Detecting Recessions in the Great Moderation: A Real-Time Analysis

By Troy Davig

The nature of the business cycle, particularly in the United States, has changed dramatically over the past several decades. In the 1970s and early 1980s, the U.S. economy often whipsawed up and down. Since then, real economic activity stabilized considerably, entering a period economists call the "Great Moderation." With the ups and downs of the economy becoming less dramatic, it has become harder to determine in real time when the economy dips into recession.

Economists have a variety of methods to determine when the economy is entering a recession. These methods range from directly analyzing a broad spectrum of data to the formal use of recession prediction models. The National Bureau of Economic Research (NBER) uses the first approach, relying on several data series to make a determination of when the economy enters or exits a recession. Their decisions are intended to be accurate, not timely. More formal recession prediction models are designed to send a timely signal, but often do not take account of how the Great Moderation has altered the business cycle.

This article uses a framework that efficiently utilizes a large set of data in a "business cycle tracking" model. The model accounts for shifts

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Troy Davig is an assistant vice president and economist at the Federal Reserve Bank of Kansas City. This article is on the bank's website at ***www.KansasCityFed.org.***

in overall economic volatility—to capture the Great Moderation—and sends a signal when the economy is shifting between periods of low and high economic activity. Historically, the low-growth regimes identified by the model correspond closely to NBER-defined recessions. Prior to the Great Moderation, the low-growth regimes were short-lived but exhibited a sharp contraction in economic activity. During the Great Moderation, the low-growth regimes have lasted longer but do not exhibit as pronounced of a decline in economic activity. In this respect, the low-growth regimes over the past few decades have basically traded "depth" for "length" compared to the earlier era.

The business cycle tracking model can be used in different ways to extract a signal regarding whether the economy is likely heading for a NBER recession. One method uses a rule-of-thumb that signals whether the economy is "in" or "not in" a condition that will likely turn into a recession. The second method generates a probability that provides a signal of "how likely" it is that the economy is heading for a recession. The methods are complementary; the difference is that one is simple to use (i.e., the rule-of-thumb) and the other requires more sophistication (i.e., computing the probability using the model).

The first section of the article addresses the anemic growth in 2008 and how this period relates to the NBER's definition of a recession. The second section describes an economic activity index that is used as input into the business cycle tracking model. The third section outlines the business cycle tracking model. The fourth section uses the model and the economic activity index to provide a reading on the current state of the business cycle.

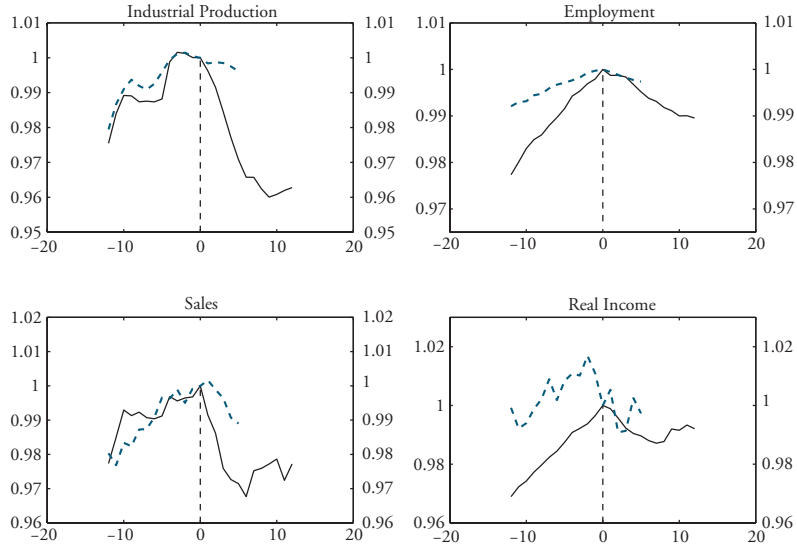
I. IS THE U.S. CURRENTLY IN AN NBER-DEFINED RECESSION?

Currently, the financial system in the United States is facing considerable strain. Financial markets are highly volatile, new jobs have posted a net loss every month this year through September, and the unemployment rate has risen from 4.4 percent in March of last year to 6.1 percent in September. Yet the National Bureau of Economic Research (NBER) has not yet declared the United States to be in a recession.

According to a common rule-of-thumb, the economy is not in a recession until national output declines for two consecutive quarters.

Chart 1

U.S. DATA AROUND NBER PEAKS



(Solid line – Average over past 7 NBER recessions, 1 = NBER peak)
(Dashed line – Data series with Dec-07 as hypothetical peak)

Despite the weakening labor market, the economy actually expanded in the first two quarters of 2008. In the second quarter, the economy grew 2.8 percent due to productivity gains, strong export growth and a temporary fiscal stimulus package. For comparison, in some of the worst quarters in the recessions of the early 1980s, the economy contracted more than 6 percent at an annual rate. In the two most recent recessions, 1990-91 and 2001, the economy experienced a less dramatic decline in total output but still saw at least a few quarters of negative growth.

Rather than rely on such a simple rule-of-thumb, the Business Cycle Dating Committee of the NBER considers several different monthly data series when determining the beginning and end of a recession. Some of the series most actively monitored by NBER include industrial production, employment, retail sales, and real income. The average behavior of each of these series around a business cycle peak is given by the dark solid line in Chart 1. On the horizontal axis, the 0 marker denotes the NBER business cycle peak. Each series is standardized, so they each equal 1 at the peak.

WHAT IS A RECESSION?

The "business cycle" is a term economists use to describe the fluctuations in the growth of the economy over time. From quarter to quarter, the economy displays volatility for a wide variety of reasons and may enter a state where the amount of economy activity actually contracts for a sustained period of time. That is, the amount of goods and services produced in the U.S. within a year, which is the definition of real gross domestic product (real GDP), declines. Sustained periods of declining real GDP are unusual, at least in recent decades, and are periods economists commonly refer to as recessions.

A common rule-of-thumb is that the economy enters a recession once it has at least two consecutive quarters of negative real GDP growth. This rule is useful but is also a bit too simplistic. Often recessions do conform to this rule—however, there are exceptions, such the 2001 recession. In the U.S., the unofficial arbiter of determining when recessions begin and end is the Business Cycle Dating Committee at the NBER. As background, the NBER was formed in 1920 as a consortium of research economists and first published its business cycle chronology in 1929. From 1929 until 1978, the business cycle chronology was periodically updated and revised. In 1978, the new president of the NBER, Martin Feldstein of Harvard University, officially established the Business Cycle Dating Committee. Their definition of a recession is as follows:[A]

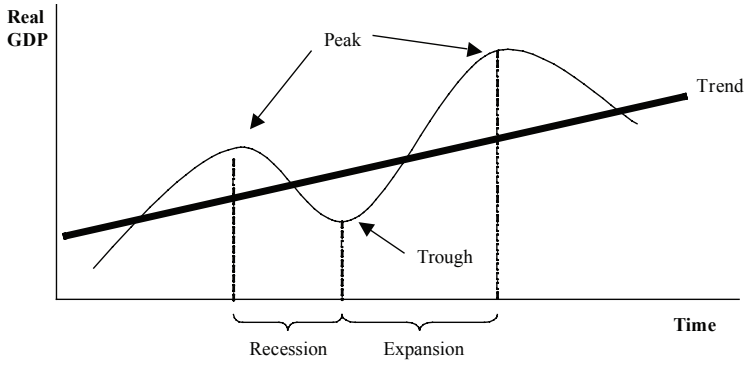
> A recession is a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales. A recession begins just after the economy reaches a peak of activity and ends as the economy reaches its trough. Between trough and peak, the economy is in an expansion. Expansion is the normal state of the economy; most recessions are brief and they have been rare in recent decades.

To more clearly fix these definitions, a stylized depiction of the business cycle is given in Figure B1. The figure also includes a straight line that denotes the trend level of real GDP, which captures the average rate of growth after smoothing out the business cycle fluctuations.

The Business Cycle Dating Committee discusses announcing a peak or trough when a sufficient amount of data have accumulated to suggest the economy may have reached a turning point. If the committee agrees that the economy has passed through a peak or trough, then it issues an announcement giving the month and year of the turning point. Since its inception, the committee has not revised any of the original announcements regarding the dating of peaks and troughs.

[A]See the NBER website for additional details: *http://www.nber.org/cycles/november2001/* (accessed August 22, 2008).

Figure B1
STYLIZED BUSINESS CYCLE



The industrial production series focuses on sectors that include manufacturing, mining, and the gas and electric industries. Overall, these sectors represent around 20 percent of the economy. The reason industrial production is of interest is that it displays business cycle fluctuations that are of interest to economists and policymakers. In contrast, sectors like consumer services grow fairly steadily, since consumer demand for services like medical and child care are fairly stable.

The peaks of the four different series are fairly synchronized on average, but over the course of a given business cycle the different series can send mixed messages. The dashed lines in Chart 1 provide the current series monitored by the NBER, treating December 2007 as a hypothetical business cycle peak. The December date is unlikely to be considered the beginning of a recession, given positive growth in the first two quarters of 2008, but it serves as a useful reference point to assess the current condition of the economy relative to past recessions. Industrial production leveled off up through July of 2008, but had yet to exhibit the sharp decline as in previous recessions. Real income appears to have some semblance of a peak, but the evidence is far from conclusive. Employment and sales are exhibiting dynamics more similar to past cycles, yet differences still remain. The bottom line is that looking at different series is very useful, but in real time they can send mixed messages that complicate determining whether the economy is in a recession. As a further complication, the individual series are likely to be revised in future months.

Due to the difficulty in determining whether the economy has entered a recession, the Business Cycle Dating Committee is patient in waiting for sufficient evidence to accumulate before making an announcement. For example, the last turning point decision, as of this writing, was on July 17, 2003, when NBER announced a trough occurred in November of 2001. The announcement, coming roughly 20 months after the trough, reflects the general purpose of the Business Cycle Dating Committee, which is to compile an accurate historical record of business cycle fluctuations. The committee does not try to make a timely call regarding the beginning or end of a recession.[1]

Some economic observers may be uninterested, or believe it simply does not matter, whether the U.S. is in an NBER-defined recession. However, this view neglects that recessions exhibit very

different dynamics than expansions. Recession dynamics cause sharply rising unemployment, which in turn leads to loss of income that lowers aggregate demand and places further jobs at risk. During a recession, the economy can shed several hundreds of thousands of jobs each month, and the amount of goods and services produced by the economy declines. For example, the recession in 2001 is generally considered to be one of the milder post-World War II recessions, yet in several months the net amount of job losses exceeded 250,000. Although the economy has been shedding jobs throughout 2008, net job losses stayed roughly below 100,000 until September.

If the economy does enter an NBER recession, as appears likely, past recessions suggest the economy will experience more job losses and a contraction in the production of goods and services.

II. OPERATING IN A DATA-RICH ENVIRONMENT: USING AN ECONOMIC ACTIVITY INDEX

Policymakers and business people are often interested in determining as quickly as possible whether the economy has entered a recession. As the previous section discussed, the NBER does not seek to make a quick decision, only an accurate one, so their decisions are not useful as a real-time indicator. Real gross domestic product is the most comprehensive measure of economic activity but has limited use as a real-time indicator because it is released with a lag and at a quarterly frequency. Hundreds of data series are available monthly that track different aspects of the economy. Yet such a broad set of data often sends mixed messages about the overall economy.

As an alternative, an appealing option is to create an index of economic activity that can be easily updated with incoming data and thus take advantage of the available data-rich environment. One method of creating such an index is to use what is called principal component analysis, a method that compresses several data series into one index number.[2] The resulting index can be interpreted similar to a stock market index, such as the Dow Jones Industrial Average, except that it gauges underlying real economic activity.

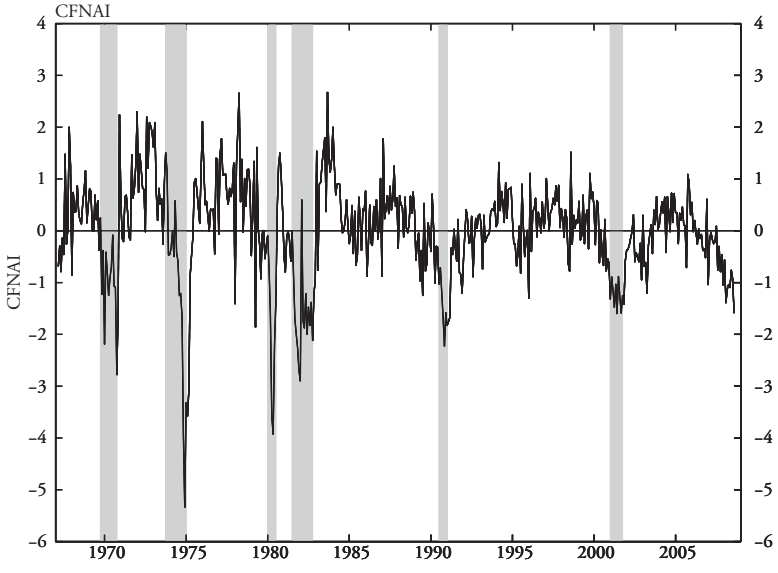
One readily available series is the Chicago Fed National Activity Index (CFNAI), originally developed by Stock and Watson (1999). The CFNAI is extracted from 85 separate economic series describing

the real economy. The data series in the CFNAI cover five broad categories of data: 1) production and income; 2) employment, unemployment, and hours; 3) personal consumption and housing; 4) manufacturing and trade sales; and 5) inventories. The CFNAI does not include financial variables because it focuses on data that directly measure real economic activity. The CFNAI has been compiled and released to the public on a regular basis beginning in January 2001 and covers 1967 to the present.

Chart 2 graphs the CFNAI against the NBER recession dates, which are indicated by the gray bars. The CFNAI is normalized to equal zero on average, so positive values denote economic activity above its trend rate of growth, whereas negative values indicate below-trend growth. A number of features of this series stand out. First, the series declines around recessions and typically falls below zero at times closely corresponding to NBER recession dates. Second, the Great Moderation is readily apparent, with volatility in the series dropping dramatically after about 1984. And third, declines in the CFNAI around recessions during the Great Moderation were not as deep, came on more gradually, and also dissipated more slowly than prior to the Great Moderation. For example, take any recession prior to 1984 and notice the CFNAI abruptly turns negative at the onset of the recession and then abruptly turns positive once the recession ends. Contrast this with after 1984 when the CFNAI turns mildly negative well before the start of each recession.

The cause of the Great Moderation is the subject of much debate. Some leading theories focus on better management of inventories, less volatile durable goods production, a shift towards a more service-based economy, and improved monetary policy.[3] These theories emphasize that a permanent, or at least long-lived, change in the economy has occurred. So going forward, economic activity should be expected to continue to expand at a relatively stable pace. Other prominent theories on the cause of the Great Moderation, however, emphasize that the economy has been buffeted by smaller shocks. Shocks refer to unanticipated events that cause businesses, consumers, and the government to adjust their behavior or policies. A sudden technological breakthrough is an example of a positive economic shock, whereas a drought is an example of a negative one. In general, the debate on the source of the Great Moderation is often couched in terms of "good policy" (i.e., the

Chart 2
CHICAGO FED NATIONAL ACTIVITY INDEX



outcome of improved business practices and government policies) versus "good luck" (i.e., smaller shocks).

The ability of economists and policymakers to track the business cycle depends to some extent on which theory is most accurate. If the good-luck theories best explain the decline in economic volatility, then the economy can return at any time to the dissonant boom-bust cycle it exhibited prior to 1984. Alternatively, if the good-policy theories prove to be a better explanation for the decline in activity, then continued low volatility is likely to occur going forward.

The next section uses the CFNAI in a model that detects sustained periods of low or negative growth, often corresponding to NBER recessions, while also accounting for how the Great Moderation has changed the dynamics of the business cycle.

CHANGES IN THE DURATION AND FREQUENCY OF RECESSIONS

In general, recessions have become shorter and expansions much longer over the past 150 years. Using the NBER business cycle chronology, a few summary statistics regarding recessions and expansions are given in Table B1. From the end of the Civil War until around the end of World War I, the U.S. had 13 recessions with an average duration of about two years. During this period, the economy was in recession about half of the time. From the end of World War I to World War II, the economy was in recession about 30 percent of the time. Then from the end of the Korean War until roughly the beginning of the Great Moderation, which many studies date as beginning around 1984, the economy was in recession about 20 percent of the time. During the Great Moderation, the economy has been in recession only 7 percent of the time, with a recession occurring about once every 12 years.

Table B1

BUSINESS CYCLE STATISTICS

Period	# of Recessions	Average Recession Duration	Average Expansion Duration	Time in Recession	Frequency of Recessions
1865-1914	13	24 months	25 months	50 percent	3.8 years
1918-1949	8	16 months	36 months	30 percent	3.9 years
1953-1982	7	11 months	46 months	20 percent	4.3 years
1983-2007	2	8 months	106 months	7 percent	12 years

III. USING A MODEL TO CHARACTERIZE SHIFTS IN THE BUSINESS CYCLE

The monthly value of the CFNAI provides a timely indicator for the current state of the economy. However, policymakers and business people would like to know at what point a decline in the CFNAI signals the onset of a recession. One difficulty that immediately arises is that fluctuations in the CFNAI in the era before the Great Moderation look different than during the Great Moderation. For example, the recent decline in the CFNAI may look similar to declines before the 1990-91 and 2001 recessions but appear different than the sharp declines that occurred prior to the Great Moderation.

To provide structure to how the Great Moderation may shift the interpretation of the CFNAI and assess how the business cycle may have changed, a model is necessary. The model in this analysis will be referred to as the "business cycle tracking" model and provides a signal indicating whether the economy is in a sustained period of low or below-trend growth.[4]

As a brief sketch, the following equation describes the primary features of the model:

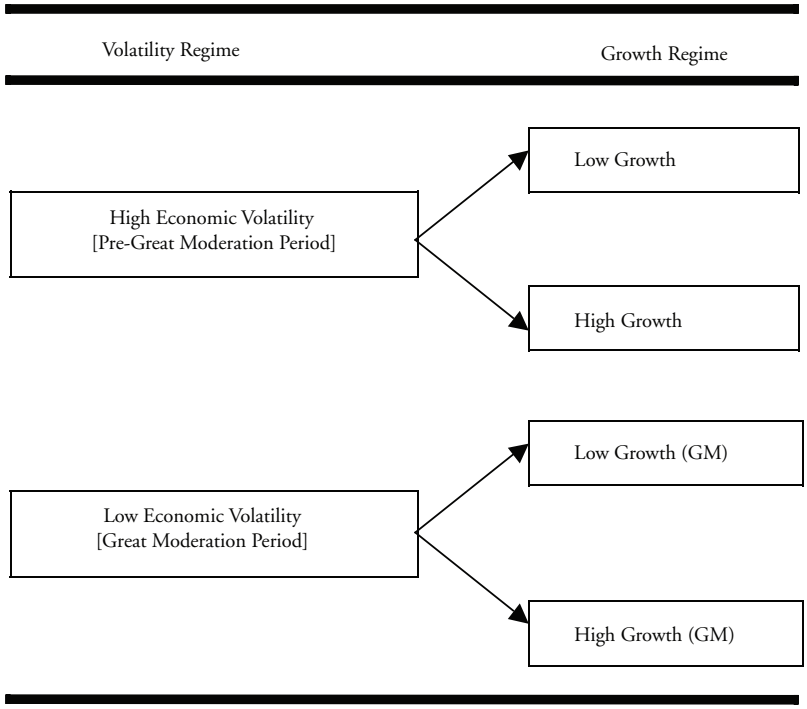
$$CFNAI_t = (1-\rho)*\mu_t + \rho*CFNAI_{t-1} + \varepsilon_t,$$

where ε_t is a random shock that is highly volatile prior to the Great Moderation and less volatile during the Great Moderation. In this model, the current value of the CFNAI is a weighted combination of the average growth rate of the CFNAI, given by μ_t, and the prior month's value of the CFNAI plus a shock. The coefficient ρ captures the persistence in the CFNAI and must lie between -1 and 1. The average growth rate μ_t can take four different values depending on whether the economy was in a high or low-growth regime and in the Great Moderation. Further details regarding the model are given in the appendix.

Figure 1 illustrates the breakdown of the four different regimes. The model allows average rates of growth prior to the Great Moderation, labeled Low Growth and High Growth, to differ from the average growth rates in the Great Moderation, labeled Low Growth (GM) and High Growth (GM).

The model captures the observation that expansions are less pronounced during the Great Moderation and recessions are less severe by requiring the following relationships to hold:

Figure 1



$$\text{Low Growth} < \text{Low Growth (GM)}$$
$$\text{High Growth} > \text{High Growth (GM)}$$

Simply stated, these inequalities indicate that the difference between the boom and bust regimes has become smaller.

An additional feature of the business cycle tracking model, which is not depicted in the diagram, is that the expected duration of the different business cycle regimes can vary depending on whether the economy was in the Great Moderation. For example, this feature allows the average length of an expansion to be longer in the Great Moderation era.

For historical analysis, data on real GDP growth could be used to estimate the business cycle tracking model.[5] The model would then provide the approximate starting date of the Great Moderation and identify historical periods when the economy entered into sustained periods of low or negative growth. However, given the quarterly frequency of real GDP and that it is released with a lag, it is of limited use for real-time analysis. Instead, the CFNAI is used to estimate the business

cycle tracking model because it is available at a monthly frequency and captures historical business cycle fluctuations, so is useful for generating a timely indicator regarding the state of the business cycle.

Taking the CFNAI as input, the model returns two different series of numbers. The first series represents the probability that the economy was in a low-volatility regime at a given date. The second series represents the probability indicating whether the economy is in a low-growth regime (i.e., below-trend growth). Since each series consists of probabilities, every value must lie between zero and one.

Turning first to the results indicating the onset of the Great Moderation, Chart 3 plots the ex-post probabilities that indicate whether the economy was in a low-volatility regime.[6] Prior to 1984, the probability was typically close to 0, indicating the economy was in a state characterized by relatively high volatility. The probability jumps around somewhat, which is due to several months where economic activity was relatively stable. The late 1960s had a brief period of stable economic growth, which corresponds to the early spike in the probability. However, the volatile 1970s pushes this probability back near zero for most of the decade. The model detects a shift to the low-volatility regime in early 1984, a date that corresponds with other studies focusing on dating the onset of the Great Moderation.[7]

An important point to keep in mind is that shifts in the volatility of overall economic activity are low-frequency events, which means they have occurred very infrequently throughout history. This does not imply that the economy will not have occasionally surprisingly high or low quarters of growth, but, in terms of tracking the current state of the business cycle, the working assumption in the model is that the economy remains in the low-volatility regime.

Turning now to the probabilities indicating the state of the business cycle, Chart 4 plots the ex-post probabilities, and Chart 5 plots the real-time probabilities that the economy was in a low or below-trend growth regime. NBER recession dates roughly correspond to the low-growth periods. Prior to 1984, the low-growth periods typically fall within the official NBER recession dates. However, in the Great Moderation, the pattern reverses—recessions typically fall into the low-growth periods, since the low-growth periods last longer than recessions. In the Great Moderation era, low-growth regimes start slightly before the onset of

Chart 3

PROBABILITY THE ECONOMY IS IN A LOW-VOLATILITY STATE

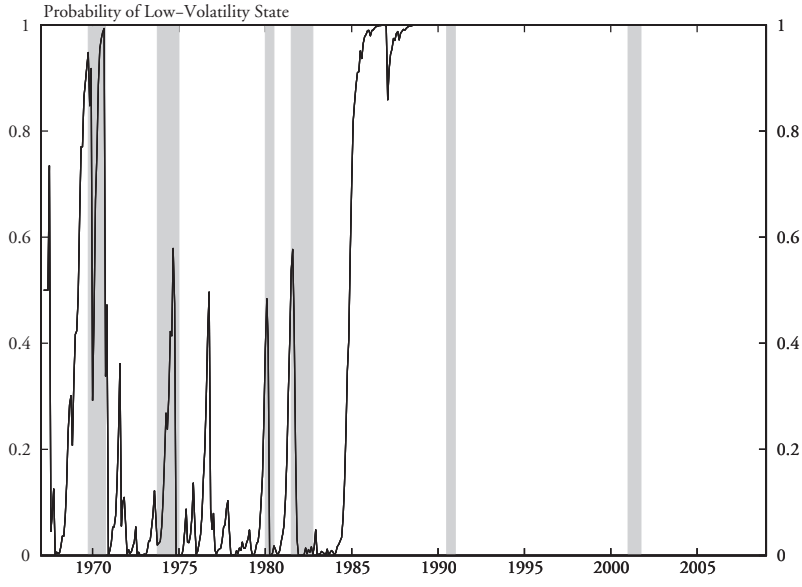


Chart 4

SMOOTHED PROBABILITIES FOR THE LOW-GROWTH STATE

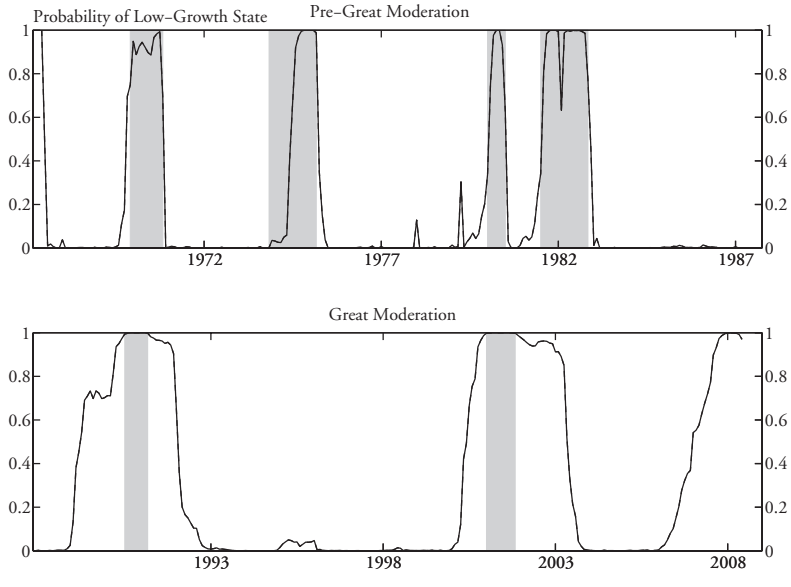
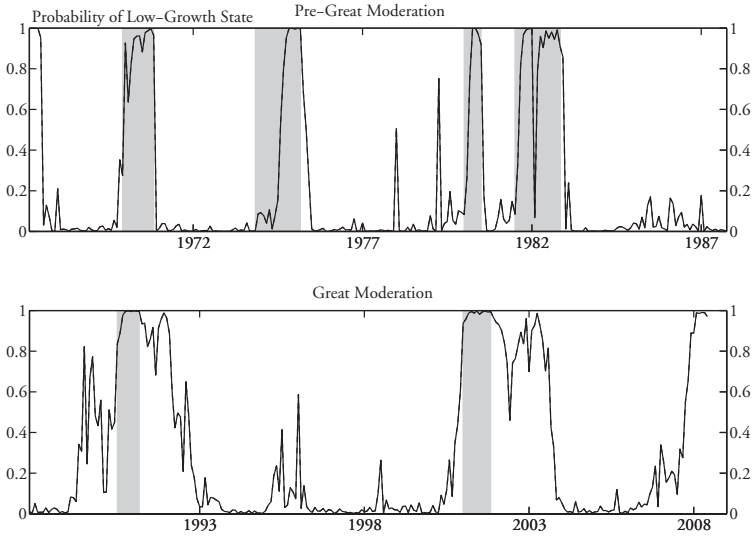


Chart 5

FILTERED PROBABILITIES FOR THE LOW-GROWTH STATE



NBER recessions and last substantially longer than the NBER-defined trough. The prolonged return to the high-growth regime can be explained by referring back to Chart 2 and noting that the CFNAI returns only gradually to positive territory.

After each of the last two recessions, each recovery also generated rather sluggish job growth—so they are often referred to as "jobless recoveries." The more gradual recoveries following the troughs are consistent with the fall in volatility during the Great Moderation. A sharp rebound in employment may be desirable but would represent a rather volatile period more consistent with the 1970s and early 1980s. However, it remains to be seen whether so-called jobless recoveries are an outgrowth of lower overall volatility, and so will be a permanent feature of business cycles going forward, or they were simply due to idiosyncratic factors associated with the last two recessions.

A related point concerns the average length of the low and high-growth regimes. Prior to the Great Moderation, the expected length of the low-growth regime, according to the model, was approximately seven months. For high-growth regimes, the expected duration was 29 months. During the Great Moderation, the expected duration for the

low-growth regime lengthened to 32 months and for the high-growth regime to 59 months. The shift in the average lengths of the different regimes is apparent in Charts 4 and 5, where the low-growth regimes have a much longer duration during the Great Moderation than in the previous era.

IV. TRACKING THE BUSINESS CYCLE

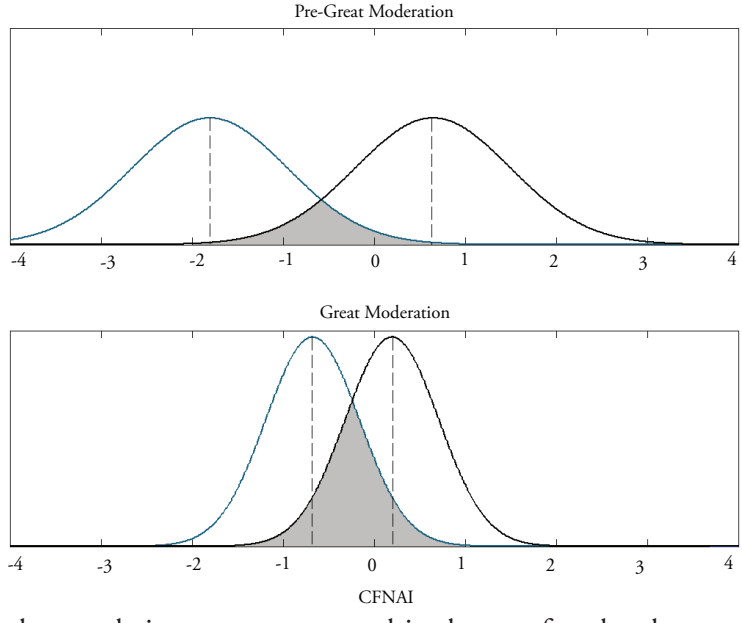
The ultimate purpose of using the CFNAI in the business cycle tracking model is to extract a signal indicating whether the economy is likely to continue expanding or slip into recession. For this purpose, there are two basic approaches. The first approach, which is intended to be simple and straightforward, uses the model to determine a rule-of-thumb that captures the state of the business cycle in real time. The second approach, which is more involved, uses the business cycle tracking model directly to generate a signal, or probability, indicating whether the economy is entering a low-growth regime.

Characterizing different business cycle regimes

The business cycle tracking model generates a signal regarding the state of the economy by determining which regime best describes a particular value of the CFNAI. Creating the signal requires using the probability distributions from the different business cycle regimes. Chart 6 shows the distributions for the regimes that are generated directly by the model. The top panel has the two distributions that describe the low-growth and high-growth regimes before the Great Moderation. The bottom panel then has the distributions during the Great Moderation. A single distribution conveys the average of the CFNAI, denoted by the vertical dashed lines, and its volatility. For example, the distribution on the left in the top panel of Chart 6 is the distribution for the CFNAI in the low-growth regime prior to the Great Moderation. On average, its value was about –1.8 but could vary anywhere between –4 and 1.[8] The height of the distribution near the tails (i.e., –4 and 1) is relatively low, indicating that extreme values far from the average are unlikely. In contrast, the distribution peaks at the average, indicating realizations of the CFNAI near the average are quite likely.

Chart 6 conveys three primary pieces of information. First, the difference between growth rates in the low and high-growth regimes is

Chart 6
IMPLIED BUSINESS CYCLE DISTRIBUTIONS



boom-bust cycle is not as pronounced in the past few decades, so the average expansion is not as dramatic and the average recession is not as deep. The second observation is that the distributions in the top panel are much more spread out, indicating higher volatility prior to the Great Moderation. The final observation is that the size of the area where the distributions overlap is much larger during the Great Moderation. This indicates that for values of the CFNAI that fall within the gray area, it is difficult to determine which business cycle regime best describes the observation. However, one feature of the business cycle tracking model is that the different business cycle regimes are persistent. This means that once the economy definitively enters a regime, it is likely to stay there for some time. So in the event an observation falls into the gray area, the model does not place much weight on the observation and instead places more weight on the regime that was in place the previous period. For example, if the probability the economy was in a high-growth regime was near 1, but the next period the CFNAI was slightly below 0, then the model would place little weight on this observation when generating the updated probability. In this case, the CFNAI would need to either

TIMELINESS OF NBER ANNOUNCEMENTS

The Business Cycle Dating Committee was officially in place for two recessions prior to the Great Moderation and for the two recessions during the Great Moderation. Evidence suggests that changes in the business cycle during the Great Moderation have made detecting recessions more difficult. Is this difficulty also apparent in the timeliness of the NBER announcements? Again, the committee does not strive to make a quick announcement, only an accurate one. However, if it is more difficult to determine when the economy has reached a turning point, the lag between the NBER turning point and the announcement should be longer in the Great Moderation period.

Table 2 gives the real-time announcement of the business cycle dating committee and the corresponding date of the business cycle turning point. For peaks, the last two peaks prior to the Great Moderation were announced five to six months after their occurrence. The two peaks during the GM were announced eight to nine months after their occurrence. For recessions the difference is even starker. During the GM, the time for the NBER to announce a trough roughly doubles.

Although this evidence is suggestive and supports the statistical analysis in the article, the changes in the timing of the announcements could reflect other factors. For example, the membership of the Business Cycle Dating Committee changes over time. The members of the committee during the last two recessions may have been more risk averse and so were more cautious in determining business cycle turning points. However, the Business Cycle Dating committee has been quite stable over the course of its existence in terms of membership. For example, Robert Hall of Stanford University has been the chair since its inception. Another potential reason not to infer too much from Table B2 is that the business cycle dating committee deliberately takes a retrospective approach. So whether the announcement is

made, say, six months or one year after a turning point, may be of little concern to the committee. However, incoming data still likely played a role in why the time between the trough and the announcement doubled during the Great Moderation. Also, the number of turning-point observations available since the formation of the NBER business cycle dating committee is very small (i.e., four turning points prior to and four during the Great Moderation), so it is inappropriate to draw any statistical conclusions based on this small set of data. Despite these caveats, the timing of the announcements and turning points is anecdotal evidence that supports the formal statistical analysis. In general, this evidence further suggests that with the onset of the Great Moderation, detecting turning points in real time is more difficult.

Table B2

Peak Date	Announcement of Peak Date	Lag Between Peak Date and Announcement
Pre-Great Moderation		
January 1980	June 3, 1980	5 months
July 1981	January 6, 1982	6 months
Great Moderation		
July 1990	April 25, 1991	9 months
March 2001	November 26, 2001	8 months

Trough Date	Announcement of Trough Date	Lag Between Trough Date and Announcement
Pre-Great Moderation		
July 1980	July 8, 1981	12 months
November 1982	July 8, 1983	8 months
Great Moderation		
March 1991	December 22, 1992	21 months
November 2001	July 17, 2003	20 months

be slightly below 0 for several periods or dramatically below 0 for a fewer number of periods for the model to begin signaling a shift to the low-growth regime.

The strength of the signal indicating which regime the economy is in depends on the relative heights of the different distributions. For example, in the Great Moderation era, an observation of -1 sends a relatively strong signal that the low-growth regime generated the observation. The reason is that the distribution for the low-growth regime is much higher at -1 than the distribution for the high-growth regime. It is certainly possible that the high-growth regime generated the -1 observation, but the relatively low height of the distribution makes it unlikely the observation came from the high-growth regime. In contrast, an observation slightly below zero in the Great Moderation would send a very weak signal indicating the regime. The reason is that the distributions have about equal height for values slightly below zero and so are equally likely to have generated the observation.

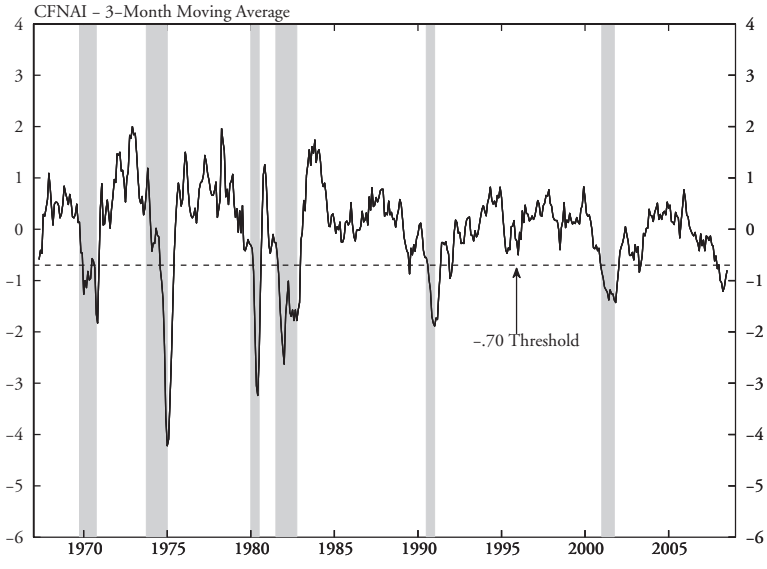
The distributions in Chart 6 also emphasize the importance of incorporating the shift in volatility into the business cycle tracking model. If the model did not have this feature, then the gradual declines and recoveries in the CFNAI over the last two recessions would send a relatively weak signal regarding an economic slowdown. Notice that the decline in the CFNAI was around 1.5 to 2.0 in each of the last two recessions. While these values certainly signal a slowing in economic activity, they still reside in the tail of the high-growth distribution for the pre-Great Moderation era. In contrast, the values 1.5 to 2.0 are solidly outside of the high-growth distribution for the Great Moderation and so produce a much stronger signal concerning an impending economic slowdown.

A rule-of-thumb for signaling a recession

Turning first to the rule-of-thumb, the press release of the CFNAI by the Federal Reserve Bank of Chicago provides a rule-of-thumb that indicates when the three-month moving average of the CFNAI falls below -0.70, then "there is an increasing likelihood that a recession has begun."[9] Chart 7 plots the three-month moving average along with this recessionary threshold. Prior to the onset of the Great Moderation, the -0.70 rule is very accurate in signaling the onset of a recession. However, in the Great Moderation, the moving average measure fell below this

Chart 7

CHICAGO FED NATIONAL ACTIVITY INDEX (3-MONTH MOVING AVERAGE)



threshold five times—not counting the most recent decline in 2008—although there were only two official NBER recessions. A signal indicating the onset of a recession when one fails to materialize can be viewed as a "false positive." During the Great Moderation, the dips below the -0.70 threshold were brief and meant only to indicate a higher likelihood that the economy is in a recession, not to convey a definitive signal. However, the relatively high number of false positives suggests a lower threshold may be appropriate during the Great Moderation.

To generate a rule-of-thumb based on the business cycle tracking model, threshold values are constructed using the distributions in Chart 6. Of course, it is always possible to find rules-of-thumb that fit the past, but it is much harder to find such rules that work well in real time. One reason for this is that the economy is constantly undergoing structural changes, with the Great Moderation being an important recent example.

Two thresholds are computed, one for before and the other for during the Great Moderation. Each threshold indicates that if a realization of the CFNAI is below it, then there is approximately a 90 percent chance the economy is in a low-growth regime. For example, the threshold for the Great Moderation implies that 10 percent of the time the economy

may be in a low-growth regime, yet the threshold would fail to send a recessionary signal.[10] The threshold prior to the Great Moderation is -1.45 and then falls to -1.31 during the Great Moderation.[11] These values may appear somewhat close, but failing to adjust the threshold to account for the Great Moderation—that is, leaving it at -1.45—would have resulted in entirely missing the onset of the 2001 recession. Also, these values are substantially below the -0.70 threshold given in the official CFNAI release and so are less likely to register false positives.[12] However, the lower value also raises the possibility of failing to signal the onset of a recession. The formal use of the business cycle distributions from the model balances the chances of making each type of error.

Chart 8 plots the CFNAI against the rule-of-thumb values from the business cycle tracking model. Prior to the Great Moderation, the threshold catches at least a few observations for each NBER recession and performs well for the recessions in the early 1980s. There is one observation in the late 1970s that drops below the threshold, yet no recession occurred. During the Great Moderation, the rule-of-thumb threshold catches the two recessions without issuing any false warnings.

The recent slowdown in economic activity has resulted in the CFNAI dropping to levels below the threshold. Thus, the rule-of-thumb suggests a high likelihood that the U.S. is either in, or heading into, a recession.

A real-time probability signal of a recession

The most recent readings from the CFNAI can be directly incorporated into the business cycle tracking model. The rule-of-thumb approach gives a binary response—that is, it either indicates the economy is "in" or "not in" a recession. Instead, the business cycle tracking model can give an estimate of the probability the economy is in a low-growth regime, which have lead to NBER-defined recessions.

As an example of this approach, Chart 9 reports the real-time probabilities for the recent low-growth regime based on data available at different points in time. This approach illustrates how the business cycle tracking model picks up the recent low-growth regime in the economy in real time. In November of 2007, the probability that the economy had entered a low-growth regime began rising. In Chart 9, the dashed line shows an increase in the probability, signaling about a 40 percent chance the economy was in a low-growth regime. In January of 2008, the model

Chart 8

CFNAI WITH THRESHOLD RECESSION INDICATORS

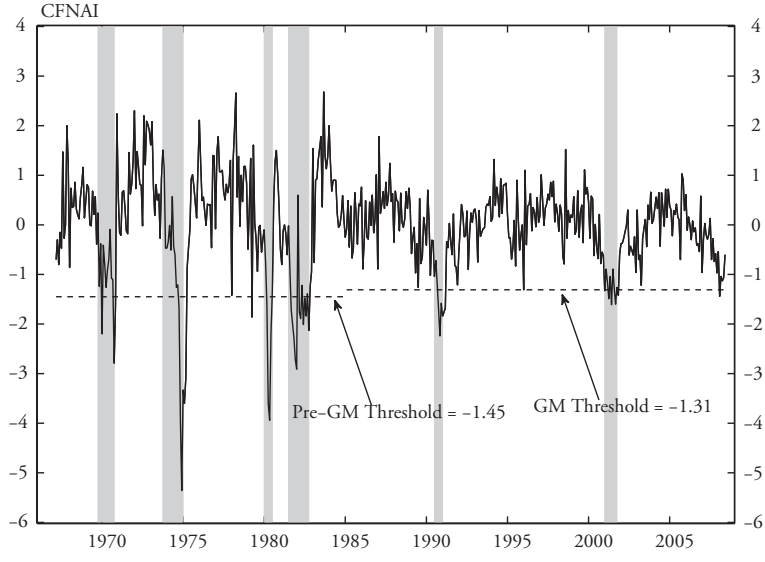
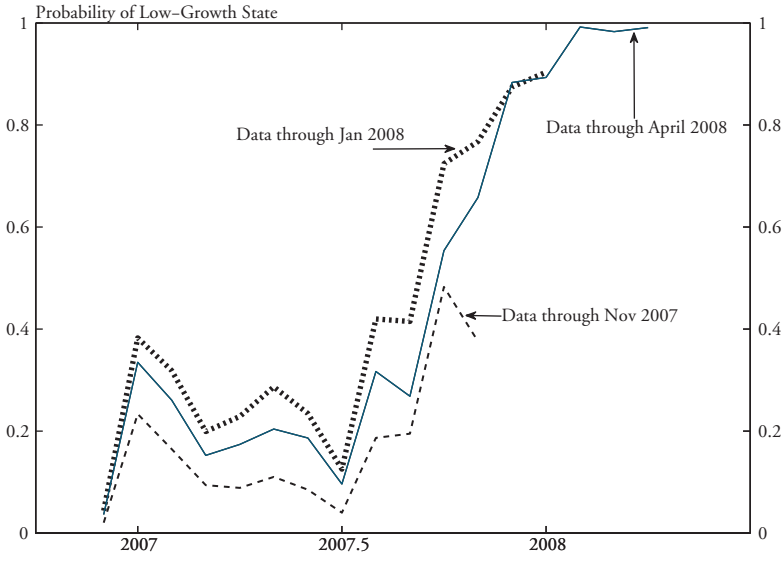


Chart 9

REAL-TIME ANALYSIS OF THE CURRENT LOW-GROWTH REGIME



was sending a much stronger signal that the economy had shifted to a lower gear. The dotted line shows a substantial rise in the probability, indicating about a 90 percent chance the economy was in a low-growth regime. The observation in April of 2008 then again led to a rise in the probability.[13]

Through 2008, the realizations of the CFNAI have consistently sent a strong signal that economy was in a low-growth regime and likely heading into an NBER-defined recession.

V. CONCLUSION

Policymakers and business people often confront a vast array of economic data when trying to infer the current state of the business cycle. Often, these data send mixed signals, are released too infrequently, or are subject to revisions that make obtaining an accurate read on the economy difficult. One appealing option for tracking economic activity is to use an index of a broad set of economic data. This approach boils the data down to one index number that is available on a monthly basis. One widely available such index is the Chicago Fed National Activity Index.

While using the CFNAI is a valuable tool for tracking the state of the business cycle, the Great Moderation has resulted in less pronounced expansions and milder recessions. As a result, the difference between expansions and recessions is less severe, so determining the current state of the economy is more difficult. However, using this index in the context of a business cycle tracking model, which accounts for how the business cycle has changed due to the Great Moderation, can generate a timely read on the state of the economy.

Currently, the model indicates an elevated probability that the economy is in a low-growth regime. The past few NBER recessions have occurred during these low-growth regimes. If structural changes in the economy that have brought about the Great Moderation remain in place, such as improved business practices and government policies, then the current low-growth regime will likely resemble the previous two episodes. In this case, real output and job growth would be modestly sluggish for a period longer than the average NBER recession.

TIMING OF NBER ANNOUNCEMENTS APPENDIX – BUSINESS CYCLE TRACKING MODEL: TECHNICAL DETAILS

The business cycle tracking model combines elements of Kim and Nelson (1999) and Bai and Wang (2008). The model describes the CFNAI as the following:

$$
\begin{aligned}
y_t &= (1-\rho)\mu^*_{R_t} + \rho y_{t-1} + \varepsilon_t, \\
\mu^*_0 &= \mu_0 + \mu_{00} D_t, \\
\mu^*_1 &= \mu_1 + \mu_{11} D_t,
\end{aligned}
$$

where y_t denotes the CFNAI, $\varepsilon_t \sim N(0, \sigma^2_{R_t})$, $R_t \in \{0,1\}$ and $D_t \in \{0,1\}$ with each following a Markov chain. Normalizations are as follows:

$$
\begin{aligned}
&\sigma_0 > \sigma_1, \\
&\mu_0 < \mu_1, \\
&\mu_0 < \mu_0 + \mu_{00}, \\
&\mu_1 > \mu_1 + \mu_{11},
\end{aligned}
$$

where the last two inequalities correspond to the "Low Growth < Low Growth (GM) and "High Growth > High Growth (GM)" from the main text. The transition probabilities for R_t are given by $P_k(i,j) = \Pr[R_t = j \mid D_t = k, R_{t-1} = i]$, which allow the expected duration of expansions and recessions to depend on whether the economy is in the Great Moderation era. The transition matrices are:

$$
P_0 = \begin{bmatrix} p_0 & 1-p_0 \\ 1-q_0 & q_0 \end{bmatrix}, \; P_1 = \begin{bmatrix} p_1 & 1-p_1 \\ 1-q_1 & q_1 \end{bmatrix},
$$

D_t describes the volatility state and follows:

$$
P_D = \begin{bmatrix} p & (1-p) \\ 0 & 1 \end{bmatrix},
$$

which imposes that the Great Moderation is an absorbing state. The full 4 x 4 transition matrix is:

$$
P = \begin{bmatrix} pP_0 & (1-p)P_1 \\ 0_{2x2} & P_1 \end{bmatrix},
$$

and the states are $S_t \in \{(\sigma_0,\mu_0),(\sigma_0,\mu_1),(\sigma_1,\mu_0+\mu_{00}),(\sigma_1,\mu_1+\mu_{11})\}$. The likelihood function is constructed using the Hamilton (1989) filter in a 4-state regime-switching framework and then maximized.

To derive a rule-of-thumb that indicates whether the economy is in the low-growth state, one approach is to set the Markov transition probabilities to their steady-state values and then use Bayes' rule. To illustrate, first derive the unconditional, or steady-state, probabilities that the economy is in the low-growth state. Prior to the Great Moderation, this steady-state probability is:

$$\bar{p}_0 = \frac{1-q_0}{2-q_0-p_0}$$

and after is:

$$\bar{p}_1 = \frac{1-q_1}{2-q_1-p_1}$$

Then according to Bayes' rule, the probability of being in the low-growth state after observing y_t is

$$\Pr[R_t = 0 \mid y_t, D_t] = \frac{\bar{p}_{D_t} f(y_t \mid R_t = 0, D_t)}{\bar{p}_{D_t} f(y_t \mid R_t = 0, D_t) + (1-\bar{p}_{D_t}) f(y_t \mid R_t = 1, D_t)},$$

where $f(y_t \mid R_t = 0, D_t)$ is the conditional density for y_t, which depends on whether t is before or after the onset of the Great Moderation (i.e., whether $D_t = 0$ or $D_t = 1$). To calculate the rule-of-thumb threshold, a simple line search finds a value of y_t such that $\Pr[R_t = 0 \mid y_t, D_t] = 0.9$. When y_t is below the threshold, there is a 90% chance the economy is in a low-growth state. As the main text indicates, the threshold for $D_t = 0$, the period prior to the Great Moderation, the threshold is -1.45, and for $D_t = 1$, the threshold is -1.31.

ENDNOTES

[1]See Chauvet and Piger (2008) for a statistical analysis of how quickly formal models can identify business cycle turning points compared to NBER announcements. Their model is accurate in identifying turning points and more quickly identifies troughs compared to official NBER announcements.

[2]Technically, principal component analysis generates more than one so-called index. Thus, there is the "first" principal component, "second" principal component… and so on. The index discussed in this article focuses on the first principal component, which captures the largest share of variation in the underlying data series. A classical treatment of this issue can be found in Theil (1971).

[3]See Blanchard and Simon (2001) and Stock and Watson (2003) for general overviews of issues related to the Great Moderation. See Perez-Quiros and McConnell (1999) for an analysis focusing on the role durable goods production and inventories, Boivin and Giannoni (2006) for an explanation that focuses on the role of monetary policy, and Justiniano and Primiceri (2006) on the role of reduced shock volatility.

[4]The business cycle tracking model is a version of the model introduced in Kim and Nelson (1999).

[5]A large literature, initiated by Hamilton (1989), takes this approach. See Cauvet and Piger (2003) and Chauvet and Hamilton (2004) for some recent examples and extensions.

[6]Ex-post, or smoothed, probabilities at each date are computed using the entire sample of data. For example, the probabilistic estimate at, say, December 1975 includes the entire sample up through July 2008. The alternative is to report real-time, or filtered probabilities, which are computed at a particular date using data only up to and including that date. In this case, the probabilistic estimate for December 1975 includes data up to this time, but not after. Ex-post probabilities are useful to obtain as complete of a probabilistic description of a data series as possible.

[7]Perez-Quiros and McConnell (1999) and Kim and Nelson (1999) date the Great Moderation as beginning in the first-quarter of 1984.

[8]When interpreting the average, recall that the CFNAI is standardized to be 0—so a positive value implies above-trend growth and a negative value implies below-trend growth.

[9]For example, see the question-and-answer panel accompanying the monthly news release that is available at the Federal Reserve Bank of Chicago's website. See also Evans, Liu and Phan-Kanter (2002).

[10]10 percent is viewed as a reasonable margin of error. Raising this percentage would generate higher thresholds (i.e., thresholds closer to zero). A higher threshold increases the chance of generating false positives but raises the potential for generating a useful signal regarding an impending slowdown. The -.70 rule-of-thumb in the official CFNAI release can be then viewed as allowing for a higher

margin of error (i.e., allowing more false positives but creating a stronger signal regarding a slowdown).

[11]The appendix provides the details on how the threshold is constructed.

[12]The threshold values are unconditional estimates, which mean they take into account that recessions are typically shorter than expansions but do not explicitly incorporate recent data observations. For example, suppose a series of observations as follows: .2, .2, .2 and then -1.5. This would be unusual, as the sudden drop in the index may be an outlier and simply reflect temporary idiosyncratic factors. In this case, the rule-of-thumb could be spuriously indicating the onset of a recession. Given this caveat, however, these rules-of-thumb can be useful for quickly interpreting what the CFNAI is saying about the state of the business cycle.

[13]Chart 9 shows how past estimates of the probability that the economy was in a low-growth regime change in light of new data. For example, the probabilities in Chart 9 at the beginning of 2008 vary depending on the end of the sample (i.e., either November 2007, January 2008, or April 2008). There are two reasons for this. First, the CFNAI is constructed basically as a weighted average of many underlying economic data series. The weights can change slightly from month to month, which can lead to small movements, or revisions, to previous values of the CFNAI. Second, the model may place more or less weight on an observation in the past in light of new data.

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