Background on the Chicago Fed National Activity Index

January 24, 2023

Summary

The Chicago Fed National Activity Index (CFNAI) is a weighted average of 85 monthly indicators of national economic activity. The CFNAI provides a single summary measure of a common factor in these national economic data. As such, historical movements in this Chicago Fed index closely track periods of economic expansion and contraction, as well as periods of increasing and decreasing inflationary pressure. The Chicago Fed's goal in releasing this index monthly is to provide an objective, "real-time" statistical measure of coincident economic activity derived from a wide range of monthly indicators. Research studies by economists at Harvard University, Princeton University, and the Federal Reserve Bank of Chicago have shown that the CFNAI often provides early indications of business cycle turning points and changes in inflationary pressure.

Origins of the CFNAI

Methodologically, the Chicago Fed National Activity Index is similar to the index of economic activity developed by James Stock (Harvard University) and Mark Watson (Princeton University) in a 1999 article on inflation forecasting.[1] They found that a single index constructed from the first principal component of 85 economic activity series forecasted inflation as well as or better than several other common models. Furthermore, in the March 2000 *Chicago Fed Letter*, Jonas D. M. Fisher, the current Chicago Fed vice president of macroeconomic research, reported that substantial increases in the activity index within the period 1960–99 forewarned periods of increasing inflation and identified threshold values of the index that signaled these periods.[2] In the 2002 third quarter issue of *Economic Perspectives*, Charles L. Evans, the current Chicago Fed president, along with Chin Te Liu and Genevieve Pham-Kanter, formalized the use of threshold rules to identify recessions and inflationary episodes.[3] In the November 2009 *Chicago Fed Letter*, Scott Brave, senior economist, expanded on this analysis.[4] Table 1 provides a summary of threshold values for the index's three-month moving average, CFNAI-MA3.

What is the CFNAI?

The economic indicators used for the CFNAI are drawn from four broad categories of data: 1) production and income (23 series), 2) employment, unemployment, and hours (24 series), 3) personal consumption and housing (15 series), and 4) sales, orders, and inventories (23 series). All of the data are adjusted for inflation, and a complete list appears in table 3.

[1] James Stock and Mark Watson, 1999, "Forecasting inflation," *Journal of Monetary Economics*, Vol. 44, No. 2, October, pp. 293–335.

[2] Jonas D. M. Fisher, 2000, "Forecasting inflation with a lot of data," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 151, March.

[3] Charles L. Evans, Chin Te Liu, and Genevieve Pham-Kanter, 2002, "The 2001 recession and the Chicago Fed National Activity Index: Identifying business cycle turning points," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 26, Third Quarter, pp. 26–43.

[4] Scott Brave, 2009, "The Chicago Fed National Activity Index and business cycles," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 268, November.

The CFNAI is a weighted average of the 85 economic indicators. Put simply, the index is the first principal component of the 85 series. If all 85 series were proportional to a single common variable plus individual noise discrepancies, the CFNAI would be the estimate of the common variable that minimizes the implied noise discrepancies in a least-squares sense.

An excellent discussion of this statistical procedure is presented in the econometrics textbook by Henri Theil.[5] Let x_t denote the 1-by-85 element row vector of data at time t. Let X_T denote the T-by-85 stacked matrix of data vectors

$$X_T = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_T \end{bmatrix}.$$

Each column of X_T contains T observations of an individual economic indicator. Prior to the construction of X_T, each individual data series is transformed from its release values in two ways. First, each series is filtered by a stationary-inducing transformation. For example, the employment and industrial production data are log-differenced so that they are in growth rates. Table 3 lists the transformation for each indicator. In some cases, as with the Institute for Supply Management's Purchasing Managers' Index, the data require no transformation. Second, each series is de-meaned and standardized; in other words, each series has a mean of zero and a standard deviation of one.

Since the CFNAI is a principal component, it is a weighted average of the 85 (transformed) economic indicators:

$$CFNAI_t = x_t a,$$

where a is an 85-by-1 vector of weights. The weights correspond to the eigenvector associated with the largest eigenvalue of the second moment matrix $X_T' X_T$.[6] The vector of weights a is time-invariant for a fixed set of data X_T. The final step in computing the $CFNAI_t$ series simply involves renormalizing the series to have a mean of zero and standard deviation of one.

The CFNAI is revised with each monthly release. For every release there are two potential reasons for minor revisions to the index. First, the underlying monthly data are released with varying degrees of delay. One of our objectives is to release the CFNAI each month in a timely fashion. Consequently, our initial release includes *projected* monthly values for approximately one-third of the 85 series. In the following month's release when these missing data become available, correcting the projection error becomes a source of revision in the CFNAI. Second, throughout the calendar year, the 85 monthly data series are systematically revised by the original reporting institutions. These revisions will also alter the underlying monthly data. Finally, the weighting vector a is reestimated each month so that changes in a will affect the history of the index. However, in practice we have found this source of revision to be small.

Figure 1 displays the CFNAI over the period March 1967–December 2022. The index is constructed to have an average value of zero and a standard deviation of one. Since economic activity tends toward a trend growth rate over time, an index reading of zero corresponds to an economy growing at trend. The underlying monthly data series are somewhat volatile; consequently, the monthly CFNAI is also quite volatile. Figure 3 displays the three-month moving average of the CFNAI, the CFNAI-MA3; the reduction in month-to-month volatility is readily apparent.

Intuitively, the CFNAI is the single index that best captures the co-movement of all 85 economic indicators within a month. To the extent that all 85 series track together in a month, the degree of co-movement will be high. In this case, the individual weights on each data series are relatively unimportant. But when the data point in different directions, the degree of co-movement is low. In this case, the individual weights critically determine how the CFNAI resolves the conflict and reports the common element. Since the CFNAI is the first principal component of the data, its

[5] Henri Theil, 1971, *Principles of Econometrics*, New York: John Wiley and Sons, pp. 46–48.

[6] This corresponds to Theil's (1971) equation (9.6), p. 48.

weights are determined by the historical importance of each variable's contribution to the overall co-movement of the 85 series.

In his November 2009 *Chicago Fed Letter*, Scott Brave also illustrated the usefulness in looking closely at the different categories of indicators that make up the index in explaining business cycles. Figure 2 plots the history of the four categories of indicators defined previously. The production and income category and the sales, orders, and inventories category tend to turn negative more quickly during a recession and turn positive once a recovery begins. The employment, unemployment, and hours category typically lags the business cycle, making its greatest negative contribution near the end of a recession. There does not appear to be any discernible pattern for the personal consumption and housing category during recessions. These observations are consistent with well-documented business cycle facts.

The CFNAI-MA3 tracks economic expansions and contractions

The CFNAI is a coincident indicator of economic expansions and contractions. To highlight this fact, it is best to focus on the CFNAI-MA3. Over the period of March 1967–December 2022, there have been eight economic recessions identified by the National Bureau of Economic Research (NBER).[7] The shaded regions in Figure 3 correspond to these recession periods. Although a total of eight recessions is a small number of events, the CFNAI-MA3 appears to be a useful guide for identifying whether the economy has moved into and out of a recession. This is useful because the definitive recognition of business cycle turning points usually occurs many months after the event. For example, even though the 1990–91 recession ended in March 1991, the NBER's Business Cycle Dating Committee did not officially announce the recession's end until 21 months later, in December 1992.

- In each of the eight recessions, the CFNAI-MA3 fell below -0.7, which corresponds to the negative horizontal dashed line in Figure 3, near the onset of the recession. The exact dates based on the CFNAI-MA3 for June 2021 can be seen in table 2.

- For the earlier recessions in the CFNAI's history, the CFNAI-MA3 moved into positive territory a few months after the official NBER date of the trough. Specifically, after the onset of a recession, when the index first crosses +0.2, the likelihood that the recession has ended according to the NBER business cycle measures is significant. The positive horizontal dashed line in Figure 3 is at +0.2. The critical question is how early does the CFNAI-MA3 reveal this turning point. We have found the re-crossing of the -0.7 threshold to be a more reliable indicator of an increasing likelihood of an end of a recession.

- In a 2011 paper, Travis J. Berge and Òscar Jordà develop a routine using a receiver operating characteristics curve (ROC) that yields another alternative threshold rule for the CFNAI-MA3 that simultaneously identifies recessions and expansions.[8] The optimal threshold for the CFNAI-MA3 as defined by Berge and Jordà (2011) as of July 2021 was -0.4. This rule places equal weight on avoiding misclassifying a recession month as a nonrecession month and a nonrecession month as a recession month. As such, our -0.7 threshold is a little more conservative in dating the start of a recession, as seen in table 2.

- In a 2012 *Chicago Fed Letter*, Scott Brave and Max Lichtenstein[9] found that the crossing of a -0.35 threshold by the CFNAI Diffusion Index (which is explained in greater detail later) signaled an increased likelihood of the beginning (from above) and end of a recession (from

[7] See http://www.nber.org/cycles.html.

[8] Travis J. Berge and Òscar Jordà, 2011, "Evaluating the classification of economic activity into recessions and expansions," *American Economic Journal: Macroeconomics*, Vol. 3, No. 2, April, pp. 246–277.

[9] Scott Brave and Max Lichtenstein, 2012, "A different way to review the Chicago Fed National Activity Index," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 298, May.

below). This threshold was determined using the Berge and Jordà ROC method. Additionally, Brave and Lichtenstein found that, on average, the CFNAI Diffusion Index signals the beginning and end of recessions a little sooner than the CFNAI-MA3. The optimal threshold for the CFNAI Diffusion Index as of July 2021 was -0.4. For more information on the CFNAI Diffusion Index, see p. 6.

The CFNAI-MA3 tracks sustained increases of inflation

The level of the CFNAI-MA3 also provides information about the likelihood of a near-term, sustained increase of inflation. For the period March 1967–December 2022, we have identified six episodes when two measures of monthly consumer core inflation increased by at least 0.75 percentage points on a year-ago basis and met certain other criteria: 1968–71, 1973–75, 1978–81, 1987–91, and 2004–08, 2021–. Core rates of inflation exclude food and energy inflation. Figure 5 displays these episodes in a graph with core inflation according to the Consumer Price Index (CPI) and the Price Index for Personal Consumption Expenditures (PCE). Details of the calculation of these dates are in the Appendix.

To determine the dates of sustained increases of inflation shown in figure 5, some judgment is required. There currently are no formal dates determined by an official government agency or an organization of distinguished economists; however, there has been a considerable amount of research pertaining to the CFNAI and inflationary phenomena. In the 2002 first quarter issue of *Economic Perspectives*, Fisher, Liu, and Zhou find that, while forecasting inflation with the CFNAI has had varied success over the period 1977–2000, there has been reasonable success in forecasting the direction of change of inflation.[10] Later, in the 2004 fourth quarter issue of *Economic Perspectives*, Fisher and Brave, motivated by past failings of inflation forecasts, find that incorporating many different models and indicator series along with the CFNAI provides a more robust inflation forecast.[11]

Figure 6 displays the CFNAI-MA3 with the first five inflation episodes shaded and the start of the sixth episode noted by a vertical line. In each of these situations, the CFNAI-MA3 rose above +0.7 (which is the lower horizontal dashed line in Figure 6) prior to or early on in the episode. The first three episodes were more severe than the most recent episodes, and in these earlier cases, the index rose to near or above +1.0 (the upper horizontal dashed line in Figure 6). It is important to note that, unlike the most recent episode, each of the first five episodes occurred at least two years after the previous business cycle trough. In the early months following the completion of an economic recession, the index has often risen strongly (rising above +0.7) without being associated with a sustained increase of inflation. In general, negative or small positive readings of the index's three-month moving average have not been associated historically with the onset of increasing inflation.

What is the purpose of releasing the CFNAI?

Research by James Stock, Mark Watson, and economists at the Chicago Fed has shown that indexes such as the CFNAI provide useful information on the current and future course of economic activity and inflation in the United States. A caveat in all statistical investigations of postwar business and inflation cycles is the number of recessions and episodes of increasing inflation is fairly small. As the CFNAI is tracked over time, additional information about its predictive power will be obtained. Another caveat is that, each of the previously discussed analyses have used economic data that may have been revised after their initial release. Evaluation of the importance of real-time economic measures requires a careful tracking of the data revisions. By releasing the CFNAI each month, the extent to which data revisions influence inferences from the index should become clearer.

Both caveats are also important with respect to the threshold values used to indicate NBER recessions and periods of increasing inflation. The thresholds have been identified with the benefit

[10] Jonas D. M. Fisher, Chin Te Liu, and Railin Zhou, 2002, "When can we forecast inflation?," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 26, First Quarter, pp. 30–42.

[11] Jonas D. M. Fisher and Scott Brave, 2004, "In search of a robust inflation forecast," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 28, Fourth Quarter, pp. 12–31.

of hindsight and the CFNAI constructed using a full sample of revised data. Until more research has been conducted on the usefulness of these thresholds in real-time assessments, caution should be exercised in using them as real-time guides. Some initial benefits of the real-time release of the CFNAI have been seen. For instance, for the 2001 recession, the CFNAI-MA3 identified the start of the recession as December 2000 in the March 5, 2001, release. Ten months later, the NBER identified the start date of the recession as March 2001. The CFNAI-MA3 then identified the end of the 2001 recession as February 2002 in the March 27, 2002, release. Sixteen months later, the NBER determined the end date to be November 2001.

The index's real-time performance during the 2007–09 recession was even better. In the March 24, 2008, release, the CFNAI-MA3 correctly identified December 2007 as the recession's start date, eight months before the NBER announcement doing the same. Similarly, it then identified the end of the recession as September 2009 in the October 26, 2009, release, nearly 11 months before the NBER announcement declaring June 2009 as the end of the recession. For more information on the real-time performance of the index, including its ability to forecast real GDP growth and core PCE inflation, see the April 2010 *Chicago Fed Letter* and November 2014 *Economic Perspectives* articles by Scott Brave and R. Andrew Butters.[12]

How has the CFNAI changed over time?

In response to the demand for real-time CFNAI research, we now release the real-time history of the CFNAI on our website.[13] Each release is available in its entirety as it was originally made available at the time of release.[14] What follows is a brief outline of the major changes to the component series of the CFNAI since its initial release in 2001 that have had a significant impact on the index's history.

SIC/NAICS conversion

In December 2002, the conversion of industry data from the Standard Industrial Classification (SIC) system to the North American Industry Classification System (NAICS) took place. A splice was utilized to generate the full historical series of the CFNAI. With stronger emphasis on emerging and service-producing industries, as well as some restructuring of the organization of different industries, the NAICS uses a more unified approach than the SIC system.

Base year changes (2003 and 2009)

In November 2003, the base year for the national income and product accounts (NIPAs) changed. In the course of updating the CFNAI, it was discovered that a handful of the original 85 indicators were no longer readily available. These series were subsequently replaced, with the changes documented in the technical report on our website. In July 2009, in addition to another base year change, the personal consumption expenditures accounts were substantially revised. While the changes had only a minimal impact on the index, they did affect the timing of previously determined episodes of increasing inflation, as documented in the Appendix.

[12] Scott Brave and R. Andrew Butters, 2010, "Chicago Fed National Activity Index turns ten–Analyzing its first decade of performance," *Chicago Fed Letter*, Federal Reserve Bank of Chicago, No. 273, April; Scott A. Brave and R. Andrew Butters, 2014, "Nowcasting Using the Chicago Fed National Activity Index," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 38.

[13] See https://www.chicagofed.org/cfnai.

[14] The December 19, 2002, release is truncated because of temporarily missing data as a result of the SIC/NAICS conversion. Data prior to 1972 was unavailable for these four series: 1) industrial production: durable goods, 2) industrial production: nondurable goods, 3) industrial production: mining, and 4) industrial production: electric and gas utilities. As a result, the CFNAI that month was generated over the 1972–2002 sample.

Other changes to indicators

The Conference Board's decision to discontinue the publication of its Help-Wanted Advertising Index (of print advertising) resulted in the loss of two indicators in September 2010. These indicators were replaced by utilizing a splicing technique similar to the SIC/NAICS conversion. The information in the Help-Wanted Advertising Index from December 2000 onward was replaced with the total job openings data from the *Job Opening and Labor Turnover Survey* (JOLTS) produced by the U.S. Bureau of Labor Statistics.

Contributions from indicator categories

In July 2011, we began making available the real-time history of the contributions from each of the four broad categories of indicators that make up the index: production and income (P&I); employment, unemployment, and hours (EU&H); personal consumption and housing (C&H); and sales, orders, and inventories (SO&I). For some releases, our records were incomplete (March 2001–July 2001). These months are represented by missing values in our archives. Additionally, from February 2001 through September 2003, contributions from five categories of indicators were originally reported. We have condensed them to the four that are provided for the index at this time. This was done by summing the contributions from the manufacturing and trade sales category and from the inventories category, and represents the contribution from the sales, orders, and inventories category during these months.

CFNAI Diffusion Index

In April 2012, we began publishing the CFNAI Diffusion Index, a metric based on the magnitude of the weight given to each of the underlying indicators in the CFNAI when constructing the index as their weighted average. The index is calculated as the sum of the absolute values of the underlying indicators whose contribution to the CFNAI is positive in a given month less the sum of the absolute values of the weights for those indicators whose contribution is negative or neutral, expressed as a proportion of the total sum of the absolute values of the weights. By construction, the sum of the absolute values of the CFNAI weights is one. To make this measure comparable to the CFNAI-MA3, we take its three-month moving average. In December 2016, we also made available its real-time history.

Real-time CFNAI Data

The partial federal government shutdown in October 2013 affected the September and October 2013 CFNAI releases. Federal agencies postponed the release of several data series used to compile the CFNAI, and the September release was subsequently postponed from October 21 to November 12. Because of the delay, the September release was able to include September personal consumption expenditure data and revised September employment data, but was not able to include September housing starts or permits. The October release included October housing starts, but did not include September or October housing permits.

The partial federal government shutdown that began in December 2018 and ended in January 2019 affected the December 2018, January 2019, February 2019, and March 2019 CFNAI releases. Federal agencies postponed the release of several data series used to compile the CFNAI, but all four releases occurred as scheduled on January 28, 2019, February 25, 2019, March 25, 2019, and April 22, 2019, respectively. The disruption to the real-time data flow in all four instances, while not as pronounced as it was following the October 2013 shutdown, did impact the construction of the CFNAI. The December release of the CFNAI did not include December housing starts and permits data in addition to November construction spending and mobile home shipments; the January release of the CFNAI did not include January and December housing starts and permits data, December construction spending, personal consumption expenditures and personal income, and real retail sales data as well as November real manufacturing trade, inventories, and sales data; the February release of the CFNAI did not include February housing starts and permits data in addition to January personal consumption expenditures and personal income, and real retail sales data; and the March release of the CFNAI did not include March housing starts and permits data, February personal consumption expenditures and personal income, and real retail sales data as well as January data for several real manufacturing trade, inventories, and sales series.

In late December 2022, we were unable to access many of the data series used to construct the CFNAI. As a result, we did not produce a formal monthly release of the CFNAI in that month for the November 2022 CFNAI estimates. However, we completed a model run on January 4, 2023, to generate those estimates, which we reported in the January 26, 2023, release.

Imputation of Missing Values and Treatment of Outliers

For series released with a multiple-month lag, the CFNAI had traditionally imputed the missing values for the last month(s) with forecasts from an autoregressive model. Beginning with the April 20, 2020, release of the CFNAI, we implemented an updated procedure that instead used nominal versions of some of these series (released with a shorter delay) and deflated the nominal values with an appropriate consumer or producer price index. We found that, after several months of testing, these values tended to outperform the autoregressive forecasts in terms of minimizing forecast errors relative to the actual data. For the May 26,
2020, release of the CFNAI, we temporarily stopped using forecasts from an autoregressive model in favor of an expectation-maximization (EM) algorithm to impute the remaining missing values. Moreover, we preserved our treatment of outliers when generating the weights used to construct the index, trimming series at six times their interquartile range, but applied these weights to the nonoutlier adjusted data to obtain the CFNAI. Beginning with the June 22, 2020, release of the CFNAI, we resumed imputing the remaining missing values using forecasts from an autoregressive model. Starting with the July 21, 2020, release of the CFNAI, we moved to an autogregressive model that used maximum likelihood estimation (MLE) and t-distributed errors with degrees of freedom estimated—which could handle error distributions with large tails and make the coefficients less sensitive to extreme values in the data.

Contact for CFNAI

The primary contact for more information about the CFNAI is Ross Cole, data scientist, of the Economic Research Department at the Federal Reserve Bank of Chicago. He can be reached at rcole@frbchi.org.

Appendix

Dates for episodes of increasing inflation

This appendix describes a method for identifying episodes of sustained increasing inflation. Two measures of core consumer prices are considered, both of which exclude volatile food and energy prices: the core Personal Consumption Expenditures (PCE) Price Index and the core Consumer Price Index (CPI). Monthly inflation rates over a 12-month period are computed for each inflation series. There are five steps for establishing an inflation episode.

1. Starting in March 1967, determine when each inflation measure reaches a minimum.

2. Then, determine the subsequent dates when each inflation measure has risen by 0.75 percentage points from its minimum. While only one series moving 0.75 percentage points can trigger a possible date, in order for this date to be considered the start of an episode the other series must be moving in an upward direction; that is, we require that there must be "co-movement."[15] These dates constitute the start of the inflation episode.

3. Determine the dates when each inflation measure has reached its maximum value and then begins a "reasonably" continuous decline, which we define as each inflation measures having fallen by 0.75 percentage points from its maximum value during the episode. These dates are taken to be the end of the inflation episode.

4. Only begin an episode when both inflation measures are above 2 percent (that is, at least one inflation measure must reach at least 2.75 percent during the episode).

5. Date the overall inflation episode by selecting the earliest start date and latest end date.

Table 4 summarizes the episodes of increasing inflation of both price series in their entirety. Criteria 2-4 have real effects on determining these episodes. For instance, they rule out a brief period during 1984 when core CPI was rising while core PCE was not; the early 2000's when core PCE barely peaked above 2 percent; and several instances in the 2010's when both core inflation measures were below 2 percent.

[15] We operationalize this constraint by imposing that if the three-month change in the 12-month inflation rate for either series is less than 0.125 percentage points at the candidate month, that date is rejected as a possible inflation episode start date.

Table 1: Interpreting the Chicago Fed National Activity Index three-month moving average (CFNAI-MA3)

If CFNAI-MA3<-0.7 following a period of economic expansion	Increasing likelihood that a recession has begun
If CFNAI-MA3>-0.7 following a period of economic contraction	Increasing likelihood that a recession has ended
If CFNAI-MA3>+0.2 following a period of economic contraction	Significant likelihood that a recession has ended
If CFNAI-MA3>+0.7 more than two years into an economic expansion	Increasing likelihood that a period of sustained increasing inflation has begun
If CFNAI-MA3>+1.0 more than two years into an economic expansion	Substantial likelihood that a period of sustained increasing inflation has begun

Table 2: CFNAI-MA3 and CFNAI Diffusion Index business cycle dates and threshold rules

	Recessions: 1967-2000									
NBER Dates	Dec-69	Nov-70	Nov-73	Mar-75	Jan-80	Jul-80	Jul-81	Nov-82	Jul-90	Mar-91
CFNAI-MA3										
< -0.7, > -0.7	Jan-70	Dec-70	Oct-74	Jun-75	Apr-80	Aug-80	Oct-81	Jan-83	Nov-90	Apr-91
< -0.7, $> +0.2$	Jan-70	Jan-71	Oct-74	Aug-75	Apr-80	Sep-80	Oct-81	Mar-83	Nov-90	Apr-92
< -0.4, > -0.4	Jan-70	Dec-70	Aug-74	Jun-75	Mar-80	Sep-80	Sep-81	Jan-83	Sep-90	May-91
CFNAI Diffusion										
< -0.35, > -0.35	Jan-70	Dec-70	Aug-74	Jun-75	Apr-80	Aug-80	Sep-81	Jan-83	Sep-90	May-91
< -0.4, > -0.4	Jan-70	Dec-70	Aug-74	Jun-75	Apr-80	Aug-80	Sep-81	Jan-83	Sep-90	May-91

	Recessions: 2001-2021					
NBER Dates	Mar-01	Nov-01	Dec-07	Jun-09	Feb-20	Apr-20
CFNAI-MA3						
< -0.7, > -0.7	Jun-01	Jul-01	Apr-08	Jul-09	Mar-20	Jul-20
< -0.7, $> +0.2$	Jun-01	Nov-03	Apr-08	May-10	Mar-20	Jul-20
< -0.4, > -0.4	Jan-01	Jan-02	Feb-08	Aug-09	Mar-20	Jul-20
CFNAI Diffusion						
< -0.35, > -0.35	Dec-00	Jan-02	Dec-07	Aug-09	Apr-20	Jun-20
< -0.4, > -0.4	Mar-01	Dec-01	Jan-08	Jul-09	Apr-20	Jun-20

Table 3: Chicago Fed National Acitivity Index Indicators
Production & Income

Indicators	**Scaled Eigenvector** [1]	**Transformation** [2]	**Haver Mnemonics** [3]
Industrial Production: Manufacturing, SA, 2012=100	0.021	DLN	IPMFG@IP
Industrial Production: Total Index, SA, 2012=100	0.020	DLN	IP@IP
Capacity Utilization: Manufacturing, SA, Percent of Capacity	0.020	DLV	CUMFG@IP
Industrial Production: Durable Manufacturing, SA, 2012=100	0.020	DLN	IPMDG@IP[5]
Industrial Production: Final Products and Nonindustrial Supplies, SA, 2012=100	0.020	DLN	IPTP@IP
Industrial Production: Durable Materials, SA, 2012=100	0.019	DLN	IP531@IP
Industrial Production: Nonindustrial Supplies, SA, 2012=100	0.019	DLN	IP54@IP
Industrial Production: Final Products, SA, 2012=100	0.019	DLN	IPFP@IP
Industrial Production: Business Equipment, SA, 2012=100	0.018	DLN	IP521@IP
Industrial Production: Materials, SA, 2012=100	0.017	DLN	IP53@IP
Industrial Production: Consumer Goods, SA, 2012=100	0.016	DLN	IP51@IP
Industrial Production: Nondurable Manufacturing, SA, 2012=100	0.016	DLN	IPMND@IP[5]
Industrial Production: Durable Consumer Goods, SA, 2012=100	0.016	DLN	IP511@IP
ISM Manufacturing: Production Index, SA, 50+ = Econ Expand	0.014	LV	NAPMOI
ISM Manufacturing: Composite Index, SA, 50+ = Econ Expand	0.013	LV	NAPMC
Industrial Production: Nondurable Materials, SA, 2012=100	0.013	DLN	IP532@IP
Real Personal Income Less Transfer Payments, SAAR, Bil. Chn. 2012$	0.012	DLN	YPLTPMH
Industrial Production: Nondurable Consumer Goods, SA, 2012=100	0.010	DLN	IP512@IP
Industrial Production: Mining, SA, 2012=100	0.006	DLN	IPB0@IP
Private Nonresidential Construction, SAAR, Mil. Chn. 2012$ (constructed)	0.005	DLN	CPV - CPVR[4,6]
Real Disposable Personal Income, SAAR, Bil. Chn. 2012$	0.002	DLN	YPDHM
Public Construction, SAAR, Mil. Chn. 2012$ (constructed)	0.002	DLN	CPG[4,6]
Industrial Production: Electric and Gas Utilities, SA, 2012=100	0.000	DLN	IPUTL@IP
Sum of absolute value of scaled eigenvector	**0.318**		

[1] The scaled eigenvector is constructed to sum to one in absolute value over all four categories.
[2] For a series y_t, the transformations $x_t = f(y_t)$ are: LV: $x_t = y_t$; DLV: $x_t = \Delta y_t$; LN: $x_t = \log(y_t)$; DLN: $x_t = \Delta \log(y_t)$
[3] Haver Mnemonics are retrieved from the USECON database except when specified.
[4] Deflated using appropriate NIPA deflators.
[5] Data are spliced to discontinued SIC series to construct full series history.
[6] Missing values in these series are replaced using the available nominal data deflated by an appropriate consumer or producer price index.

Employment, Unemployment & Hours

Indicators	**Scaled Eigenvector** [1]	**Transformation** [2]	**Haver Mnemonics** [3]
All Employees: Private Nonfarm Payrolls, SA, Thousands	0.020	DLN	LAPRIVA
All Employees: Total Nonfarm Payrolls, SA, Thousands	0.019	DLN	LANAGRA
All Employees: Goods-Producing Industries, SA, Thousands	0.019	DLN	LAGOODA
All Employees: Manufacturing, SA, Thousands	0.018	DLN	LAMANUA
All Employees: Durable Goods Manufacturing, SA, Thousands	0.018	DLN	LADURGA
All Employees: Service-Producing Industries, SA, Thousands	0.017	DLN	LAPSRVA
All Employees: Retail and Wholesale Trade, SA, Thousands (constructed)	0.016	DLN	LATRDA[6]
All Employees: Services, SA, Thousands (constructed)	0.016	DLN	LASRVSA[4]
All Employees: Nondurable Goods Manufacturing, SA, Thousands	0.016	DLN	LANDURA
Ratio: Help-Wanted Advertising/JOLTS: Job Openings to Number Unemployed, SA	0.015	LV	LJJTLA/LTU[8]
Civilian Unemployment Rate, SA, Percent	-0.015	DLV	LR
Civilian Employment: Sixteen Years & Over, SA, Thousands	0.015	DLN	LE
Civilian Employment: Nonagricultural Industries, SA, Thousands	0.015	DLN	LENA
All Employees: Construction, SA, Thousands	0.014	DLN	LACONSA
Civilian Unemployment Rate: Men, 25-54 Years, SA, Percent	-0.014	DLV	LRM25
Weekly Initial Claims For Unemployment Insurance, SA, Thousands	-0.013	DLV	LICM
Index of Help-Wanted Advertising/JOLTS: Job Openings, SA	0.012	LV	LJJTLA[7]
Average Weekly Hours: Manufacturing, SA, Hours	0.011	DLV	LRMANUA
ISM Manufacturing: Employment Index, SA, 50+ = Econ Expand	0.011	LV	NAPMEI
All Employees: Finance, Insurance and Real Estate, SA, Thousands	0.011	DLN	LAFIREA
All Employees: Transportation and Public Utilities, SA, Thousands (constructed)	0.011	DLN	LATPUTA[5]
Average Weekly Overtime Hours: Manufacturing, SA, Hours	0.009	DLV	LOMANUA
All Employees: Mining, SA, Thousands	0.003	DLN	LAMINGA
All Employees: Government, SA, Thousands	0.002	DLN	LAGOVTA
Sum of absolute value of scaled eigenvector	**0.330**		

[1] The scaled eigenvector is constructed to sum to one in absolute value over all four categories.
[2] For a series y_t, the transformations $x_t = f(y_t)$ are: LV: $x_t = y_t$; DLV: $x_t = \Delta y_t$; LN: $x_t = \log(y_t)$; DLN: $x_t = \Delta \log(y_t)$
[3] Haver Mnemonics are retrieved from the USECON database except when specified.
[4] LAINFOA + LAPBSVA + LAEDUHA + LALEIHA + LASRVOA
[5] LATTULA - LAWTRDA - LARTRDA
[6] LAWTRDA + LARTRDA
[7] Spliced with LHELP.
[8] Spliced with LHELPR.

Personal Consumption & Housing

Indicators	**Scaled Eigenvector** [1]	**Transformation** [2]	**Haver Mnemonics** [3]
Personal Consumption Expenditures, SAAR, Bil. Chn. 2012$	0.013	DLN	CBHM
Real Retail Sales, SA, Mil. Chn. 2012$	0.011	DLN	RSH[4,5]
Real Retail Sales: Durable Goods, SA, Mil. Chn. 2012$ (constructed)	0.011	DLN	RSDH[4,5]
Personal Consumption Expenditures: Services, SAAR, Bil. Chn. 2012$	0.011	DLN	CSBHM
Personal Consumption Expenditures: Durable Goods, SAAR, Bil. Chn. 2012$	0.010	DLN	CDBHM
Real Retail Sales: Nondurable Goods, SA, Mil. Chn. 2012$ (constructed)	0.010	DLN	RSNH[4,5]
Housing Units Authorized by Building Permits, SAAR, Thousands of Units	0.009	LN	HPT
Housing Starts, SAAR, Thousands of Units	0.009	LN	HST
Housing Starts: South, SAAR, Thousands of Units	0.009	LN	HSTS
Housing Starts: West, SAAR, Thousands of Units	0.009	LN	HSTW
Personal Consumption Expenditures: Nondurable Goods, SAAR, Bil. Chn. 2012$	0.008	DLN	CNBHM
Housing Starts: Midwest, SAAR, Thousands of Units	0.008	LN	HSTMW
Personal Consumption Expenditures: Motor Vehicles, SAAR, Bil. Chn. 2012$	0.007	DLN	CDVHM@USNA
Housing Starts: Northeast, SAAR, Thousands of Units	0.007	LN	HSTNE
Manufacturers' Shipment of Mobile Homes, SAAR, Thousands of Units	0.005	LN	HSM
Sum of absolute value of scaled eigenvector	**0.137**		

[1] The scaled eigenvector is constructed to sum to one in absolute value over all four categories.
[2] For a series y_t, the transformations $x_t = f(y_t)$ are: LV: $x_t = y_t$; DLV: $x_t = \Delta y_t$; LN: $x_t = \log(y_t)$; DLN: $x_t = \Delta \log(y_t)$
[3] Haver Mnemonics are retrieved from the USECON database except when specified.
[4] Data are spliced to discontinued SIC series to construct full series history.
[5] Missing values in these series are replaced using the available nominal data deflated by an appropriate consumer or producer price index.

Sales, Orders & Inventories

Indicators	**Scaled Eigenvector** [1]	**Transformation** [2]	**Haver Mnemonics** [3]
Real Manufacturing and Trade: Sales, SA, Mil. Chn. 2012$	0.018	DLN	TSTH[5]
Sales: Manufacturing: Durable Goods, SA, Mil. Chn. 2012$	0.016	DLN	TSMDH[4,5]
Sales: Manufacturing, SA, Mil. Chn. 2012$	0.016	DLN	TSMH[4,5]
Real Manufacturing and Trade: Inventory/Sales Ratio, SA, Chn. 2012$	-0.015	LV	TRTH[5]
Sales: Wholesale: Durable Goods, SA, Mil. Chn. 2012$	0.015	DLN	TSWMDH[4,5]
Inventory/Sales Ratio: Manufacturing, SA, Chn. 2012$	-0.015	LV	TRMH[4,5]
Real Man. New Orders: Consumer Goods & Materials, SA, Mil. Chn. 1982$	0.015	DLN	A0M008@BCI
ISM Manufacturing: New Orders Index, SA, 50+ = Econ Expand	0.014	LV	NAPMNI
Sales: Merchant Wholesalers, SA, Mil. Chn. 2012$	0.013	DLN	TSWMH[4,5]
Inventory/Sales Ratio: Merchant Wholesalers, SA, Chn. 2012$	-0.012	DLV	TRWMH[4,5]
Real Manufacturers' New Orders: Durable Goods Industries, Bil. Chn. 2012$	0.011	DLN	A0M007@BCI[5]
Sales: Manufacturing: Nondurable Goods, SA, Mil. Chn. 2012$	0.010	DLN	TSMNH[4,5]
Inventory/Sales Ratio: Retail Trade, SA, Chn. 2012$	-0.007	DLV	TRRH[4,5]
ISM Manufacturing: Suppliers Deliveries Index, SA, 50+ = Slower	0.007	LV	NAPMVDI
ISM Manufacturing: Inventories Index, SA, 50+ = Econ Expand	0.007	LV	NAPMII
Sales: Wholesale: Nondurable Goods, SA, Chn. 2012$	0.007	DLN	TSWMNH[4,5]
Real Man. New Orders: Nondef. Capital Goods Industries, SA, Mil. Chn. 1982$	0.005	DLN	A0M027@BCI[5]
Inventories: Retail Trade EOP, SA, Mil. Chn. 2012$	0.004	DLN	TIRH[4,5]
Real Manufacturing & Trade Inventories EOP, SA, Mil. Chn. 2012$	0.004	DLN	TITH[5]
Inventories: Manufacturing: Nondurable Goods EOP, SA, Mil. Chn. 2012$	0.003	DLN	TIMNH[4,5]
Inventories: Merchant Wholesalers EOP, SA, Mil. Chn. 2012$	0.002	DLN	TIWMH[4,5]
Inventories: Manufacturing EOP, SA, Mil. Chn. 2012$	0.002	DLN	TIMH[4,5]
Inventories: Manufacturing: Durable Goods EOP, SA, Mil. Chn. 2012$	0.000	DLN	TIMDH[4,5]
Sum of absolute value of scaled eigenvector	**0.215**		

[1] The scaled eigenvector is constructed to sum to one in absolute value over all four categories.
[2] For a series y_t, the transformations $x_t = f(y_t)$ are: LV: $x_t = y_t$; DLV: $x_t = \Delta y_t$; LN: $x_t = \log(y_t)$; DLN: $x_t = \Delta \log(y_t)$
[3] Haver Mnemonics are retrieved from the USECON database except when specified.
[4] Data are spliced to discontinued SIC series to construct full series history.
[5] Missing values in these series are replaced using the available nominal data deflated by an appropriate consumer or producer price index.

Table 4: Increasing inflation episodes

	Episode I		Episode II		Episode III		Episode IV		Episode V		Episode VI	
	PCE	CPI	PCE	CPI	PCE	CPI	PCE	CPI	PCE	CPI	PCE	CPI
$\Delta\pi > 0.75, \pi > 2.0$	Feb-68	Feb-68	May-73	Sep-73	Jun-77	May-78	Dec-87	Mar-88	Oct-04	Jun-04	Apr-21	Apr-21
$\Delta\pi < -0.75$	Oct-71	Mar-71	May-75	May-75	Jun-81	Jul-80	Jul-91	Jul-91	Nov-08	Jun-07		
	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
Episode dates	Feb-68	Oct-71	May-73	May-75	Jun-77	Jun-81	Dec-87	Jul-91	Oct-04	Nov-08	Apr-21	
CPI means Consumer Price Index. PCE means Personal Consumption Expenditures Price Index.												

Figure 1: Chicago Fed National Activity Index (CFNAI)

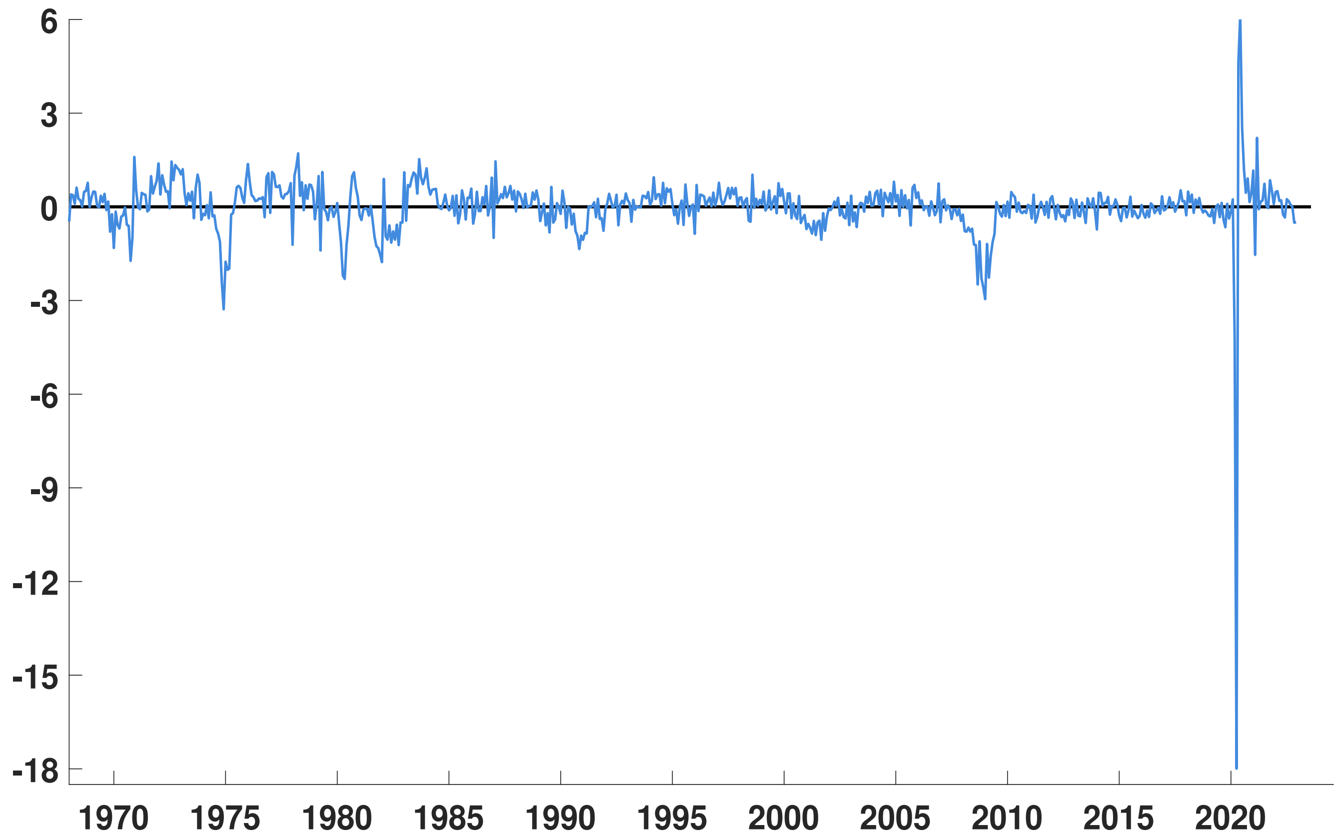


Figure 2: CFNAI group contributions

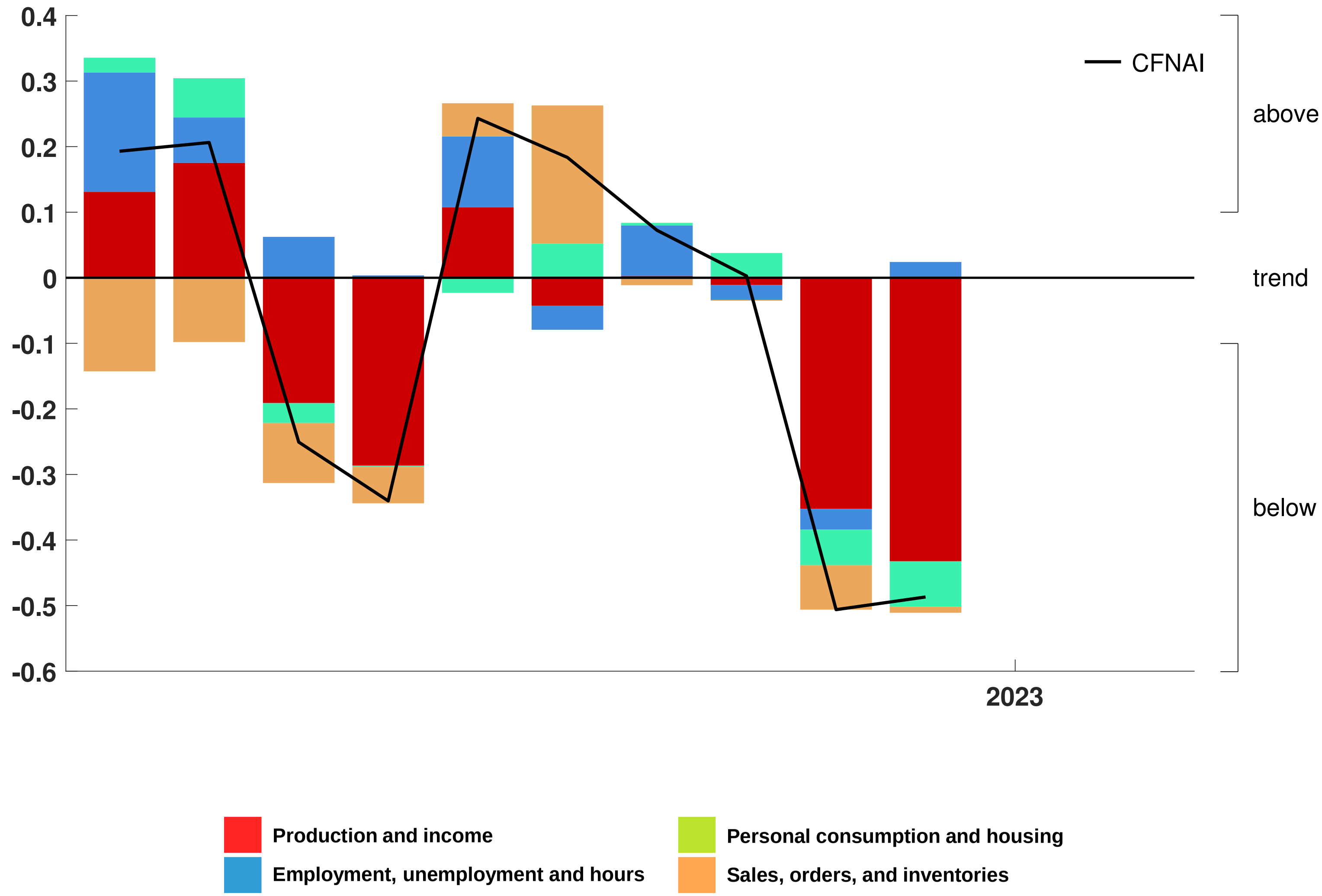
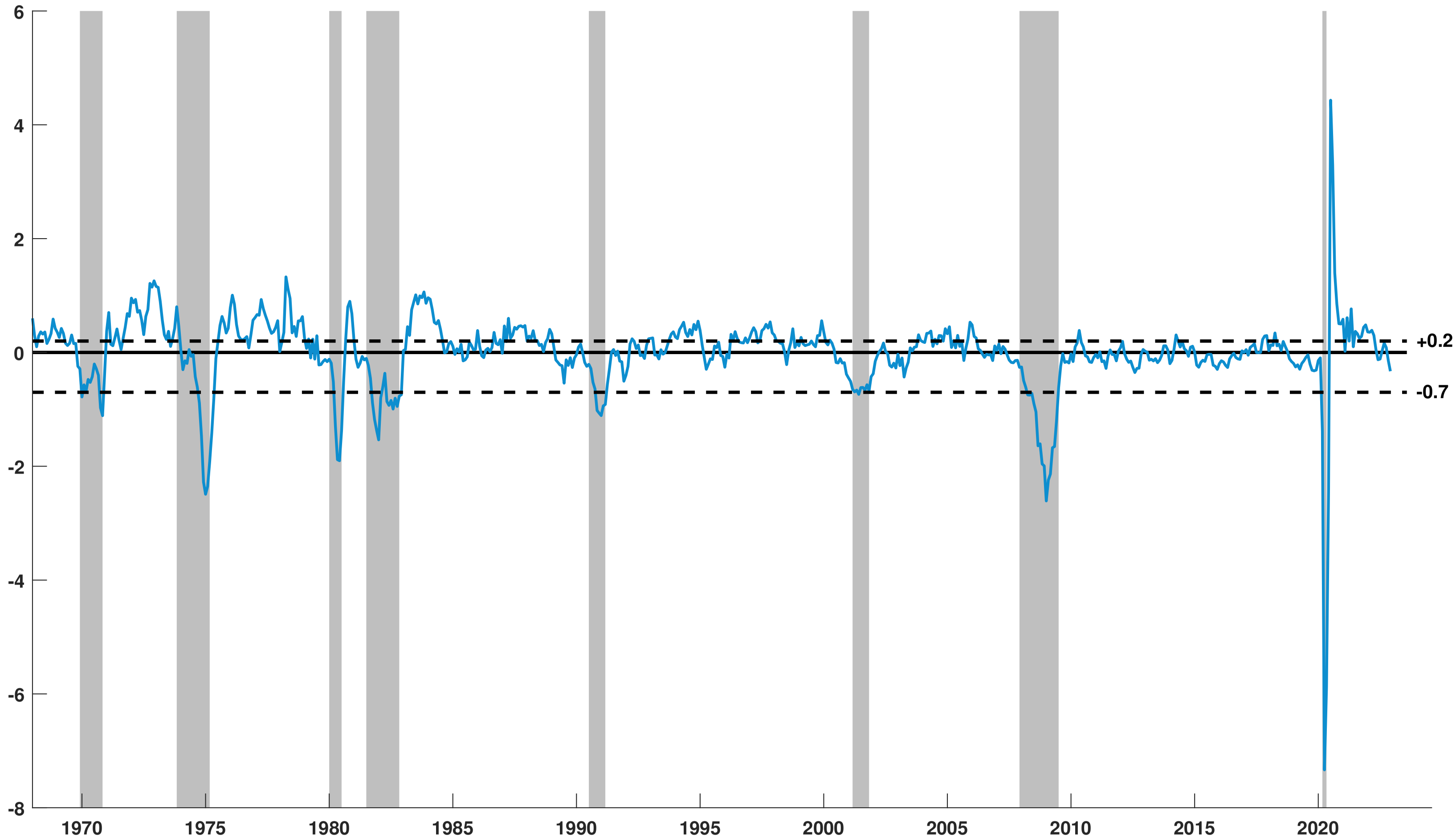
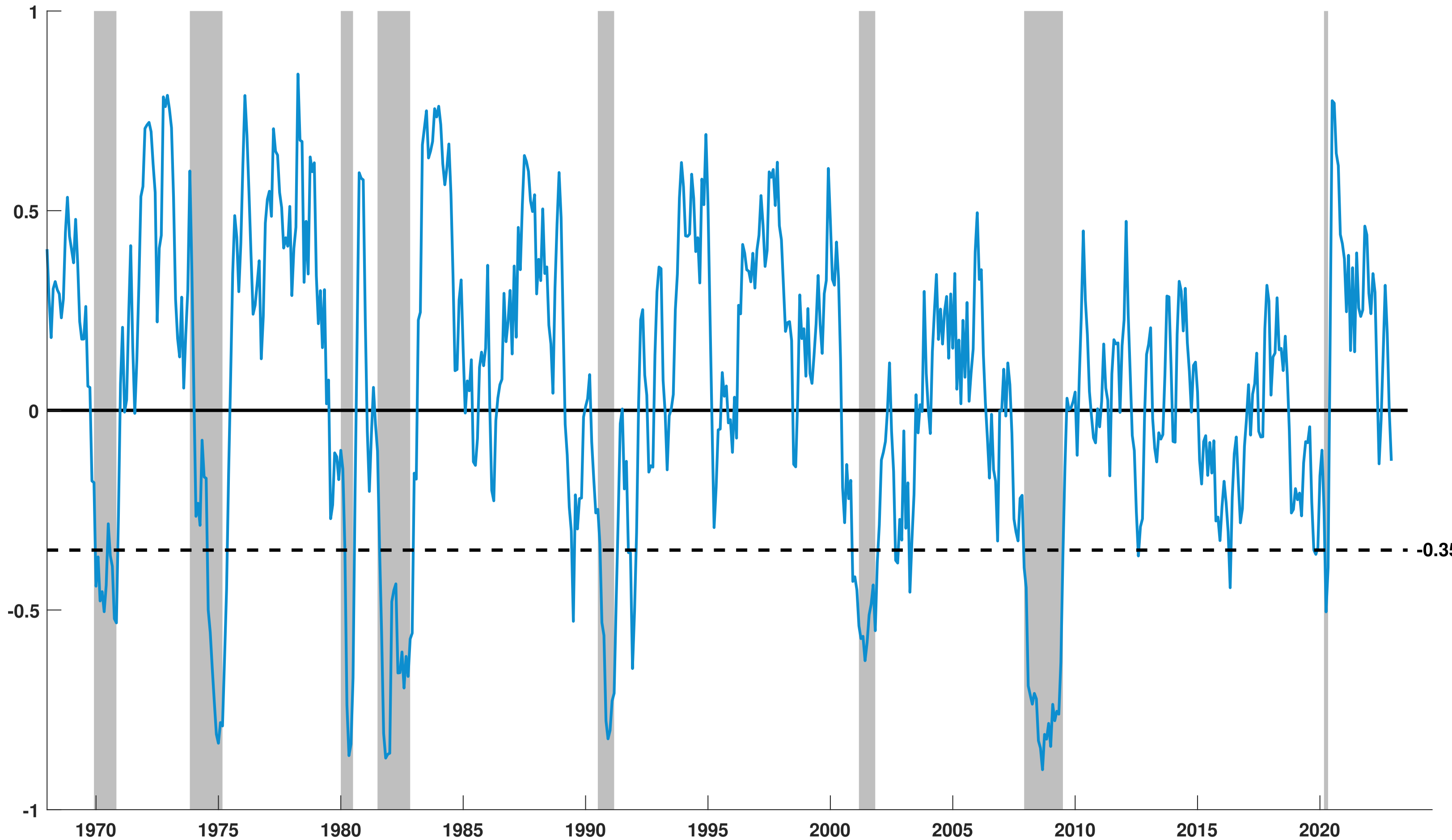


Figure 3: Chicago Fed National Activity Index three-month moving average (CFNAI-MA3) and business cycles



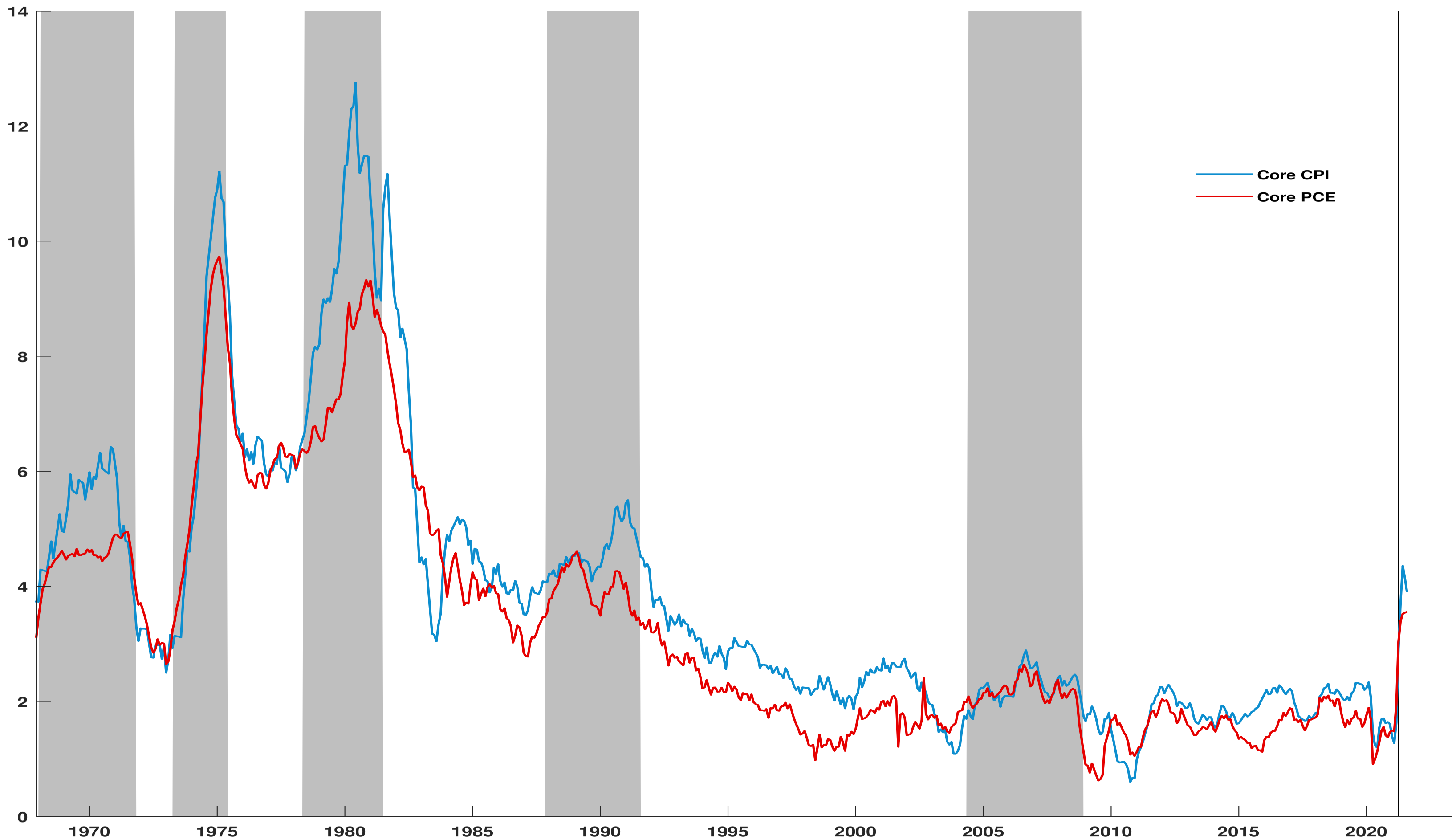
Notes: Shading indicates official periods of recession as identified by the National Bureau of Economic Research. Following a period of economic expansion, an increasing likelihood of a recession has historically been associated with a CFNAI-MA3 value below –0.70. Conversely, following a period of economic contraction, an increasing likelihood of an expansion has historically been associated with a CFNAI-MA3 value above –0.70 and a significant likelihood of an expansion has historically been associated with a CFNAI-MA3 value above +0.20.

Figure 4: CFNAI Diffusion Index and business cycles



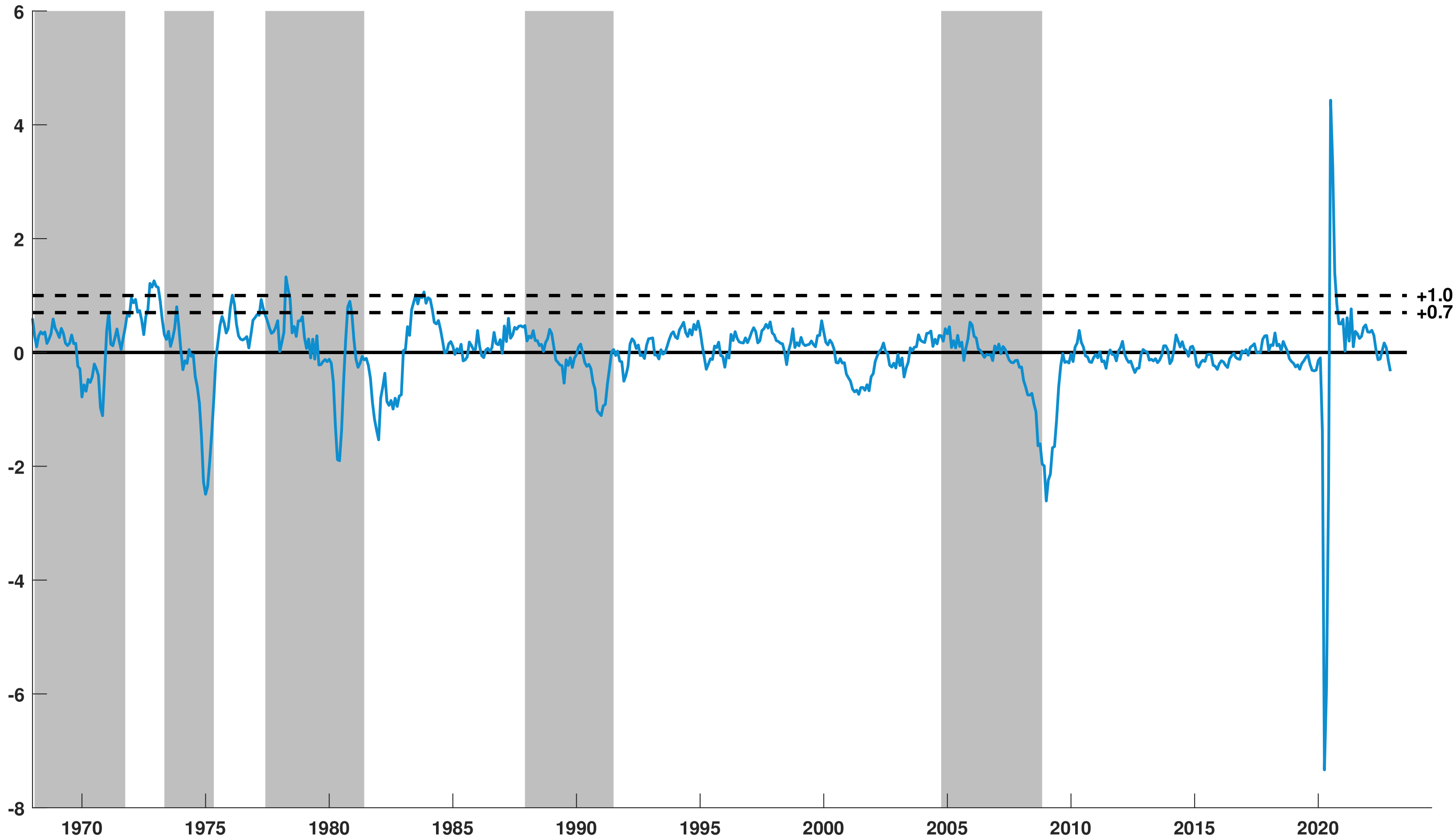
Notes: Shading indicates official periods of recession as identified by the National Bureau of Economic Research. The CFNAI Diffusion Index represents the three-month moving average of the sum of the absolute values of the weights for the underlying indicators whose contribution to the CFNAI is positive in a given month less the sum of the absolute values of the weights for those indicators whose contribution is negative or neutral in a given month. Periods of economic expansion have historically been associated with values of the CFNAI Diffusion Index above −0.35.

Figure 5: Core inflation and increasing inflation episodes



Notes: Core CPI means Consumer Price Index minus food and energy prices. Core PCE means Personal Consumption Expenditures Price Index minus food and energy prices. Shading represents periods of sustained increasing inflation; the vertical line indicates the start of the most recent period.

Figure 6: Chicago Fed National Activity Index three-month moving average (CFNAI-MA3) and increasing inflation episodes



Notes: Shading represents periods of sustained increasing inflation; the vertical line indicates the start of the most recent period. An increasing likelihood of a period of sustained increasing inflation has historically been associated with values of the CFNAI-MA3 above +0.70 more than two years into an economic expansion. Similarly, a substantial likelihood of a period of sustained increasing inflation has historically been associated with values of the CFNAI-MA3 above +1.00 more than two years into an economic expansion.