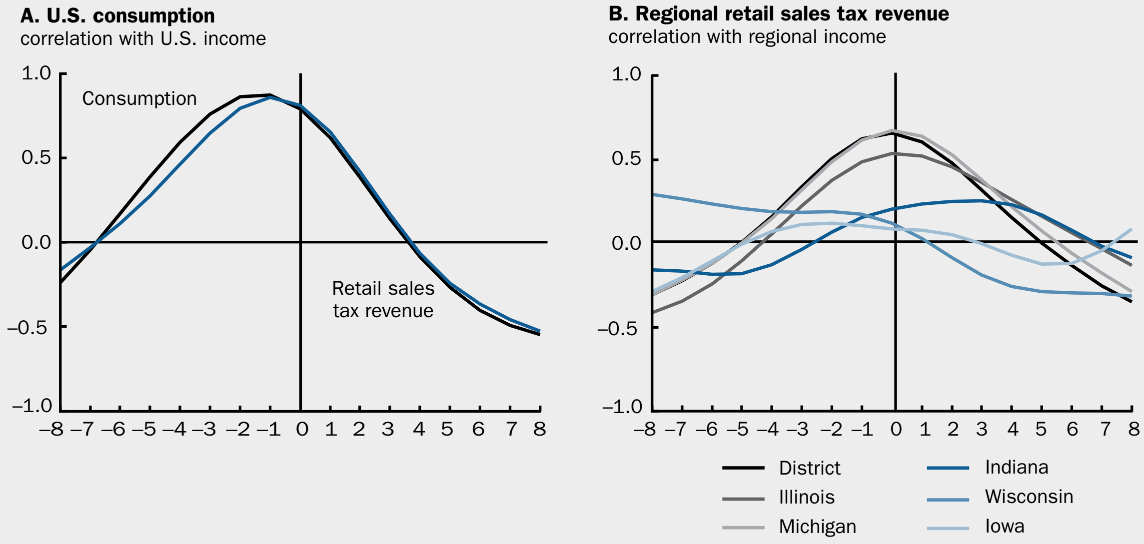
payroll employment, average weekly hours in manufacturing, initial unemployment insurance claims, the unemployment rate, and the real wage.

We find that both national measures of labor input—nonfarm employment and average hours—are positively correlated with national income over the business cycle (see figure 8). Total employment's peak correlation of 0.91 occurs at a lag of one quarter, while average hours has a peak correlation of 0.83 at a lead of two quarters. In contrast, both indicators of national unemployment—initial unemployment claims and the unemployment rate—have a negative correlation with national income over the business cycle. Initial unemployment claims is a leading indicator, with a minimum correlation of –0.86, which occurs at a lead of two quarters. The unemployment rate, which is well known to be highly countercyclical, has a minimum correlation with national income of –0.91, which occurs at a zero lead/lag, making it a coincident indicator. Finally, we find that the correlation of the real wage and income is not significantly different from zero at all leads and lags. All these findings are consistent with earlier business cycle studies of national labor market dynamics.

Figure 9, which features regional labor market data, reveals that the cross-correlation functions of District-level labor and income data have very similar shapes to their national counterparts in figure 8. There are some slight differences in the location of peak/minimum correlations. However, variables that were leading or lagging indicators at the national level continue to be leading or lagging indicators at the District level.

**FIGURE 7**

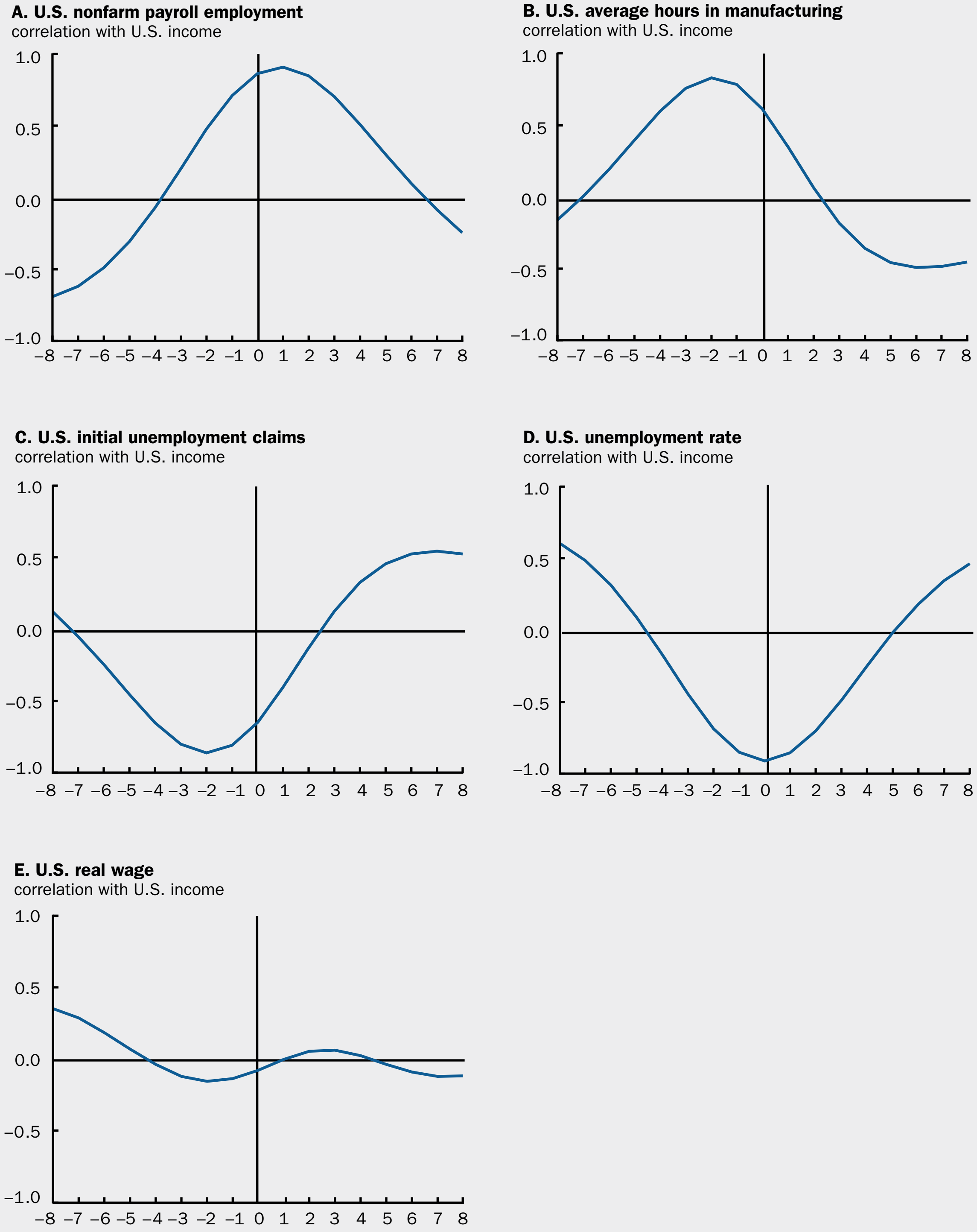
**Within region: Consumption and retail sales tax revenue**




Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis from Haver Analytics and the U.S. Census Bureau.

**FIGURE 8**

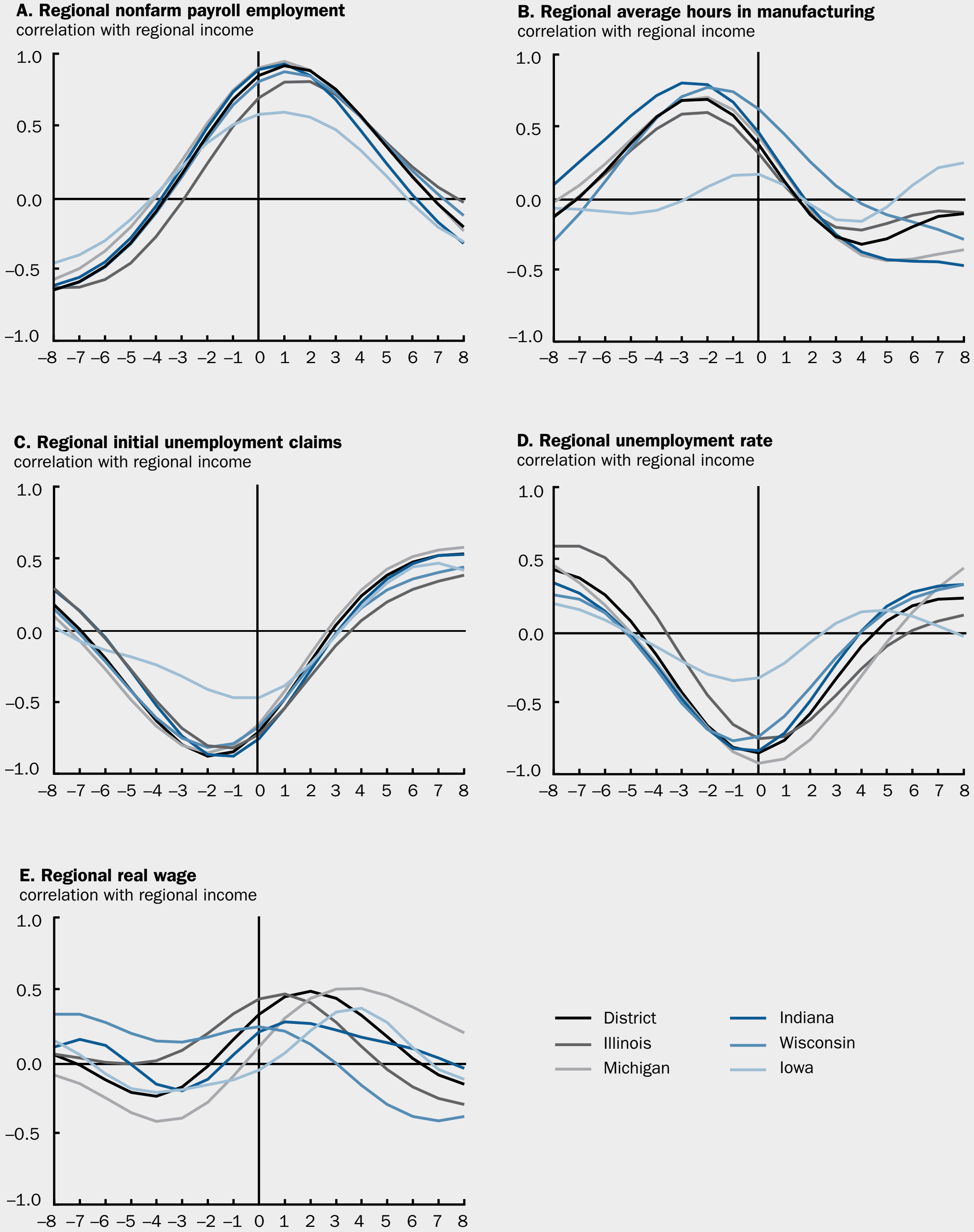
**Within region: U.S. labor**




Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and U.S. Department of Labor from Haver Analytics.

## FIGURE 9

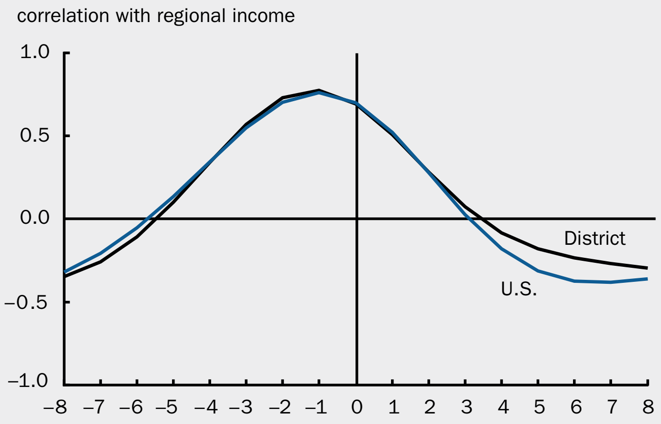
### Within region: Regional labor




Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and U.S. Department of Labor from Haver Analytics.

FIGURE 10

**Within region: Industrial electricity consumption**




Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis from Haver Analytics and the Board of Governors of the Federal Reserve System.

Labor market data for Illinois, Indiana, Michigan, and Wisconsin also closely resemble the national labor market data. Total employment and average hours have significant positive correlations with income, while initial unemployment claims and the unemployment rate have significant negative correlations with income at similar leads and lags as those for the District and nation. We also find that the correlation of the real wage and income is close to zero at all leads and lags. In the case of Iowa, estimates of the correlation between labor market activity and income over the business cycle are less precise than for the other states. The most obvious example is the cross-correlation function of average hours and income for Iowa, which is insignificant at all leads and lags.[7]

Panel A of table 3 (p. 54) reveals that the state labor market fluctuations and national labor market fluctuations show similar persistence. All measures are highly persistent, with the real wage displaying the lowest persistence and employment the highest persistence.

With the exception of initial unemployment claims, cyclical fluctuations in labor market variables at both the national and state levels are less volatile than for income (see table 3, panel B). In most cases, employment is more volatile than average hours and unemployment. There is no clear ranking for the real wage. The initial unemployment claims category, on the other hand, is considerably more volatile than income, with a relative volatility of 7.43 at the national level and between 5.04 and 9.09 for the District states.

Overall, these findings suggest that the cyclical properties of District state labor markets are virtually identical to those of the national labor market.

### *Capital utilization*

The final dimension of comparison is capital utilization. Measures of capital utilization, such as industrial electricity usage, are only available at the national and District levels. We find at the national level that electricity usage/capital utilization has a strong positive relationship with income (see figure 10). The peak correlation for these series (0.76) occurs with a lead of one quarter. The District cross-correlation function has an almost identical shape to the nation's, including a peak correlation of 0.77, which occurs at a lead of one quarter. These results suggest that electricity usage is a reliable leading indicator of District-level cyclical activity.

## Conclusion

Our within-region results suggest that we can expand Lucas's (1977) comment about business cycles to read that irrespective of the time period or *size of the economy*, business cycles are all alike. This is welcome news for business cycle theorists, since it suggests that models that have been developed or are being developed to explain national business cycles are applicable to subnational business cycles. Our results are also of interest to those charged with the formulation of U.S. monetary policy, since they imply that the U.S. and the Seventh District fit Mundell's notion of a single optimal currency area, which suggests that the "best" monetary policy for the U.S. is also the "best" monetary policy for the Seventh District and the District states.

## NOTES

[1]Iowa is the only state that is wholly within the Seventh Federal Reserve District's boundaries, while the District includes the southern portions of Wisconsin and Michigan and the northern portions of Illinois and Indiana. Since data at the state level are based on state boundaries, our study includes parts of Wisconsin, Michigan, Illinois, and Indiana that are in other Federal Reserve districts.

[2]See Owyang, Piger, and Wall (2005), table 6, p. 615.

[3]See Burns and Mitchell (1946), p. 3.

[4]For detailed information on the discussion that follows, please see Burns and Mitchell (1946), pp. 72–76.

[5]This article follows Harding and Pagan (2002). Broad indicators of activity, such as GDP, typically arrive with a considerable lag and are only available on a quarterly basis, so researchers have followed Burns and Mitchell's approach to identifying business cycles by using techniques that extract common fluctuations from a potentially large cross section of disaggregate data that arrives more frequently than broad indicators. This is the thinking that underlies the popular diffusion index approach of Stock and Watson (1998). The outcomes from these exercises, such as the Chicago Fed National Activity Index (CFNAI), yield measures of the business cycle that are consistent with business cycles estimated using a single broad indicator, such as GDP.

[6]Interested readers may contact the authors for copies of these additional figures and tables.

[7]Labor market data are widely used in studies of regional business cycles. For example, Crone and Clayton-Matthews (2005) use monthly total nonfarm payroll employment, average weekly hours in manufacturing, real wage, and the unemployment rate to estimate all 50 state-level business cycles using the Stock and Watson (1989) common factor approach. They find that these employment indicators are coincident indicators of the employment business cycle for four of the District states. The one exception is Illinois, for which average weekly hours in manufacturing is a leading indicator, with a lead of one month.

## APPENDIX: DESCRIPTION OF DATA

The data on real U.S. gross domestic product, consumption, and investment come from the national accounts published by the U.S. Bureau of Economic Analysis (BEA).

For the regional level analysis, we use quarterly personal income data (published by the BEA). Personal income includes all sources of earnings, such as wages, interest and dividends, proprietor's income, and other miscellaneous labor income, by place of residence.

Since consumption is not directly available at the state level, we proxy for consumer expenditure by using retail sales tax revenue data. The data on retail sales tax revenue are published by the U.S. Census Bureau on a quarterly basis and provide the quarterly estimates of sales and gross receipts taxes on goods and services for individual states.

To proxy for residential investment at the state level, we use the data on housing construction permits and home sales. The data set on construction permits covers new privately owned housing units and is collected and published by the U.S. Census Bureau. We also use data on the number of home sales, including new and existing privately owned single-family houses, condominiums, and cooperative housing; these data are published by the National Association of Realtors.

Our measure of capital utilization is electricity power use, by industry, which is published by the Board of Governors of the Federal Reserve System as part of its industrial production and capacity utilization data release, Federal Reserve Statistical Release G.17. The data are limited to national and District measures of electricity power use, by industry.

Our labor market indicators include data on initial unemployment claims (that is, the number of people filing new claims for state unemployment insurance), average weekly hours in the manufacturing sector, and total nonfarm payroll employment. These data are recorded by the local state governments and published by the U.S. Department of Labor. Also included in our data set is the unemployment rate, which represents the fraction of the labor force that is unemployed. These unemployment rate series are published monthly by the U.S. Bureau of Labor Statistics. Our measure of nominal wages is total wage and salary disbursements, by place of work, from the BEA's personal income data divided by the product of total nonfarm payroll employment and average weekly hours in manufacturing.

All nominal data are deflated by the national Personal Consumption Expenditures Price Index to yield real consumption based measures of economic activity. We explored alterative approaches that deflated nominal data by either the Midwest Census Region Consumer Price Index or metropolitan Consumer Price Indexes. These approaches yield virtually identical results to those reported in this article.

## REFERENCES


**Backus, D. K., and P. J. Kehoe,** 1992, "International evidence of the historical properties of business cycles," *American Economic Review*, Vol. 82, No. 4, September, pp. 864–888.

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

**Christiano, L. J., and T. J. Fitzgerald,** 2003, "The band pass filter," *International Economic Review*, Vol. 44, No. 2, May, pp. 435–465.

**Clayton-Matthews, A., and J. H. Stock,** 1998–99, "An application of the Stock/Watson index methodology to the Massachusetts economy," *Journal of Economic and Social Measurement*, Vol. 25, No. 3/4, pp. 183–233.

**Cooley, T. F. (ed.),** 1995, *Frontiers of Business Cycle Research*, Princeton, NJ: Princeton University Press.

**Crone, T. M., and A. Clayton-Matthews,** 2005, "Consistent economic indexes for 50 states," *Review of Economics and Statistics*, Vol. 87, No. 4, November, pp. 593–603.

**Fisher, J. D. M.,** 2001, "A real explanation for heterogeneous investment dynamics," Federal Reserve Bank of Chicago, working paper, No. WP-2001-14.

**Harding, D., and A. Pagan,** 2002, "Dissecting the cycle: A methodological investigation," *Journal of Monetary Economics*, Vol. 49, No. 2, March, pp. 365–381.

**Hess, G. D., and K. Shin,** 1998, "Intranational business cycles in the United States," *Journal of International Economics*, Vol. 44, No. 2, April, pp. 289–313.

**King, R. G., and S. T. Rebelo,** 1999, "Resuscitating business cycles," in *Handbook of Macroeconomics*, Vol. 1B, M. Woodford and J. B. Taylor (eds.), Amsterdam: Elsevier.

**Kouparitsas, M. A.,** 2002, "Understanding U.S. regional cyclical comovement: How important are spillovers and common shocks?," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 26, No. 4, Fourth Quarter, pp. 30–41.

**Lucas, R. E.,** 1977, "Understanding business cycles," *Carnegie-Rochester Series on Public Policy*, Vol. 5, pp. 7–29.

**Mundell, R. A.**, 1961, "A theory of optimum currency areas," *American Economic Review*, Vol. 51, No. 4, September, pp. 657–665.

**Orr, J., R. Rich, and R. Rosen,** 1999, "Two new indexes offer a broad view of economic activity in the NewYork–New Jersey region," *Current Issues in Economics and Finance*, Federal Reserve Bank of New York, Vol. 5, No. 14, October, pp. 1–6.

**Owyang, M. T., J. Piger, and H. J. Wall,** 2005, "Business cycle phases in U.S. states," *Review of Economics and Statistics*, Vol. 87, No. 4, November, pp. 604–616.

**Stock, J. H., and M. W. Watson,** 1998, "Diffusion indexes," National Bureau of Economic Research, working paper, No. 6702, August.

**__________,** 1989, "New indexes of coincident and leading economic indicators," in *NBER Macroeconomic Annual 1989*, O. J. Blanchard and S. Fischer (eds.), Cambridge, MA: MIT Press, pp. 351–394.