

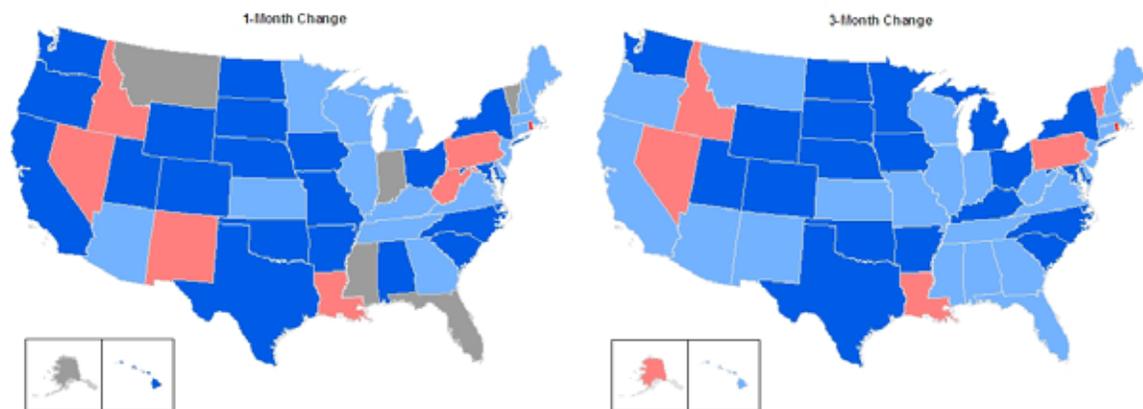
April 2008

**Marking NBER Recessions with State Data<sup>1</sup>**

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As talk of a recession has increased, data from the individual states are telling us another story: Although the nation is slowing, it is not showing a recession. These data, the state coincident indexes, which track economic activity for every state in the U.S., are released monthly by the Federal Reserve Bank of Philadelphia. Each state coincident index compiles labor market conditions and real wage data into a single variable representative of the state's economic activity.<sup>2</sup> As of February, seven state coincident indexes have declined over the past month, six posted zero growth, and 37 have increased (15 states are below 3 percent annualized growth). Over the past three months, seven have declined and 43 have increased. See the maps in Chart 1.

**Chart 1. February 2008 One-Month and Three-Month Changes in the State Coincident Indexes**



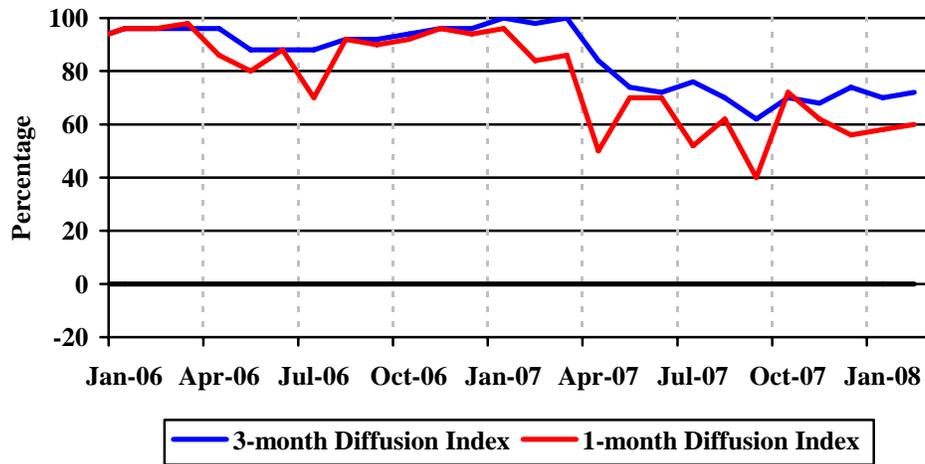
\* Dark Blue: greater than 3% annualized; Light Blue: between 0% and 3% annualized; Grey: 0% growth; Light Red: between 0% and -3% annualized; Dark Red: less than -3% annualized

<sup>1</sup> The views expressed here are those of the author and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or of the Federal Reserve System. Jason Novak is a senior economic analyst and can be contacted at [Jason.Novak@phil.frb.org](mailto:Jason.Novak@phil.frb.org).

<sup>2</sup> See <http://www.philadelphiafed.org/econ/indexes/coincident/> for papers detailing the methodologies used to construct the indexes.

Over the past two years, state-level activity slowed during the first and second quarters of 2007 but remained steady for the remainder of the year and into early 2008, according to the one-month and three-month diffusion indexes shown in Chart 2. (These diffusion indexes are calculated as the percentage of state coincident indexes growing minus the percentage declining; 100 and -100 are the maximum and minimum values, respectively.)

**Chart 2. Diffusion Indexes: One-Month and Three-Month  
(January 2006-February 2008)**



Are we in a recession and can we convincingly determine one are questions worth investigating. In this note, we try to determine whether the diffusion indexes charted above can give us insight about the current state of the economy and whether declines in the indexes can mark recessionary periods. Before we can address this, we need to define recession. A common definition, which we will refer to as the folk definition, defines a recession as at least two consecutive quarters of negative real GDP growth. However, the definition most widely accepted by policymakers and academics is the one released by the National Bureau of Economic Analysis (NBER). We should take a few moments to clarify because these two definitions are often confused.

**Definition of Recession**

The NBER, the accepted governing body of recession dating, does not use just movements in GDP to determine when a recession has occurred. In a memo dated January 7, 2008, the NBER defines a recession as follows:<sup>3</sup>

“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.”

<sup>3</sup> For the full memo, see [http://www.nber.org/cycles/jan08bcd\\_memo.html](http://www.nber.org/cycles/jan08bcd_memo.html).

Real GDP receives considerable attention from the NBER when marking recession dates. The memo goes on to state that GDP is “the single best measure of aggregate economic activity”; however, it is not the sole deciding factor, as it is in the folk definition. The committee prefers to produce a monthly chronology and, therefore, looks at monthly employment and personal income less transfer payments for further information on turning points. The key to the committee’s process is flexibility: There is no fixed rule for weighting the importance of each data series, an approach that allows the committee to adjust depending on current economic conditions.

In addition, the two definitions sometimes do not match up because real GDP is often revised. If we used today’s numbers, the folk definition would not match the 2001Q1-2001Q3 NBER recession because real GDP grew in 2001Q1, according to the revised data. The official statistics did record a decline in GDP in that three-quarter period, but only temporarily, in reports published from 2002Q3 to 2004Q2. (These reports can be found in the Philadelphia Fed’s real-time data set.<sup>4</sup>) So analysts looking for a recession in GDP information would not have found out until a year after the recession.

Policymakers and analysts use the NBER recessions because they are concrete in timing and authoritative. Unfortunately, availability of current business cycle information from the committee is delayed, making its data less useful to current policy-making decisions.

### Timing of NBER Recession Dating

It is quite common for the NBER to release its analysis well after the peak of economic activity, that is, the start of a recession. The NBER’s goal is to effectively and accurately mark business cycles, not to offer information critical to current market participants. Economic turning points are volatile periods, and according to this rationale, it is better to wait until the dust settles when an accurate picture of the data is available. Table 1 below shows the four most recent recessions and NBER release dates for each peak and trough.

**Table 1. NBER Release Dates for Official Business Cycle Peaks and Troughs\***

	NBER Cycle Date	Date of Public Release	# of Months Passed Since Cycle Date
Peak	Jan 1980	Jun 1980	5
Trough	Jul 1980	Jul 1981	13
Peak	Jul 1981	Jan 1982	6
Trough	Nov 1982	Jul 1983	9
Peak	Jul 1990	Apr 1991	9
Trough	Mar 1991	Dec 1992	22
Peak	Mar 2001	Nov 2001	8
Trough	Nov 2001	Jul 2003	21

\* Recessions start one month after the peak and end at the trough. Official cycle dates and public release dates were drawn from <http://www.nber.org/cycles/cyclesmain.html>.

<sup>4</sup> The Philadelphia Fed’s real-time data set can be accessed at <http://www.philadelphiafed.org/econ/forecast/real-time-data/index.cfm>.

The public does not learn about the start of a recession, according to the NBER committee designation, until anywhere between five and nine months after its start date, with an average of seven months. The NBER takes longer to report troughs — 16 months, on average. The drawback to using NBER designations is the reporting delay. Policymakers could therefore greatly benefit from an earlier warning of an NBER stylized recession through statistical modeling.

### **NBER Recessions and States**

The NBER defines a recession as a broad economic downturn. States should provide a useful link to national fluctuations in the business cycle because states are components of the nation, and economic activity at the national level is simply the sum of economic activity (in dollar terms) of the component states.

States have differing industry mixes, labor force characteristics, and resources. Some states will lead the nation into a given recession because they are more susceptible to the contraction of particular industries or economic practices. However, because recessions are usually different from one another, it would be extremely difficult to pick states that would consistently lead the national business cycle.

According to Owyang, Piger, and Wall (2005),<sup>5</sup> the past four NBER recessions differ markedly by their state-level origins. Both of the NBER recessions in the 1980s were preceded by declines in the country's heartland, the Mississippi Valley, while the 1990-91 NBER recession started on the coasts. The 2001 NBER recession was very mild compared with the three previous ones; some states did not even follow the nation downward. If we were to use individual states as markers of NBER recessions, we could easily choose the wrong states. Using all of them, we are more confident that we will successfully mark a recession.

### **Analysis Using a Diffusion Index**

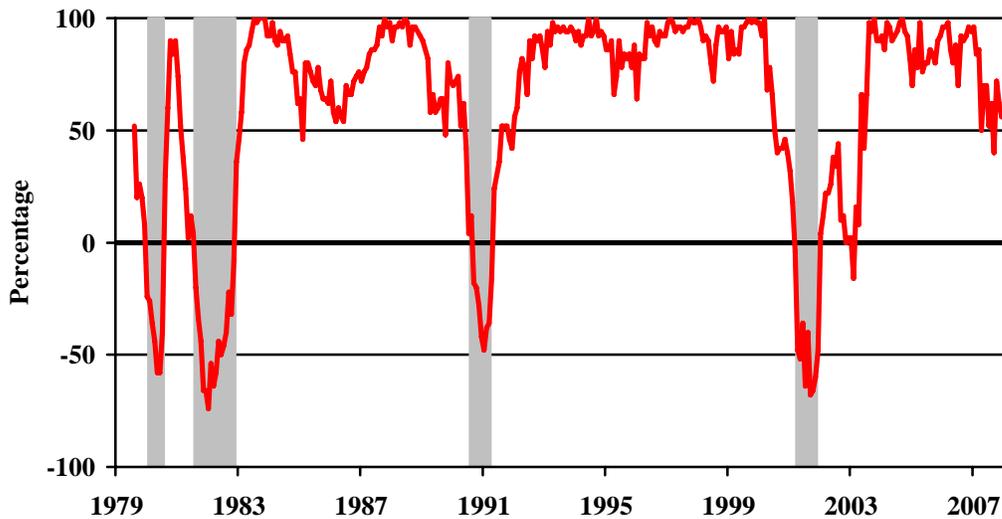
In this analysis, we focus on the one-month and three-month diffusion indexes to mark NBER recessions using a probit regression framework. To calculate the one-month (or three-month) diffusion index, we evaluate all 50 state coincident indexes to find whether they have decreased, increased, or remained unchanged since the previous month (or three months ago), to obtain an index of the percentage of states that are growing minus the percentage declining. These indexes are recalculated each month.

Charts 3 and 4 plot the one-month and the three-month diffusion indexes, respectively, over time against the NBER recessions. When the economy is out of a recession, the indexes are normally between 50 and 100, which means that there are at least 25 more states whose economic activity is increasing rather than decreasing. During a recession, the diffusion indexes are often negative, meaning that the number of states with decreasing economic activity is higher than the number with increasing economic activity. Further, the diffusion indexes are falling when the economy enters a recession and increasing when the economy is exiting a recession.

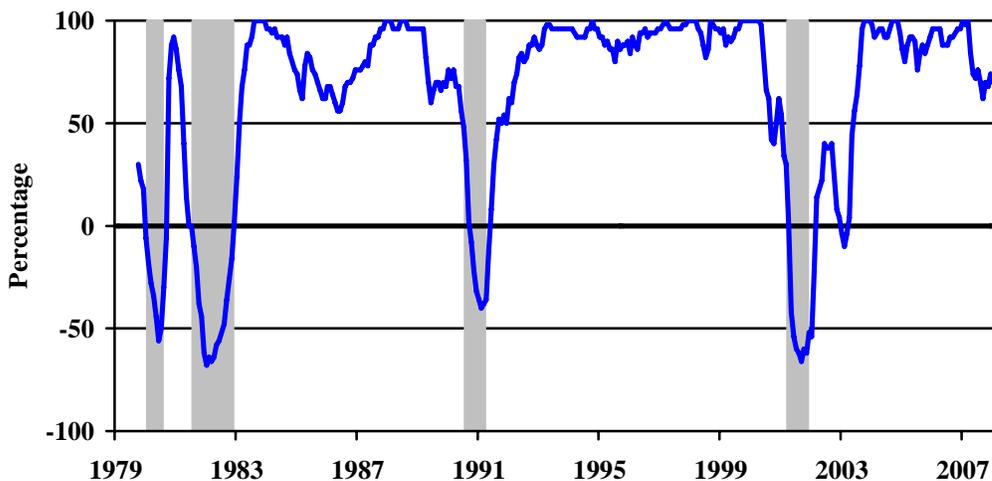
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<sup>5</sup> Michael T. Owyang, Jeremy Piger, and Howard J. Wall, "Business Cycle Phases in the United States," *Review of Economics and Statistics*, 87:4 (November 2005), pp. 604-16.

**Chart 3. One-Month Diffusion Index (August 1979-February 2008)**

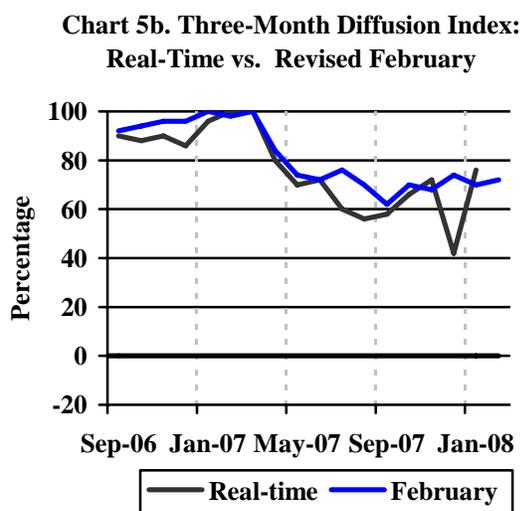
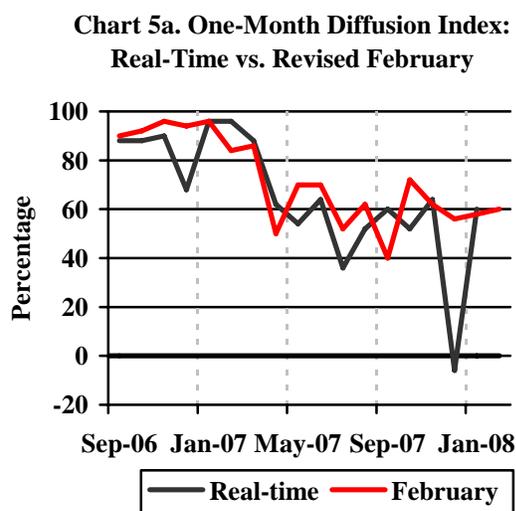


**Chart 4. Three-Month Diffusion Index (October 1979-February 2008)**



Over the period from 1979-2007, the one-month diffusion index goes negative in six episodes, four of which are during recessions. Of those four, the diffusion index crosses zero within one month of the NBER-determined peak date. The two most recent negative periods occurred in November 2002 and February 2003 and lasted only one month each time. The three-month diffusion index had five periods of negativity, four of which started zero to two months after each NBER recession. The fifth lasted the first three months of 2003. Both diffusion indexes match up well with the recessions, and it is important to note that these data are released much earlier than the NBER official releases. So, it is possible that the diffusion indexes could give us advance warning of recessions.

Using the diffusion indexes has its drawbacks in that they encounter the same issue that causes the NBER to wait: revisions to data. Revisions enter the diffusion indexes through the state coincident indexes in two places. First, the BLS revises its employment and unemployment data monthly, often revising the previous month, and it rebenchmarks the two most recent years of each series every January, a process that involves appending new information to the BLS' survey results. The second area in which revisions can affect a coincident index is the modeling process. The methodology is recursive, which means that when new information enters the model, previous index values can be modified to refine the path. While these revisions are often small, the most recent January BLS rebenchmark dramatically increased the level of the diffusion indexes in the fourth quarter. The December value was most affected. Pre-revision, the one-month diffusion index was -6 percent, but by February, it had been revised to 56 percent; the three-month diffusion index was less affected but still showed a sizable revision from 42 to 74 percent. In Charts 5a and 5b, real-time data for each index are plotted against revised data up to February 2008. Each real-time point represents the preliminary number released at that date in time.

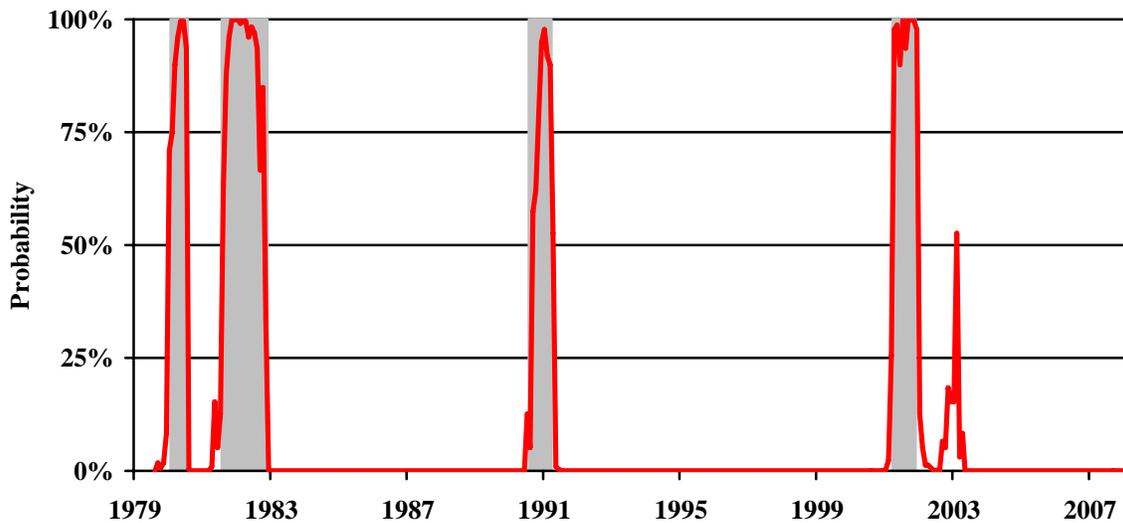


The monthly revisions seem less pronounced in the three-month diffusion index, as well as in the two rebenchmark months (January 2007 and January 2008). For this reason, we analyzed two models: one that is more conservative, using the three-month diffusion index, and one that is more dependent on current monthly data, using the one-month diffusion index.

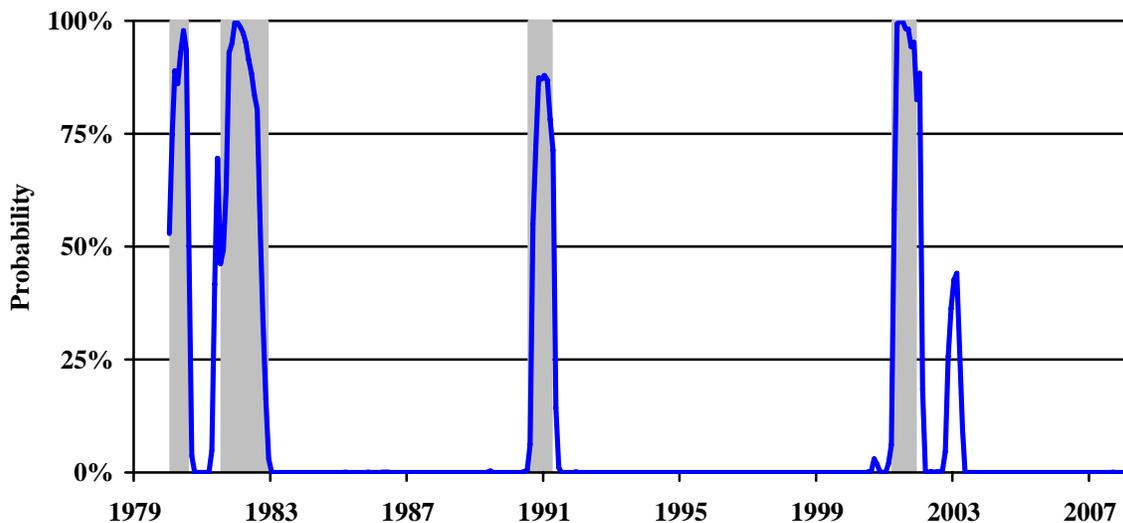
We tested for the presence of a statistical relationship between NBER recession dates and each diffusion index separately using probit models.<sup>6</sup> A probit framework is commonly used when the dependent variable represents a yes-no (binary) event like a recession. This is different from a more typical linear model where we find a linear relationship between two continuous variables. A probit model attempts to capture the probability of the event, in this case a recession. The recession probabilities created from both models are charted below with the NBER recession dates (Charts 6 and 7).

<sup>6</sup> For description of the one-month and three-month models, see the Appendix.

**Chart 6. Recession Probabilities (One-Month Diffusion Index Model)**



**Chart 7. Recession Probabilities (Three-Month Diffusion Index Model)**



Probabilities from the probit models are interpreted as the likelihood of being in a recession *now*, that is, the month of observation. For example, according to the February 2008 probabilities, both models suggest that there is a 0 percent chance that we were in an NBER recession as of February.

### **Clear Signal of a Recession**

Recession probabilities are clearly higher when the economy is in an NBER recession (Charts 6 and 7). But at what point do the model results suggest that the national economy is in a recession? One decision rule would be to say that the model indicates recession when the probability is above 50 percent. However, any cutoff is necessarily arbitrary. The key is to avoid two situations: when the model signals an increased probability and there is no recession (false positive) and when the model does not signal with a high probability and there is an

NBER recession (false negative). Therefore, minimizing the sum of both types of errors would be an effective method to achieve both goals. Our analysis of recessions since 1979 shows that the errors are minimized when a 55 percent cutoff is used for the one-month and three-month models.

The actual NBER recession dates span 38 months during 1979-2007 (four distinct continuous periods). Although the overlap between the high probabilities and the NBER recession dates is not a perfect union, the important characteristic is that the high probabilities form distinct periods in sync with the NBER. Our one-month model suggests (using the 55 percent cutoff point) that we were in an NBER stylized recession for 38 months, concentrated around four periods that roughly match the NBER recession dates. There were two false positives and two false negatives. The three-month model with the 55 percent cutoff suggests 37 months of recession with four false positives and five false negatives (three of which occurred during the 1981 recession).

**Derived Benefit?**

Two important periods in recessions are the start and end dates. We stated earlier that the NBER announcements lag the actual recession start dates with an average of seven months (16 months for expansions). Below is a table for each NBER recession start date and its corresponding model-derived start date followed by the NBER announcement date. The model-derived dates are the dates when the models suggest that the recession started, given the 55 percent cutoff for the one-month and three-month models.

**Table 2. NBER Recession Dates and Model-Derived Start Dates**

<b>Recession</b>	<b>NBER Date</b>	<b>One-Month Model</b>	<b>Three-Month Model</b>	<b>NBER Announcement</b>
I	Feb 1980	Jan 1980	Feb 1980	Jun 1980
II	Aug 1981	Aug 1980	Sep 1980	Jan 1982
III	Aug 1990	Sep 1990	Oct 1990	Apr 1991
IV	Apr 2001	Apr 2001	Apr 2001	Nov 2001

In every case, the model-derived dates are within one to two months of the NBER recession start date. If economists had been armed with these exact model results during the past four recessions, when did they know of these increased probabilities? The state coincident indexes are released dependent on the Bureau of Labor Statistics’ state-level employment reports, which are released with a 20- to 28-day lag.<sup>7</sup> Therefore, we would have data on the recession start date within one month using the one-month model and one to three months using the three-month model. If the relationship were to hold in the future, the benefit gained from the model would be around four to six months’ lead time.

<sup>7</sup> January is a special case because the data release lags the normal schedule by about 20 days (40-45 total) because of the BLS rebenchmarking process.

The table below marks NBER expansions using the same cutoff points as in Table 2 but measured when the probability reaches below the cutoffs following a recession. Both models are similarly effective in marking expansions. While the one-month diffusion index has a range of zero to one month, the three-month model is zero to two months. Expansion II was marked by early identification using both models. The NBER’s identification of expansions has taken longer for the two most recent turning points, leading to a 16-month average over the past four expansions. The models suggest a lead time of 13 to 14 months before the expansion announcement.

**Table 3. NBER Expansion Start Dates**

<b>Expansion</b>	<b>NBER Date</b>	<b>One-Month Diffusion Index</b>	<b>Three-Month Diffusion Index</b>	<b>NBER Announcement</b>
I	Aug 1980	Aug 1980	Aug 1980	Jul 1981
II	Dec 1982	Nov 1982	Oct 1982	Jul 1983
III	Apr 1991	Apr 1991	May 1991	Dec 1992
IV	Dec 2001	Jan 2002	Feb 2001	Jul 2003

**Conclusion**

Comparing the resulting probabilities from the probit model with actual NBER recession dates suggests that using a diffusion index can give economists four to six months’ lead time in marking recessions. However, there are some caveats. First and most critical, the relationship viewed could strictly be the result of the data period. With a lack of causality, this statistical relationship could break down in future periods. However, the national economy is the sum of the state economies, so their aggregate effects may well hold over time. That is, if the states decline or increase, those state statistics will have a negative or positive proportional effect on national statistics. A second caveat is that data revisions to the state coincident indexes and their underlying data could contribute to the models’ success in marking NBER recessions. Our model was estimated using the most up-to-date information available, data that have been revised over time. Further research will investigate the effect of data revisions on recession probabilities.

## APPENDIX

### Estimating the One-Month Diffusion Index Model

In our empirical model the dependent variable is 1 when the economy is in an NBER-defined recession and 0 otherwise. The independent variable is the one-month diffusion index. The model will generate probabilities of being in a recession now. The basic model structure is as follows:

$$\text{Probit}(y=1|x) = a + b_1 * D(t) + E$$

where  $D(t)$  represents the one-month diffusion index. The data are monthly, and the period of investigation is September 1979 to April 2007. The period under analysis covers four recessions.

The coefficients were estimated using maximum likelihood. The variable coefficient is negative and statistically significant at the 1 percent level, and the model fit, represented by a pseudo R squared, is 0.863. Probit model coefficients are interpreted differently from those generated by a normal regression model. The predicted values represent a Z-score, and those values are then transformed into a probability using the standard cumulative distribution. If a coefficient is significant and negative, it increases the *probability* that the final condition is 1. The probit model results are below:

$$\text{NBER Recession Probability} = \Phi[-0.90 - 0.06 * D(t)],$$

where  $\Phi$  is the standard normal cumulative distribution function. The one-month diffusion index is negatively related to NBER recessions, and as it increases in size, it contributes to increased deviations from the norm, that is, higher recession probabilities.

### Estimating the Three-Month Diffusion Index Model

A model was created using the three-month diffusion index. The model is a two-variable probit of the NBER recessions. The three-month diffusion index and the three-month change in the three-month diffusion index are the independent variables. The structure is as follows:

$$\text{Probit}(y=1|x) = a + b_1 * D3(t) + b_2 * (D3(t) - D3(t-3)) + E$$

where  $D3(t)$  represents the three-month diffusion index. The model fit was less than the one-month diffusion index, represented by the pseudo R-squared value of 0.801. Actual equation estimates are below:

$$\text{NBER Recession Probability} = \Phi[-0.96 - 0.04 * D3(t) + -0.02 * (D3(t) - D3(t-3))],$$

where  $\Phi$  is the standard normal cumulative distribution function.