Identifying State-Level Recessions

By Jason P. Brown

Although the U.S. economy is in its eighth year of expansion since the Great Recession, some states are nevertheless in recession. The timing of states entering an economic downturn often differs from the nation as a whole: the onset and duration of recessions depend on factors that typically differ in each business cycle. A global recession such as the Great Recession is often widespread, dampening economic growth across most regions and sectors of the United States. But other downturns may be more concentrated. For example, in the 2001 recession, the manufacturing sector was hit especially hard.

States with higher concentrations in specific sectors may enter downturns earlier than other states—and may remain in them longer. For example, energy-producing states in the Tenth Federal Reserve District entered a recession in 2015 and 2016 following the 70 percent decline in the price of oil from June 2014 to February 2016. In contrast, most non-energy-producing states experienced moderate but steady growth over the last two years. Energy-producing states have a larger share of employment and output in the oil and gas sector; as a result, declining or sustained low oil prices can decrease exploration and

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drilling, decrease activity in other sectors, and thereby dampen overall economic activity.

In this article, I use two approaches to determine whether the seven states of the Tenth District are in a recession. The first approach is helpful for identifying regional recessions retrospectively over the last four decades, while the second approach is more helpful for identifying regional recessions in real time. When applied to the seven states of the Tenth District, both approaches indicate that Oklahoma and Wyoming entered downturns in early to mid-2015. The second approach suggests Kansas and New Mexico entered recessions beginning in late summer 2016. On average, recessions in energy-producing states occur more frequently but are typically shorter than recessions in non-energy-producing states.

Section I discusses some of the measurement issues involved in identifying regional recessions compared with national recessions. Section II uses an algorithm to identify the timing and duration of past regional recessions. Section III develops a formal model that categorizes state-level economic activity into two regimes—low growth/recession and high growth/expansion. This approach allows me to identify in real time when states slip into recession.

I. The Challenges of Identifying State Recessions

Identifying economic turning points for individual states is challenging for a number of reasons. First, while the National Bureau of Economic Research (NBER) Business Cycle Dating Committee identifies national recessions, neither it nor any other comparable organization dates state-level recessions. Moreover, the NBER has no fixed timeline for determining recession dates and often announces the beginning of a recession a year or more after it occurs. Second, timely state-level economic indicators are limited. The broadest measure, gross state product, is only available quarterly and is published with a lag of around six months (versus one month for advance estimates of U.S. gross domestic product). Similarly, quarterly measures of state-level personal income are published with about a three-month lag. Although monthly labor market indicators are available at the state and metropolitan level from the Bureau of Labor Statistics' Current Employment Statistics and Current Population Survey, it is not obvious which set or combination of indicators would be best to monitor and summarize state-level economic activity.

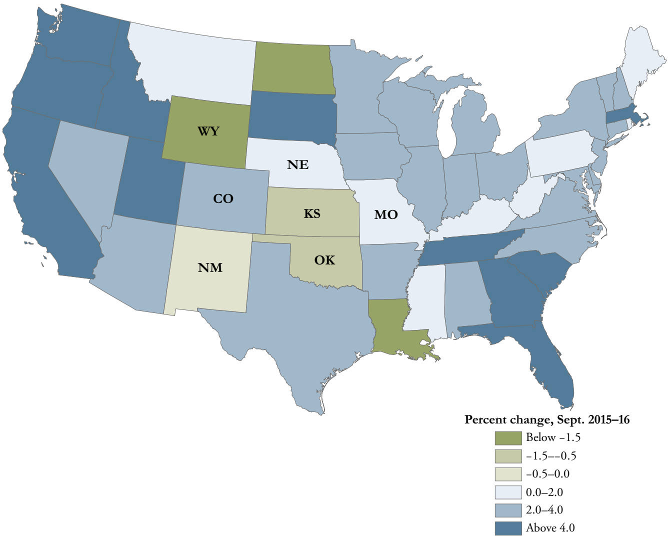
One possible alternative is the Federal Reserve Bank of Philadelphia's state coincident index, a timely and comprehensive measure of each state's economic activity. The Philadelphia Fed's coincident index captures each state's current economic conditions by combining four state-level indicators—nonfarm payroll employment, average hours worked in manufacturing by production workers, the unemployment rate, and wage and salary disbursements deflated by the consumer price index (U.S. city average). The trend for each state's index is set equal to the trend of its real GDP. Each month, the Bank releases an updated version of each state's entire index that also includes the most recent month for which data are available. These regular updates are important, because the underlying state-level data can be subject to substantial revision.

Changes in the coincident index suggest that several states in the Tenth District experienced declining economic activity over the past year. Map 1 shows that the energy-producing states in the District, namely Oklahoma, Wyoming, Kansas, and New Mexico, accounted for four of six states in the entire country where economic activity declined from September 2015 to September 2016 (the other two states were North Dakota and Louisiana, also energy-producing states). Map 2 shows that the pace of decline accelerated in some states beginning in the middle of 2016. From June to September 2016, economic activity declined faster in Kansas and New Mexico than in Oklahoma or Wyoming.

Growth in each state's index may be a useful indicator for measuring state-level business cycles. However, growth alone is not enough to identify recessions. The next two sections discuss two approaches for identifying state-level recessions. I first use the Bry-Boschan method, as it is a standard and simple approach for identifying turning points in economic indicators. The Bry-Boschan method—like the NBER—typically dates recessions with a substantial lag. As a result, I also use a Markov regime-switching model, which is more complex but offers more flexibility to identify state-level recessions in real time.

Map 1

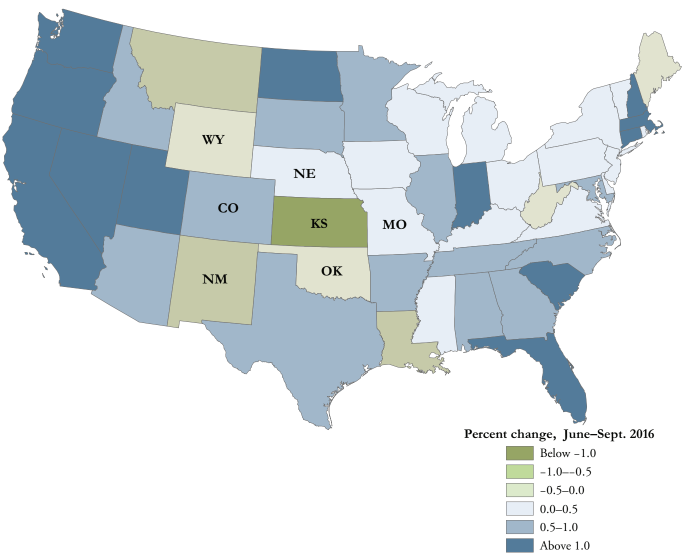
Growth in the Economic Activity Index by State, September 2015 to September 2016



Sources: Federal Reserve Bank of Philadelphia and author's calculations.

Map 2

Growth in the Economic Activity Index by State, June 2016 to September 2016



Sources: Federal Reserve Bank of Philadelphia and author's calculations.

II. Using the Bry-Boschan Method to Identify U.S. Recessions

The Bry-Boschan (B-B) method is a popular approach to business cycle dating because it is straightforward and easy to implement. The B-B method is designed to identify the peaks and troughs in the level of a time series—in other words, the turning points between economic expansions and contractions. To do so, the algorithm requires users to specify not only a window of time over which to identify these turning points but also a minimum length of time for each phase (expansion or contraction) and cycle (the period between two peaks or two troughs). I use a window of 12 months, where each phase is at least six months, and a complete cycle is 24 months. As the algorithm rolls through the data, it looks six months ahead and six months behind each month to identify local minima and maxima. When the algorithm discovers local minima or maxima, it determines whether they are possible turning points. Candidate turning points satisfy two conditions: phases are at least six months long and complete cycles are at least 24 months long.[1]

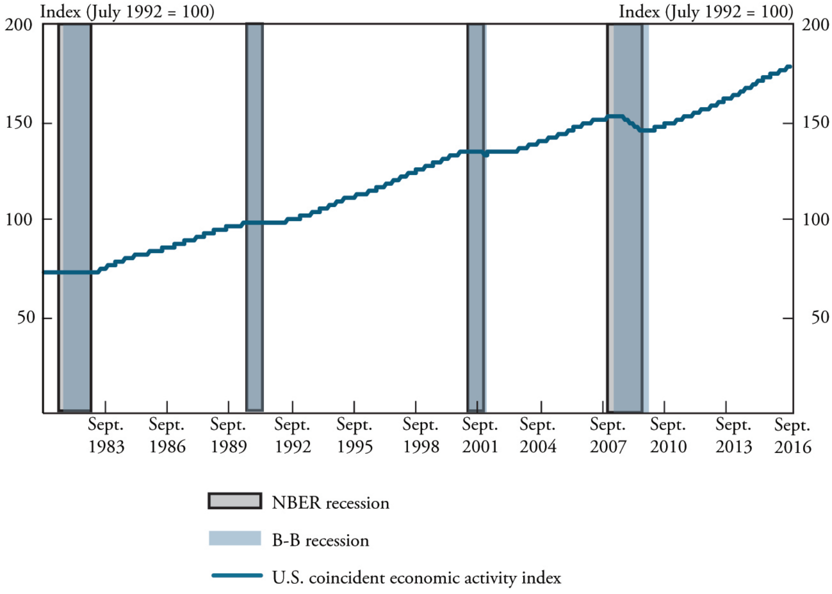
As a result of these imposed conditions, however, the B-B algorithm may be limited in identifying turning points in real time—its accuracy improves as time passes and more data in the series are available to satisfy the cycle constraint. For example, if a downturn occurred in the last few months of available data, the B-B algorithm would not likely identify it until a full six months had passed.

To gain some confidence in applying the B-B method to regional data using the Philadelphia Fed's state coincident index, I first apply the method to the Bank's national coincident index (calculated in the same way as the state indexes) and compare the results with the NBER's dating of past U.S. recessions. The B-B method is unlikely to exactly identify the NBER-defined recessions, as the process used by the Business Cycle Dating Committee is somewhat subjective. The Committee does not have a fixed rule or algorithm for identifying expansions and recessions but instead applies its judgement when dating business cycles. As a result, it is unlikely that applying any particular fixed algorithm to a coincident indicator of economic activity will exactly replicate the NBER's dating.

Nevertheless, the turning points identified by both the B-B method and the NBER are similar for most recessions. Chart 1 shows the

Chart 1

U.S. Business Cycles



Sources: NBER, Federal Reserve Bank of Philadelphia, and author's calculations.

Table 1

Difference in Dating of U.S. Recessions

Recession	Timing relative to NBER (months)	
	Enter	Exit
1981–82	1	0
1990–91	1	1
2000–01	0	2
2008–09	3	4
Average	1.25	1.75

Note: A positive number indicates that the B-B algorithm identified the U.S. economy entering/exiting a recession later than the NBER.
Sources: NBER, Federal Reserve Bank of Philadelphia, and author's calculations.

U.S. coincident index from September 1980 to September 2016. The gray shading indicates NBER-defined recessions, while the light blue shading shows recessions determined by the B-B algorithm. In most cases, the shading overlaps. For a more detailed comparison, Table 1 reports the time difference (measured in months) between the B-B method's entry and exit dates for the last four recessions and those dated by the NBER. Averaging across recessions, the B-B method suggests the United States entered or exited a recession 1.5 months later than the official NBER designation. Thus, applying the B-B method to the U.S. coincident index appears to produce similar business cycle dates as the NBER, offering some confidence in dating regional recessions with a similar method.

Using the B-B method to identify state-level recessions

Given the relative success of the B-B method in replicating NBER recession dates at the national level, I use the B-B method and state-level coincident indexes to identify business cycles in Tenth District states. I start the analysis in 1979, the first year for which state coincident indexes are available. Table 2 summarizes the number, duration, and time spent in state-level recessions for the seven states of the Tenth District. Over the past four decades, each District state spent more time in recession than did the United States (52 months). From April 1979 to September 2016, the United States was in recession 12 percent of the time. In contrast, Missouri was in recession about 27 percent of the time, followed closely by Oklahoma at 24 percent. Over the period of analysis, all District states had four to five recessions except Wyoming, which had six. The average recession duration was shortest in Nebraska (15 months) and longest in Missouri (31 months). For the United States as a whole, the average recession duration was 13 months.

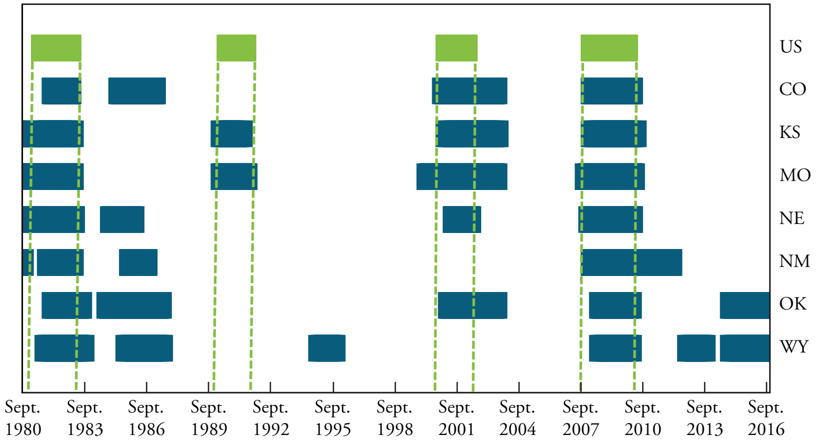
Chart 2 illustrates that the timing of District states entering recessions often differs from the United States as a whole (see Appendix Table A-1 for a list of all recession entry and exit dates). Kansas, Missouri, and Nebraska tend to enter downturns before the United States as a whole. The states with the most oil and gas production (New Mexico, Oklahoma, and Wyoming) typically enter recessions later than the United States but also exit them later. Notably, none of the states in the Tenth District has exited a recession before the nation.

Table 2
Summary of Recessions by District State

State	Number of months in recession	Time in recession (percent)	Number of recessions	Average duration (months)
Colorado	79	17.6	4	20
Kansas	88	19.6	5	18
Missouri	122	27.1	4	31
Nebraska	76	16.9	5	15
New Mexico	74	16.4	4	18
Oklahoma	107	23.8	5	22
Wyoming	91	20.2	6	14
United States	52	11.6	4	13

Sources: Federal Reserve Bank of Philadelphia and author's calculations.

Chart 2
Timing of District versus U.S. Recessions



Note: U.S. recessions in the chart correspond to turning points identified by the B-B method for a more direct comparison of state-level recessions using the same method.
Sources: Federal Reserve Bank of Philadelphia and author's calculations.

In addition, some Tenth District states experienced recessions that the United States as a whole never entered. Colorado, Nebraska, New Mexico, Oklahoma, and Wyoming experienced a state-level recession during 1985–86 while the United States was in a period of general expansion. Around this time, a steep decline in the price of oil caused drilling and production to halt and overall economic activity in oil- and gas-producing states to slow. As a result, the energy-producing states in the Tenth District experienced a downturn while the rest of the nation continued to grow. Nebraska's recession was likely due to the slowdown in agriculture that occurred around the same time.

Oklahoma and Wyoming experienced additional state-level recessions. Wyoming had short downturns in 1995 and 2013 coinciding with declines in coal prices (1995) and coal production (2013). And Oklahoma and Wyoming both entered recessions at the beginning of 2015: oil prices declined steeply in the second half of 2014, leading to significant declines in economic activity in both states.

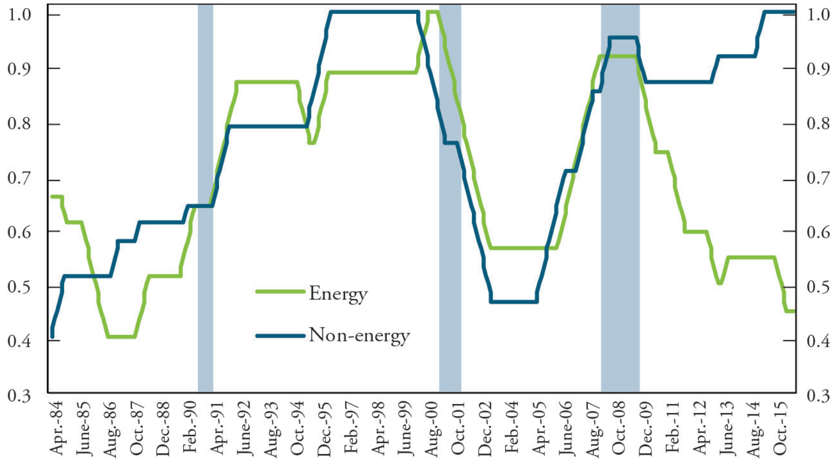
Synchronization of state business cycles

Certain economic shocks can affect the entire energy sector, causing energy-producing states to become more synchronized—that is, more likely to be in the same phase of the business cycle—than non-energy producing states. Less apparent, however, is whether this exposure to sector-specific shocks causes energy-producing states to become less synchronized with U.S. business cycles than non-energy-producing states. To address this issue, I construct measures of synchronization of District states with each other and with the United States, grouping states into energy and non-energy-producing categories. These measures indicate whether each group of states is in the same phase of the business cycle (expansion or recession) as the other group and the overall U.S. economy.

One way to measure the degree to which turning points across states are synchronized is to calculate an index of concordance as used by Harding and Pagan. An index of concordance measures the share of time two data series spend in the same phase of expansion or contraction at the same time.[2] The overall value of the index is bounded between 0 and 1, with larger values indicating a higher level of synchronicity between two states. An exact reading of 1 would indicate that two states were in the exact same phases of the business cycle in each month over the sample period.

Chart 3

Energy versus Non-Energy States' Concordance with U.S. Business Cycles



Notes: The concordance is the share of time over a five-year window in which the energy states (New Mexico, Oklahoma, and Wyoming) and the non-energy states (Colorado, Kansas, Missouri, and Nebraska) were in the same phase of the business cycle as the United States. Blue shading represents U.S. recessions identified using the B-B method.
Sources: Federal Reserve Bank of Philadelphia and author's calculations.

Given the potential similarities between energy-producing states, I calculate concordance indexes for two groups: New Mexico, Oklahoma, and Wyoming (energy-producing states) and Colorado, Kansas, Missouri, and Nebraska (non-energy-producing states).[3] I then determine how long each group of states spent in the same phases of the business cycle with the United States and with each other.

In general, Tenth District states were much more synchronized during periods of economic expansion. Chart 3 shows a five-year rolling window of the concordance measure. In the 1990s, both groups of states experienced robust and prolonged growth. As a result, it is not surprising that the non-energy states were perfectly synchronized with the United States for most of the mid- to late-1990s. Conversely, both energy and non-energy states were less synchronized during and after U.S. recessions, since District states entered and exited phases at different times.

On average, the non-energy-producing states were synchronized with the United States 77 percent of the time, while the energy-producing states were synchronized with the nation only 70 percent of the time. The difference between the two groups is most likely due to oil price shocks that energy-producing states were subject to outside of nationwide recessions. Synchronization between the energy-producing states and the United States reached its lowest point (0.4) in the mid-1980s during an oil supply shock. Synchronization between the energy-producing states and the nation remained low following the Great Recession and moved lower yet into 2016. Unlike synchronization across countries, synchronization across states seems to be driven by the sectors of the economy affected most during a downturn, with each recession being unique.

III. Identifying Regional Recessions in Real Time

Although the B-B method appears to be an effective way to identify past state-level recessions, it is less useful in identifying recessions in real time. As such, I use a Markov regime-switching model (proposed by Hamilton) to identify more recent turning points. The Markov regime-switching model is more complex than the B-B method, but it does not require a specific window of time to be pre-selected for each phase in the business cycle. This flexibility allows it to more closely identify the start of recessions.

The model, which is widely used in business cycle dating, provides an alternative way to identify turning points by allowing the average growth rate to switch between different regimes (for example, between a high-growth and low-growth regime). The timing of these regimes and the growth rates within them are then estimated from the data. The model can be expressed as:

$$Y_t = c(S_t) + \phi Y_{t-1} + \varepsilon_t, \tag{1}$$

where Y_t is the month-to-month growth in the state-level coincident index, c represents the mean growth rate that switches between high or low average growth regimes (S_t), ϕ is the autoregressive coefficient on previous growth Y_{t-1}, and ε_t accounts for differences in growth not captured by the model.[4] The model can be generalized to allow regime-switching in the persistence of growth (L_t) and in the volatility of growth (V_t) as shown by:

$$Y_t = c(S_t) + \phi(L_t)\, Y_{t-1} + \sigma(V_t)\varepsilon_t. \tag{2}$$

With this specification, each state can be in one of eight possible regime combinations. The variables S_t, L_t, and V_t allow the average growth rate to be high or low, the persistence of growth to be high or low, and the volatility of growth to be high or low at each point in time depending upon the regime. Each of the regimes across the variables are assumed to be independent of one another. While it need not be the case, the low average growth regime turns out to indicate when a state is in recession. In addition, while more than two regimes can be considered for each variable—such as high, medium, and low for each regime type (see Foerster and Choi)—I consider only two, because it is more consistent with economies being in expansions or recessions.

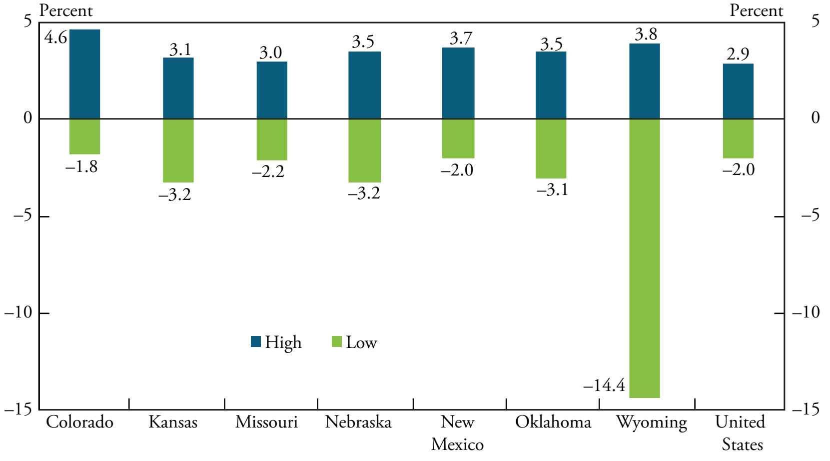
Moving from one regime to another is assumed to follow a Markov process, where the regime at a given point in time depends on the probability of being in that same regime in the previous period. In this case, P^c_{hh} and P^c_{ll} measure the probability that the state economy will be in the high or low average growth regime if it was in that regime in the previous period. Similarly, P^c_{hl} and P^c_{lh} measure the probability of switching from the high to low or low to high growth regimes. The expected duration of remaining in a regime is approximated by $1/\left(1-P^c_{ll}\right)$ for the low growth/recession regime and by $1/\left(1-P^c_{hh}\right)$ for the high growth/expansion regime.

Average growth regimes

Persistence and volatility in growth are important for determining regime probabilities, but seem to matter less in explaining growth for most states. As a result, the subsequent discussion focuses primarily on the average growth regime. The average growth rate in the high-growth and low-growth regimes differs greatly across states. Chart 4 reports annualized growth rates by state.[5] Colorado has the highest average growth in the high-growth regime (4.6 percent), as well as the highest average growth in the low-growth regime (–1.8 percent) compared with other District states. These results are consistent with Colorado's persistent and faster growth in the region. Following Colorado, Wyoming has the next highest average growth in the high-growth regime (3.8 percent). However, Wyoming has the lowest growth of all Tenth District states in the low-growth regime (–14.4 percent). This result is striking but consistent with Owyang, Piger, and Wall, who estimate a nearly –15.0 percent growth rate in Wyoming's low-growth regime from 1979 to 2002.[6]

In addition, Wyoming's growth is more volatile than most District states (Table A-1). One explanation for this volatility may be Wyoming's share of economic activity from the mining sector, which is among the

Chart 4
Average Annualized Growth by Regime



Sources: Federal Reserve Bank of Philadelphia and author's calculations.

highest in the nation (Brown). Lower or higher volatility in growth is consistent with previous findings that regions that depend more on resource extraction are more subject to boom-bust cycles and slower growth over time (Jacobsen and Parker).

The remaining District states have similar growth rates in the high-growth (3.0 to 3.7 percent) and low-growth (–2.0 to –3.2 percent) regimes. For comparison, U.S. average growth is 2.9 percent in the high-growth regime and –2.0 percent in the low-growth regime. Of all the Tenth District states, Missouri is the most similar to U.S. average growth by regime. Missouri is also the District state with the most similar industrial composition to the nation (Federal Reserve Bank of Kansas City).

Both expansion and recession phases of the states' business cycles are persistent. However, the probability of a state remaining in a high-growth regime or expansion is higher than remaining in the low-growth regime or recession (Table 3). Kansas and Wyoming have the highest probability of remaining in an expansion phase in a given month at 0.985, with an expected duration of 67 months. During a downturn, Kansas and Missouri have the highest probability of remaining in recession at around 0.96, with an expected duration of just over two years.

Table 3
Regime Probabilities and Expected Duration

State	Expansion		Recession	
	Probability of remaining	Expected duration (months)	Probability of remaining	Expected duration (months)
Colorado	0.977	43	0.922	13
Kansas	0.985	67	0.960	25
Missouri	0.981	53	0.961	25
Nebraska	0.971	34	0.849	7
New Mexico	0.958	24	0.839	6
Oklahoma	0.956	23	0.883	9
Wyoming	0.985	67	0.875	8

Note: Expected duration is calculated by $1/(1-P^c_{hh})$ for expansion and $1/(1-P^c_{ll})$ for recession.

The estimated expected duration of recessions in each District state ranged from eight to 25 months. With the exception of Wyoming, the Markov regime-switching model indicates that energy-producing states spend less time in both expansionary and recessionary phases than non-energy states. The estimated ranges nearly match the phase and cycle lengths (12 and 24 months, respectively) used in the B-B method; the close fit suggests the cycle length estimated from the Markov regime-switching model could be used to set parameters for the B-B method.

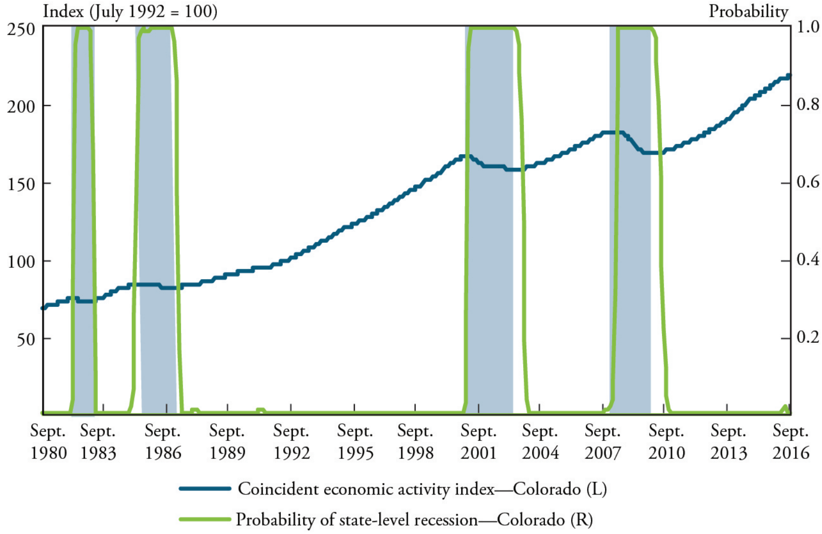
Comparing two methods of business-cycle dating

The B-B and Markov regime-switching methods identify many of the same recessions, though the exact dates of the turning points can differ by a few months. Chart 5, Panels A–G illustrate the business cycles identified for each state in the Tenth District under both methods. The shaded regions denote recessionary periods identified by the B-B algorithm, the blue line shows the state-level coincident index, and the green line shows the probability of recession from the Markov regime-switching model. A reading above 0.5 indicates the low-growth regime consistent with a recessionary period. The panels in Chart 5 show that, generally, the Markov regime-switching model identifies the same recessions as the B-B method. For example, the green line in Panel A borders the recessions identified by the blue shading, suggesting that both methods identified recessions in Colorado in 1981–82, 1985–86, 2001, and 2008–09. However, the two methods differ with respect to

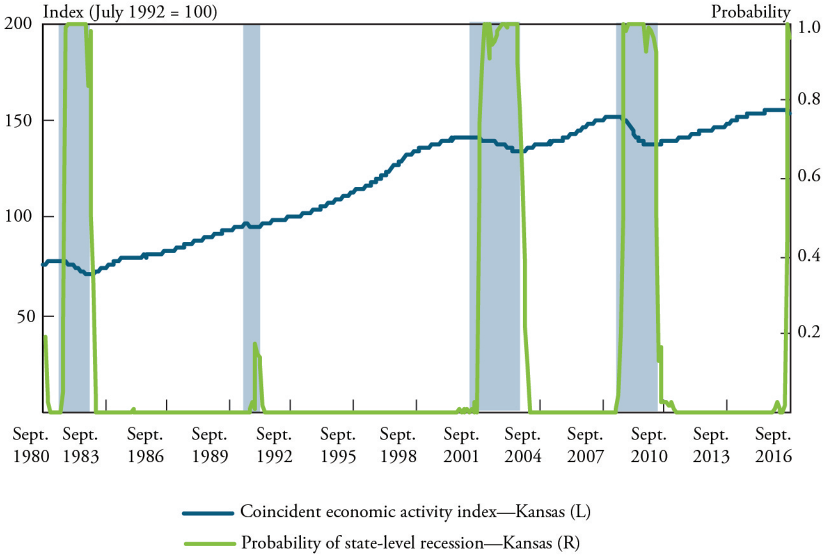
Chart 5

Business Cycles of Tenth District States

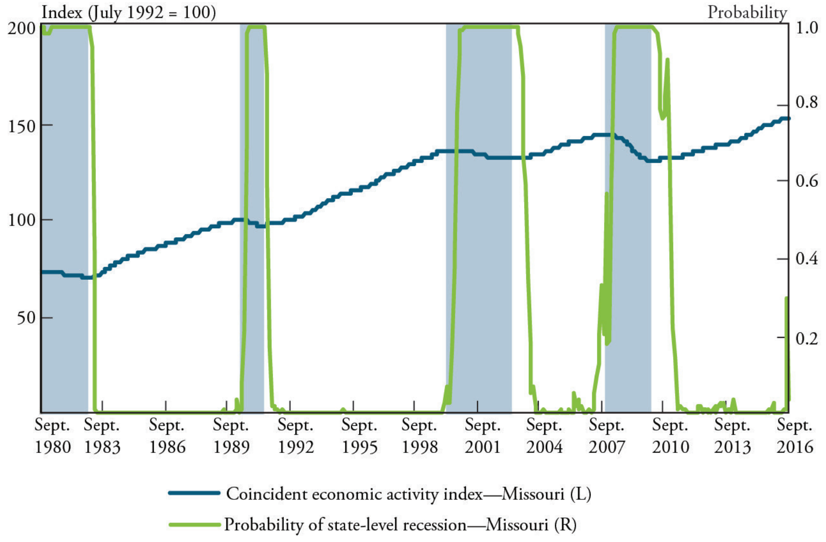
Panel A: Colorado



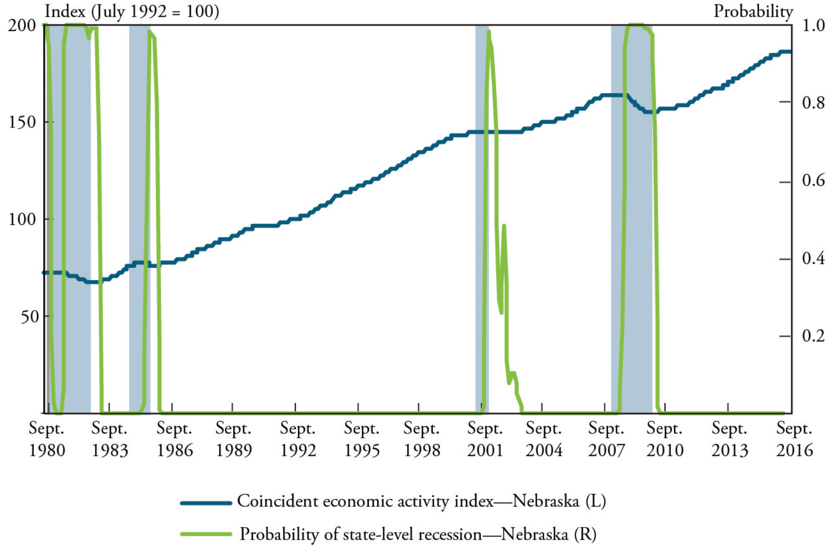
Panel B: Kansas



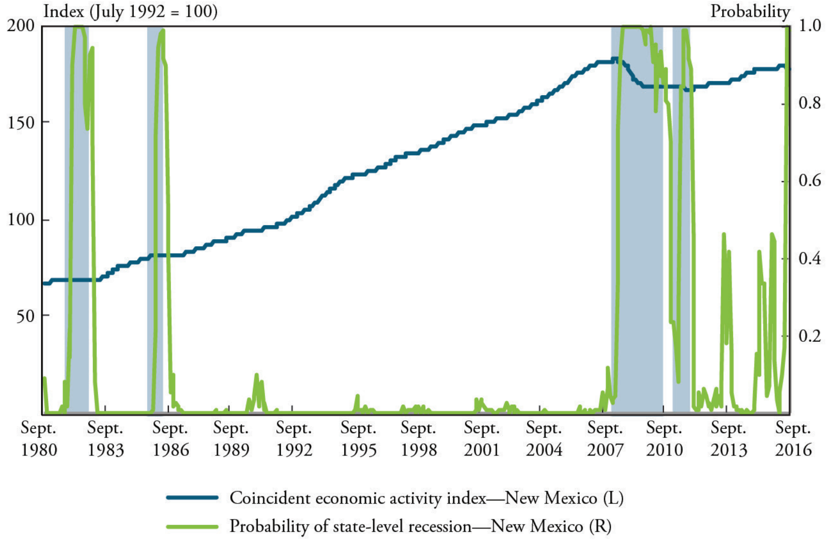
Panel C: Missouri



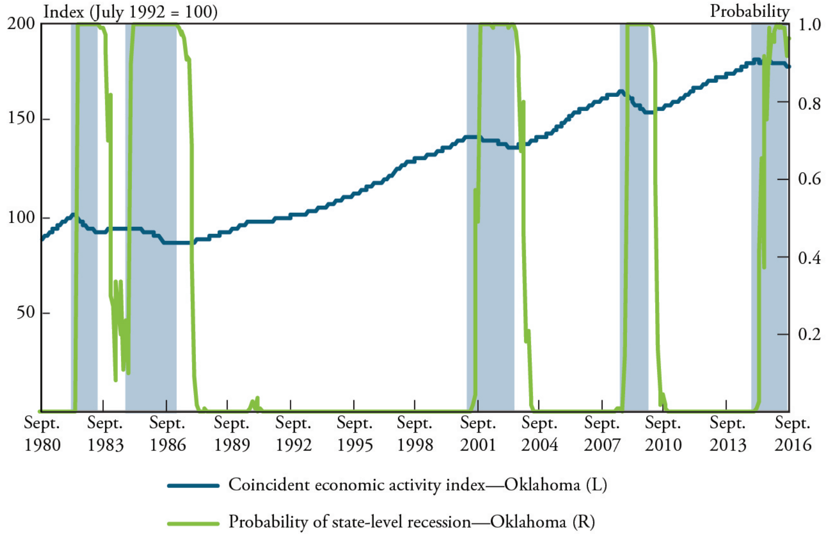
Panel D: Nebraska



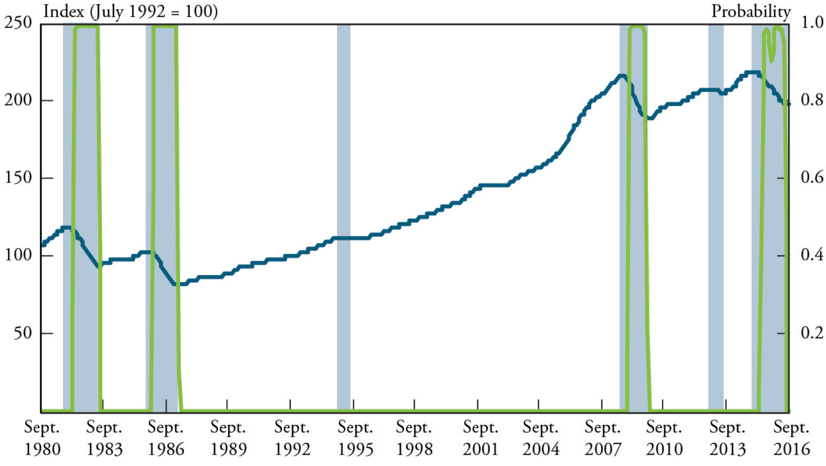
Panel E: New Mexico



Panel F: Oklahoma



Panel G: Wyoming



Sources: Federal Reserve Bank of Philadelphia and author's calculations.

Table 4

Contemporaneous Recession Dating

State	2015–16			
	B-B Enter	RS Enter	B-B Exit	RS Exit
Colorado				
Kansas		Aug.-16		?
Missouri				
Nebraska				
New Mexico		July-16		?
Oklahoma	Jan.-15	May-15	?	?
Wyoming	Jan.-15	June-15	?	July-16

Note: Question mark indicates that the state was still in recession as of September 2016.
Sources: Federal Reserve Bank of Philadelphia and author's calculations.

timing. In general, the regime probabilities identify downturns slightly later than the B-B method.

In addition, only the Markov regime-switching model identified the start of recessions in early to mid-2016 in Kansas (Panel B) and New Mexico (Panel E). The blank entry for Kansas and New Mexico in the "B-B Enter" column of Table 4 shows that the B-B method did not identify these more recent recessions. The most likely reason is that not enough time had passed to satisfy the cycle-length constraint of six months: the B-B method would likely not identify these recessions until January or February 2017.

While there could be numerous causal factors for recent state recessions, changes in oil prices are likely a main driver. Over the past couple of years, the price of oil fell substantially mostly due to changes in expectations of future oil demand relative to available supply (Davig and others). Oil price declines are a plausible explanation for recent recessions in New Mexico, Oklahoma, and Wyoming (given their relative dependence on the oil and gas sector) and may be a contributing factor in Kansas as well. As of September 2016, Kansas, New Mexico, and Oklahoma still appeared to be in recession, with Wyoming possibly exiting in the prior months (Table 4). It is worth noting, however, that the most recent readings of the coincident index can be subject to (generally small) revisions.

According to the Markov regime-switching model, the most recent downturns occurred in New Mexico (July 2016) and Kansas (August 2016). The rise in the recession probability in both states follows several months of slowing growth and then declining economic conditions in those states. The B-B method did not identify these recessions, likely because of the cycle- and phase-length constraints. However, as time passes, the B-B method will likely identify a turning point. Both methods have unique advantages in dating state-level recessions: the B-B method can more precisely identify recessions after they occur, while the Markov regime-switching model may offer a better real-time indication of recessions.

IV. Conclusion

States and regions may enter economic downturns even when the nation as a whole continues to grow. The energy-producing states in the Tenth Federal Reserve District, for example, have often diverged from the United States as a whole over the past 35 years. In the mid-1980s, Oklahoma, New Mexico, and Wyoming entered recessions due to an oil supply shock that dramatically reduced the price of oil. More recently, a similar phenomenon has occurred, as global supply and demand for oil are out of balance. The subsequent drop in oil prices and oil-related activity hit Wyoming first followed by Oklahoma, New Mexico, and Kansas. As of September 2016, Oklahoma, New Mexico, and Kansas were still in recession, with Wyoming appearing to exit in late summer.

The combined results from two recession dating methods show that Tenth District states spend more time in recession compared with the United States as a whole. Moreover, the results show that energy-producing states typically enter and exit national recessions later and have more frequent (but shorter) recessions than non-energy-producing states. While both methods are useful in identifying state-level recessions, the Markov regime-switching model appears better than the Bry-Boschan method in identifying recessions in real time.

Appendix

Additional Tables

Table A-1

Timing of District State Recessions

State	1981–82		1990–91		2001		2008–09	
NBER dated	Enter	Exit	Enter	Exit	Enter	Exit	Enter	Exit
United States	Aug.-81	Nov.-82	Aug.-90	Mar.-91	Apr.-01	Nov.-01	Jan.-08	June-09
B-B dated								
United States	Sep.-81	Nov.-82	Sep.-90	Apr.-91	Apr.-01	Jan.-02	Apr.-08	Oct.-09
Colorado	Mar.-82	Nov.-82			Feb.-01	June-03	Apr.-08	Jan.-10
Kansas	July-81	Dec.-82	May-90	Feb.-91	Apr.-01	July-03	Apr.-08	Mar.-10
Missouri	Apr.-79	Dec.-82	May-90	May-91	May-00	June-03	Jan.-08	Feb.-10
Nebraska	Mar.-81	Jan.-83			Aug.-01	Mar.-02	Mar.-08	Jan.-10
New Mexico	Dec.-81	Dec.-82					Apr.-08	Sep.-10
Oklahoma	Mar.-82	May-83			May-01	June-03	Sep.-08	Dec.-09
Wyoming	Nov.-81	June-83					Sep.-08	Dec.-09

Sources: NBER, Federal Reserve Bank of Philadelphia, and author's calculations.

Table A-2

Timing of District State Recessions

State	Average growth regime		Auto-correlation regime		Volatility regime	
	High	Low	High	Low	High	Low
Colorado	0.0038*** (39.971)	–0.0015*** (–7.989)	–0.0022 (–0.044)	–0.0965*** (–2.017)	2.9e-06*** (3.452)	--
Kansas	0.0026*** (23.759)	–0.0027*** (–4.634)	0.1090 (1.008)	0.0509 (1.106)	9.8e-06** (2.554)	4.6e-06*** (4.675)
Missouri	0.0025*** (18.356)	–0.0018*** (–14.031)	0.0177 (0.411)	–0.0031 (–0.080)	3.4e-06*** (4.224)	--
Nebraska	0.0029*** (33.926)	–0.0027*** (–9.015)	0.0639 (0.558)	0.0465 (1.608)	5.6e-06 (1.486)	2.8e-06*** (3.640)
New Mexico	0.0031*** (24.226)	–0.0017*** (–6.521)	0.1665*** (3.866)	–0.0105 (–0.200)	2.9e-06*** (3.109)	--
Oklahoma	0.0029*** (18.968)	–0.0026*** (–9.973)	–0.0022 (–0.032)	–0.0249 (–0.447)	5.2e-06*** (4.408)	--
Wyoming	0.0032*** (16.987)	–0.0120*** (–44.486)	0.0269 (0.516)	0.0232 (0.551)	9.7e-06*** (6.775)	--
United States	0.0024*** (43.765)	–0.0017*** (–13.176)	0.0784*** (3.260)	–0.0071 (–0.092)	1.1e-06** (2.190)	

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level
Note: T-statistics are reported in parentheses.
Sources: NBER, Federal Reserve Bank of Philadelphia, and author's calculations.

Endnotes

[1]Results are robust to changes in the window, cycle, and phase. However, if the time period for the phase is made too short, the algorithm tends to identify more turning points. In both recessions and expansions, brief reversals in economic activity may occur. As a result, setting the parameters to time periods too short could lead to false positive indications of recessions.

[2]The index of concordance between state i and j is: $IC_{ij}=n^{-1}\left(\sum_{t=1}^{T} P_{it}P_{jt}+\left(1-P_{it}\right)\left(1-P_{jt}\right)\right)$, where P_{it} = P_{jt} = 1 indicates that states i and j are in expansion, P_{it} = P_{jt} = 0 indicates the states are in recession at time t, and n is the total number of time periods.

[3]Colorado and Kansas do produce oil and gas but on a much smaller scale than New Mexico, Oklahoma, and Wyoming.

[4]Owyang, Piger, and Wall; and Hamilton and Owyang use a similar model to investigate business-cycle phases in U.S. states.

[5]Complete results of the Markov regime-switching model are reported in Appendix Table A-2.

[6]Owyang, Piger, and Wall's estimate of Wyoming average month-over-month growth in the low-growth regime is −1.246 , which is −14.95 percent at an annualized rate.

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