Nowcasting and Forecasting with Big Data

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The views expressed herein are solely those of the authors and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

This version of the Central Banking Seminar presentation includes the presenter’s notes, which were retained to offer readers additional background and context.
Outline

- Monitoring Economic Conditions: Then and Now
- The Real Time Data Flow
- Forecasting and the Importance of Now
- The Nowcasting Framework
- Nowcasting in Practice
- Nowcasting during a Government Shutdown
- Nowcasting around the World
Outline

- Monitoring Economic Conditions: Then and Now
  - The Real Time Data Flow
  - Forecasting and the Importance of Now
  - The Nowcasting Framework
  - Nowcasting in Practice
  - Nowcasting during a Government Shutdown
  - Nowcasting around the World
Handling large and complex data sets was a challenge that macroeconomists engaged in real-time analysis faced long before so-called big data became pervasive in other disciplines. Burns and Mitchell pioneered business cycle analysis at the NBER in the late 1930s, scrutinizing hundreds of data series in search of patterns and regularities. What they uncovered was systematic co-movement among the series and a pervasiveness of fluctuations across different sectors and different kinds of economic activities. This led them to identify the broad recurrence of two states in the economy: expansions and recessions.

There were parallel advances in measurement. Simon Kuznets pioneered efforts to collect a very large and complex set of measurements on the economy and to organize and synthesize them in a system of coherent aggregates—the national accounts—during the Great Depression.

For more discussion, see Bok et al., Macroeconomic Nowcasting and Forecasting with Big Data (2018).
The collection of expert forecasts has a long tradition. The oldest is the Survey of Professional Forecasters, which began in 1968.

Professional forecasters use a combination of approaches. A special survey conducted by the Real-Time Data Research Center at the Philadelphia Fed in 2009 revealed that the majority of the SPF panelists use mathematical models to form their projections, but also apply subjective adjustments to their pure model-generated forecasts. Interestingly, the use of models is predominant for short-horizon forecasts, less so for long-horizon projections. However, not all forecasters monitor economic conditions at high frequency: only 5 out of 25 respondents seem to update their forecasts at higher than monthly frequency.

New methodologies in time-series econometrics have made possible the development of platforms for real-time forecasting that combine formal models for big data and filtering into nowcasting.

Broadly speaking, the nowcast can be thought of as a model-based counterpart to conjunctural analysis (in which central bankers and economists at trading desks engage daily). It is based on statistical filtering techniques applied to a dynamic factor model. These techniques are very common in big data analytics since they effectively summarize the information contained in large data sets through a small number of common factors.

The nowcasting model unites several analytical approaches for monitoring current economic conditions that are typically used independently. As indexes of coincident and leading indicators do, our model characterizes current economic activity by condensing the information into a few factors that summarize business cycle conditions. The model mimics the behavior of market participants and professional forecasters, by tracking all relevant measures of economic activity, making predictions that are constantly updated in response to unexpected developments in economic releases.

Unlike professional forecasters who combine a variety of unrelated models and apply some form of judgment, using a single formal model allows for a transparent and internally coherent analysis of the real-time data flow. The model, in essence, codifies within an econometric framework the best practice and expert knowledge in business cycle analysis. This is a significant change in paradigm.

The general finding is that these automated forecasts are as accurate as, and highly correlated with, the forecasts produced by institutions and experts.

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**Monitoring Economic Conditions | Then and Now**

- **Forecasting with Judgment and Models**
  - Coincident indicators, Bridge equations, Structural Models, NBER-ASSA Survey of Professional Forecasters, Blue Chip, Institutional forecasts.

- **Nowcasting**
  - **Model-based** counterpart to conjunctural analysis
  - **Real-time** reading of the news flow
  - **Continuously updated** prediction of GDP growth

"[Nowcasting is among] [t]he current suite of tools for handling large series and complicated data flows…. [U]sing a single model … rather than a suite of small models or judgment, provides a scientific way to use the real-time data flow." (Stock and Watson, Twenty Years of Time Series Econometrics in Ten Pictures, Journal of Economic Perspectives, p. 71, 2017)
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- **The Real Time Data Flow**
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- Nowcasting around the World
The Real-Time Data Flow
The relevant information on the state of the economy is conveyed to markets through the release of macroeconomic reports.

Market analysts track the major releases to detect early signals. News, generated when released data differs from expectations, leads them to update their projections.

This slide presents a screenshot of the Bloomberg ECO calendar for the United States. The bars in the “Relevance” column (R) offer a measure of the number of alert subscribers and is a measure for the weight that market monitors put on the release.
## The Real-Time Data Flow (World)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event</th>
<th>Period</th>
<th>Surp(%) Actual</th>
<th>Prior</th>
<th>S</th>
<th>Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/04</td>
<td>00:00</td>
<td>Exports YoY</td>
<td>Aug</td>
<td>2.7% -0.8%</td>
<td>1.7% 53.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>00:00</td>
<td>Imports YoY</td>
<td>Aug</td>
<td>-8.0% -12.5%</td>
<td>-5.9% 38.46</td>
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<td></td>
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<tr>
<td>10/04</td>
<td>00:00</td>
<td>Trade Balance MYR</td>
<td>Aug</td>
<td>10.70b 10.92b</td>
<td>14.27b 46.15</td>
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<td></td>
</tr>
<tr>
<td>10/04</td>
<td>01:00</td>
<td>Markit India PMI Services</td>
<td>Sep</td>
<td>48.7</td>
<td>52.4 70.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>01:00</td>
<td>Markit India PMI Composite</td>
<td>Sep</td>
<td>49.8</td>
<td>52.6 70.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>02:06</td>
<td>Consumer Confidence Index</td>
<td>Sep</td>
<td>121.8</td>
<td>123.1 26.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>02:15</td>
<td>RBI Repurchase Rate</td>
<td>Oct</td>
<td>5.15% 5.15%</td>
<td>5.4% 94.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>02:15</td>
<td>RBI Reverse Repo Rate</td>
<td>Oct</td>
<td>4.90% 4.90%</td>
<td>5.1% 68.42</td>
<td></td>
<td></td>
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<tr>
<td>10/04</td>
<td>02:15</td>
<td>RBI Cash Reserve Ratio</td>
<td>Oct</td>
<td>4.00% 4.00%</td>
<td>4.0% 63.16</td>
<td></td>
<td></td>
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<tr>
<td>10/04</td>
<td>02:32</td>
<td>Money Supply M3 YoY</td>
<td>Aug</td>
<td>12.8%</td>
<td>10.0% 66.67</td>
<td></td>
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<tr>
<td>10/04</td>
<td>02:45</td>
<td>Budget Balance YTD</td>
<td>Aug</td>
<td>-123.1</td>
<td>-109.7b 40.00</td>
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<td></td>
</tr>
<tr>
<td>10/04</td>
<td>03:30</td>
<td>Markit Germany Construction PMI</td>
<td>Sep</td>
<td>50.1</td>
<td>46.3 50.00</td>
<td></td>
<td></td>
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<tr>
<td>10/04</td>
<td>03:30</td>
<td>Foreign Reserves</td>
<td>Sep</td>
<td>-$220.4</td>
<td>$221.7b 80.77</td>
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<td></td>
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<tr>
<td>10/04</td>
<td>03:30</td>
<td>Forward Contracts</td>
<td>Sep</td>
<td>-$33.1b</td>
<td>$32.0b 26.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:00</td>
<td>Money Supply Narrow Def</td>
<td>Sep</td>
<td>10.56t</td>
<td>10.63 33.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:00</td>
<td>Deficit to GDP YTD</td>
<td>2Q</td>
<td>4.0%</td>
<td>4.1% 16.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:00</td>
<td>New Car Registrations YoY</td>
<td>Sep</td>
<td>1.3% -1.6%</td>
<td>36.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:10</td>
<td>Foreign Reserves</td>
<td>Sep</td>
<td>-$469.4</td>
<td>$468.17 42.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:26</td>
<td>CPI YoY</td>
<td>Sep</td>
<td>6.7%</td>
<td>6.7% 0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:30</td>
<td>WIFO Quarterly Economic Forecasts</td>
<td>Sep</td>
<td>57.1</td>
<td>56.4 0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>04:45</td>
<td>Markit/Stanbic IBTC Bank PMI</td>
<td>Sep</td>
<td>-17100-12030m83.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>05:00</td>
<td>Trade Balance</td>
<td>Sep P</td>
<td>-17100-12030m83.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>05:00</td>
<td>Istat Releases Revised Quarterly National Account Series</td>
<td>Aug</td>
<td>-3.0% -2.1% 6.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>06:00</td>
<td>Industrial Output MoM</td>
<td>Aug</td>
<td>2.0% -1.3%</td>
<td>20.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>06:00</td>
<td>Industrial Output WDA YoY</td>
<td>Aug</td>
<td>2.0% -1.3%</td>
<td>20.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>07:00</td>
<td>Vehicle Production</td>
<td>Sep</td>
<td>318900</td>
<td>337462 35.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>07:00</td>
<td>Vehicle Exports</td>
<td>Sep</td>
<td>284243</td>
<td>281811 30.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/04</td>
<td>07:00</td>
<td>Effective Exchange Rate</td>
<td>Sep</td>
<td>284243</td>
<td>281811 30.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Real-Time Data Flow

- Macro releases make front-page news.

GLOBAL MARKETS-Stocks, oil fall, dollar rises after U.S. data

US stock futures trade higher after jobs report disappoints

TREASURIES-Yields fall after wages data for October disappoints

U.S. Treasury Bond Prices Fall on Strong Data

US Treasury yields climb after stronger industrial production data

FOREX-Dollar index adds on upbeat durable goods data

US Treasury yields fall after strong housing starts data

U.S. Stocks Rise On Above Expected U.S. GDP Growth
The Altavilla, Giannone, and Modugno paper cited here found that macroeconomic surprises explain a large part of asset price fluctuations, up to one-third of the quarter-to-quarter fluctuations in government bond yields.
## The Data

<table>
<thead>
<tr>
<th>Release</th>
<th>Timing</th>
<th>Delay</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Spending</td>
<td>first business day of the month, two months prior</td>
<td>33</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>ISM Manufacturing Report on Business</td>
<td>first business day of the month, one month prior</td>
<td>3</td>
<td>ISM</td>
</tr>
<tr>
<td>ISM Non-Manufacturing Report on Business</td>
<td>third business day of the month, one month prior</td>
<td>5</td>
<td>ISM</td>
</tr>
<tr>
<td>U.S. International Trade in Goods and Services</td>
<td>first full week of the month, two months prior</td>
<td>35</td>
<td>BEA, Census Bureau</td>
</tr>
<tr>
<td>Manufacturers' Shipments, Inventories, and Orders</td>
<td>first week of the month, two months prior</td>
<td>35</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>ADP National Employment Report</td>
<td>first Wednesday of the month, one month prior</td>
<td>5</td>
<td>ADP</td>
</tr>
<tr>
<td>Employment Situation</td>
<td>first Friday of the month, one month prior</td>
<td>7</td>
<td>BLS</td>
</tr>
<tr>
<td>Manufacturing and Trade Inventories</td>
<td>first full week of the month, two months prior</td>
<td>44</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Job Openings and Labor Turnover</td>
<td>second week of the month, two months prior</td>
<td>42</td>
<td>BLS</td>
</tr>
<tr>
<td>U.S. Import and Export Price Indexes</td>
<td>middle of the month, one month prior</td>
<td>13</td>
<td>BLS</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>ninth business day of the month, one month prior</td>
<td>14</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Producer Price Index</td>
<td>middle of the month, one month prior</td>
<td>14</td>
<td>BLS</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>middle of the month, two months prior</td>
<td>37</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Empire State Manufacturing Survey</td>
<td>15th of the month, current month</td>
<td>-14</td>
<td>New York Fed</td>
</tr>
<tr>
<td>Manufacturing Business Outlook Survey</td>
<td>third Thursday of the month, current month</td>
<td>-11</td>
<td>Philadelphia Fed</td>
</tr>
<tr>
<td>Industrial Production and Capacity Utilization</td>
<td>middle of the month, one month prior</td>
<td>17</td>
<td>Federal Reserve Board</td>
</tr>
<tr>
<td>Consumer Price Index</td>
<td>middle of the month, one month prior</td>
<td>18</td>
<td>BLS</td>
</tr>
<tr>
<td>New Residential Construction</td>
<td>12th business day of the month, one month prior</td>
<td>16</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Advance Economic Indicators</td>
<td>last week of the month, one month prior</td>
<td>28</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>New Residential Sales</td>
<td>17th business day of the month, one month prior</td>
<td>26</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Advance Durable Goods</td>
<td>third week of the month, one month prior</td>
<td>26</td>
<td>Census Bureau</td>
</tr>
<tr>
<td>Personal Income and Outlays</td>
<td>last week of the month, one month prior</td>
<td>30</td>
<td>BEA</td>
</tr>
<tr>
<td>Gross Domestic Product</td>
<td>last week of the month, prior quarter</td>
<td>28</td>
<td>BEA</td>
</tr>
<tr>
<td>Productivity and Costs</td>
<td>first week of the month, prior quarter</td>
<td>34</td>
<td>BLS</td>
</tr>
</tbody>
</table>
The New York Fed Staff Nowcast employs 37 data series. They are represented in a standardized format (with a mean of zero and a variance of 1) and spaced for visibility. Individual series are bolded in slides 13-49 to emphasize their respective dynamics.
Big Data for Monitoring Macroeconomic Conditions

Real gross domestic product (QoQ % chg. AR)

Big Data for Monitoring Macroeconomic Conditions

ISM mfg.: PMI composite index (Index)

Big Data for Monitoring Macroeconomic Conditions

CPI-U: All items (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

Manufacturers' new orders: Durable goods (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

Retail sales and food services (MoM % chg.)
Big Data for Monitoring Macroeconomic Conditions

New single-family houses sold (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

Housing starts (MoM % chg.)


1  5  9  13  17  21  25  29  33  37
Big Data for Monitoring Macroeconomic Conditions

Civilian unemployment rate (Ppt. chg.)

Big Data for Monitoring Macroeconomic Conditions
Big Data for Monitoring Macroeconomic Conditions

PPI: Final demand (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

ADP nonfarm private payroll employment (Level chg.)
Big Data for Monitoring Macroeconomic Conditions

Empire State Mfg. Survey: General business conditions (Index)

Big Data for Monitoring Macroeconomic Conditions

Merchant wholesalers: Total inventories (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

Value of construction put in place (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions


Big Data for Monitoring Macroeconomic Conditions

Import price index (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

ISM non-mfg.: NMI composite index (Index)

Big Data for Monitoring Macroeconomic Conditions

ISM mfg.: Price index (Index)
Big Data for Monitoring Macroeconomic Conditions

Building permits (Level chg.)
Big Data for Monitoring Macroeconomic Conditions

Capacity utilization (Ppt. chg.)

Big Data for Monitoring Macroeconomic Conditions

CPI-U: All items less food and energy (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions
Big Data for Monitoring Macroeconomic Conditions

Nonfarm business sector: Unit labor cost (QoQ % chg. AR)

Big Data for Monitoring Macroeconomic Conditions

JOLTS: Total job openings (Level chg.)

Big Data for Monitoring Macroeconomic Conditions

Real personal consumption expenditures (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

PCE: Chain price index (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions
Big Data for Monitoring Macroeconomic Conditions

Export price index (MoM % chg.)

1 5 9 13 17 21 25 29 33 37
Big Data for Monitoring Macroeconomic Conditions
Big Data for Monitoring Macroeconomic Conditions

Manufacturers' unfilled orders: Durable goods (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

Manufacturers' inventories: Durable goods (MoM % chg.)
Big Data for Monitoring Macroeconomic Conditions

Real gross domestic income (QoQ % chg. AR)
Big Data for Monitoring Macroeconomic Conditions

Real disposable personal income (MoM % chg.)

Big Data for Monitoring Macroeconomic Conditions

Exports: Goods and services (MoM % chg.)


1 5 9 13 17 21 25 29 33 37
Big Data for Monitoring Macroeconomic Conditions

Imports: Goods and services (MoM % chg.)

The chart plots the joint evolution of all data employed in our nowcasting model over time.

These are the same kind of data that Burns and Mitchell were looking at in the 1940s in their research on identifying the business cycle. It can be argued that their careful screening for pattern using "unsupervised classification" is what many decades later became machine learning.
The three-dimensional surface plot presents time-series data grouped by category (for example, “labor” or “income” data) and color coded accordingly.

The heat map on the horizontal plane highlights the data’s co-movement, with yellow indicating positive values and red indicating negative values. The fact that yellow (indicating economic booms) and red (recessions) tend to bunch together in time capture the fact that macroeconomic variables tend to move together, despite their apparent heterogeneity, giving rise to business cycles.
The deep ridge in the 2008-09 period corresponds to the Great Recession, a time when all macroeconomic variables were deeply depressed compared with their historical averages. A similar, but less uniform red ridge is also evident in the early 1990s and early 2000s, periods that correspond to shallower and less widespread recessions.

The gray shaded areas indicate NBER recessions.

For more discussion, see “Opening the Toolbox: The Nowcasting Code on GitHub,” Federal Reserve Bank of New York Liberty Street Economics, August 10, 2018.
The colored dotted lines report all data series that enter the model, plotted in standard deviations from their mean. Gray shaded areas indicate NBER recessions.
The solid black line illustrates quarterly GDP growth. The colored dotted lines report all data series that enter the model, plotted in standard deviations from their mean. Gray shaded areas indicate NBER recessions.

No one indicator can be a silver bullet that solves the problem of accurately tracking the evolution of the economy in real time. A more promising approach is, instead, combining the information contained in many available releases. Given the number of these releases, and the hundreds of statistics that they often include, designing such an approach is once again a big data challenge, essentially the same one faced by Kuznets in developing GDP: how to synthesize the complexity of the U.S. economy through one summary statistic. GDP provides an answer to this question based on accounting principles. Nowcasting addresses the same challenge through statistical modeling.
The green and red lines highlight regions of positive and negative quarterly GDP growth. The colored dotted lines report all data series that enter the model, plotted in standard deviations from their mean. Gray shaded areas indicate NBER recessions.

The business cycle turns out, ex post, to be very close to the peaks and troughs of GDP growth. Indeed, the definition of a “technical recession,” one when there are two consecutive quarters of negative real GDP growth, is a popularized version of algorithms derived to identify business cycle turning points. This bridges with the careful work dedicated to the construction of GDP data in the National Income and Product Accounts.
The green and red lines highlight regions of positive and negative quarterly GDP growth. The dashed lines give GDI growth. The colored dotted lines report all data series that enter the model, plotted in standard deviations from their mean. Gray shaded areas indicate NBER recessions.

GDP and GDI are constructed from different data but give the same results.
The blue line gives the common factor estimated from the dynamic factor model.

The pervasiveness of common fluctuations across different sectors of the economy implies strong cross-sectional correlations, suggesting that the bulk of fluctuations is essentially driven by a few common sources. Dynamic factor models build on this basic fact to provide a parsimonious and yet suitable representation for the macroeconomic series.

The basic premise of the dynamic factor model used in our nowcasting framework is to exploit the co-movement in the data to extract a latent common factor. In the model, all series load on—that is, they are allowed to move with—a global factor, as well as on “local” factors that capture the co-movement among certain groups of series, for instance, those pertaining to the labor market or coming from surveys. Projecting the common factor onto all the data series specified produces a broad summary measure of economic activity.
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The current quarter predictions ("nowcasts") from the Survey of Professional Forecasters track closely with observed data. To match historic SPF data, we splice real GDP with real GNP. Professional forecasters find the most success predicting the current and next quarter. There is considerable uncertainty for longer horizons, reflected in the flattening of the orange line in subsequent quarters in the next few slides.
Forecasting the Business Cycle

Survey of Professional Forecasters: 1-Quarter Ahead Forecast

- Realized GDP/GNP growth
- Median SPF forecast
- Individual SPF forecasts


Real GDP/GNP growth, percent change (annual rate)
Forecasting the Business Cycle

Survey of Professional Forecasters: 2-Quarter Ahead Forecast

Realized GDP/GNP growth
Median SPF forecast
Individual SPF forecasts
Forecasting the Business Cycle

Survey of Professional Forecasters: 3-Quarter Ahead Forecast
Four quarters ahead, the SPF forecast is nearly unchanged.
We show root mean square errors for GDP forecasts at horizons 0 (i.e., nowcast) to 4 quarters ahead. Errors are computed on the evaluation sample 1985–2014 as the difference between the latest available GDP estimate and three types of GDP projections. *** and ** indicate SPF forecasts that are significantly more accurate than those of the naive AR model at the 1% and 5% levels, respectively, based on a Diebold-Mariano tests with a quadratic loss function.

How successful are professional forecasts? Apparently, there is little predictability of real GDP growth beyond the current and next quarter. The table above reports the SPF forecast error statistics alongside those of a naïve statistical model: The big gain of SPF forecasts is at horizon 0 (the forecast of the current quarter). For reference, the table also includes the root mean square error of the BEA’s advance GDP release assessed relative to its most recent revised value.

See Bok et al. (2018) for more detail.
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- Nowcasting Around the World
Nowcasting literally means to forecast the present. More figuratively, it characterizes the modern approach to monitoring current economic conditions in real time.

The nowcast can be thought of as a model-based counterpart to conjunctural analysis (the kind of analysis underlying the judgmental forecasts presented in the beginning of the presentation).

The main idea of nowcasting is to analyze and interpret the macroeconomic news flow by continuously updating the predictions of key variables, like real GDP growth, for each data release.

- Monitoring current economic conditions in real time by predicting the present
  - **Model-based** counterpart to conjunctural analysis
  - Real-time reading of the **newsflow**
  - Continuously updated **nowcast** of GDP growth
The development of nowcasting has been made possible thanks to recent advances in the econometrics of high-dimensional data.

Nowadays, we can process the large and complex set of data that are constantly monitored by economists at central banks, on trading desks, and in the media. That data set covers essentially everything from manufacturing and inventories to the sentiment of purchasing managers, from labor market indicators to transportation services and international trade.

The approach is based entirely on automated procedures, designed to mimic best practices without relying on any judgment or subjective prior information. Thanks to the automation, new information is processed within minutes of the release.

**Big-Data Analytics**

- **High-dimensional data**
  - Includes the large and complex data monitored by economists at central banks, trading desks, and in the media

- **Entirely automated**
  - Mimics best practice without relying on any judgment or subjective prior information

- **Real-time**
  - Digests new information within minutes of the releases
In order to minimize human intervention and subjective choice, it is key to use unified and internally consistent econometric approaches, which are simple and transparent, hence robust. This straightjacket has not created any disadvantage; the benefit, apart from robustness, is that it allows for a coherent analysis of the link between macro news and cyclical developments.

With a coherent and internally consistent econometric model, the news flow is naturally processed in the same way as by any informed person. First, the surprise component is extracted from the data. Second, these surprises are translated into a common unit, which is their impact on key macroeconomic indicators, say, the GDP nowcast or corporate profits.

---

**Digesting the Newsflow**

- Coherent analysis of the link between macro news and cyclical developments
  - **Extract** the news/surprise component from data
    - Actual data minus model-based forecasts
  - **Translate** the news in a common unit
    - What’s the impact of the news on GDP growth?
The engine of the platform is the Dynamic Factor Model, equipped with advanced filtering techniques, of the kind used in robotics.

Methodology

- Dynamic factor model
  - Few factors capture the salient features of business cycle fluctuations
    - Flexibility, parsimony, robustness

- Filtering techniques
  - Efficient processing of real-time information
    - Mixed frequencies, jagged edges, missing data
### The Real-Time Data Flow

<table>
<thead>
<tr>
<th>Data Series</th>
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<tbody>
<tr>
<td>All employees: Total nonfarm</td>
<td>G</td>
<td>Level change (thousands)</td>
</tr>
<tr>
<td>Real gross domestic product</td>
<td>S</td>
<td>QoQ % change (annual rate)</td>
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<tr>
<td>ISM mfg.: PMI composite index</td>
<td>R</td>
<td>Index</td>
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<tr>
<td>CPI-U: All items</td>
<td>L</td>
<td>MoM % change</td>
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<tr>
<td>Manufacturers new orders: Durable goods</td>
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<td>MoM % change</td>
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<tr>
<td>Retail sales and food services</td>
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<td>MoM % change</td>
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<td>New single family houses sold</td>
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<td>MoM % change</td>
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<tr>
<td>Housing starts</td>
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<td>MoM % change</td>
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<tr>
<td>Civilian unemployment rate</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>Industrial production index</td>
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<td>MoM % change</td>
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<tr>
<td>PPI: Final demand</td>
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<td>MoM % change</td>
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<tr>
<td>ADP nonfarm private payroll employment</td>
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<td>Level change (thousands)</td>
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<tr>
<td>Empire State Mfg. Survey: General business conditions</td>
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<td>Index</td>
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<tr>
<td>Merchant wholesalers: Inventories: Total</td>
<td></td>
<td>MoM % change</td>
</tr>
<tr>
<td>Value of construction put in place</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>Philly Fed Mfg. business outlook: Current activity</td>
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<td>Index</td>
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<tr>
<td>Import price index</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>ISM nonmanufacturing: NMI composite index</td>
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<td>Index</td>
</tr>
<tr>
<td>Building permits</td>
<td></td>
<td>Level change (thousands)</td>
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<tr>
<td>Capacity utilization</td>
<td></td>
<td>Ppt. change</td>
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<tr>
<td>PCE less food and energy: Chain price index</td>
<td></td>
<td>MoM % change</td>
</tr>
<tr>
<td>CPI-U: All items less food and energy</td>
<td></td>
<td>MoM % change</td>
</tr>
<tr>
<td>Inventories: Total business</td>
<td></td>
<td>MoM % change</td>
</tr>
<tr>
<td>Nonfarm business sector: Unit labor cost</td>
<td></td>
<td>QoQ % change (annual rate)</td>
</tr>
<tr>
<td>JOLTS: Job openings: Total</td>
<td></td>
<td>Level change (thousands)</td>
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<tr>
<td>Real personal consumption expenditures</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>PCE: Chain price index</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>ISM mfg.: Employment index</td>
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<td>MoM % change</td>
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<tr>
<td>Export price index</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>Manufacturers shipments: Durable goods</td>
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<td>MoM % change</td>
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<tr>
<td>Mfrs. unfilled orders: All manufacturing industries</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>Manufacturers inventories: Durable goods</td>
<td></td>
<td>MoM % change</td>
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<tr>
<td>Real gross domestic income</td>
<td></td>
<td>MoM % change</td>
</tr>
<tr>
<td>Real disposable personal income</td>
<td></td>
<td>QoQ % change (annual rate)</td>
</tr>
<tr>
<td>Exports: Goods and services</td>
<td></td>
<td>MoM % change</td>
</tr>
</tbody>
</table>
| Imports: Goods and services                                                |       | MoM % change                               

- **Housing and construction**  |  
- **Manufacturing**            |  
- **Surveys**                  |  
- **Retail and consumption**   |  
- **Income**                   |  
- **Labor**                    |  
- **International trade**      |  
- **Others**                   |  

**CENTRAL BANKING SEMINAR PRESENTATION / Federal Reserve Bank of New York / October 8, 2019**
Given the richness of the available macroeconomic information, what might be the role for the ever-growing alternative sources of big data, such as internet search queries, electronic payments, or online prices in monitoring the economy? Choi & Varian (2012) and Askitas (2015), for example, show that Google Trends data can improve the forecasting of timely economic indicators, such as automobile sales and initial claims, when compared to a univariate autoregressive model. However, Li (2016) and Gil et al. (2017) show that Google search queries and other alternative data have limited marginal information content once one takes into account the range of economic data already available. See Bok et al. (2018) for more discussion.

We leave financial variables out of the New York Fed Staff Nowcast. They tend to be quite volatile and, therefore, in our experience, have a limited role in GDP growth nowcasting once a rich set of macroeconomic variables have been included. For further discussion, see “Hey, Economist! How Do You Forecast the Present?,” Liberty Street Economics, June 16, 2017.

### Alternative Data Sources

- What types of data are useful in the context of nowcasting?
- Is there a role for financial information?
- Is there a potential role for alternative data?
- Statistical agencies already produce big and high-quality macroeconomic data
  - Widely followed and intensively exploited
- It takes work to bring new alternative data to comparable quality
  - Distill signal from noise
    - Seasonality, outliers, other irregularities
  - Reliability and replicability
    - Setting standards, quality control
The Machinery | The Data
Burns and Mitchell meet Kuznets
Forecasting the Business Cycle

Survey of Professional Forecasters: Nowcast

- Realized GDP/GNP growth
- Median SPF forecast
- Individual SPF forecasts
- FRBNY nowcast


Real GDP/GNP growth, percent change (annual rate)
Outline

- Monitoring Economic Conditions: Then and Now
- The Real Time Data Flow
- Forecasting and the Importance of Now
- The Nowcasting Framework
- **Nowcasting in Practice**
  - Nowcasting during a Government Shutdown
  - Nowcasting around the World
The staff nowcast is updated on the New York Fed's public website each Friday (except on federal holidays) at 11:15 a.m., using data available up to 10 a.m.

https://www.newyorkfed.org/research/policy/nowcast
The figure shows the weekly updates of the nowcast, i.e., the predictions of the model based on the information available at the dates indicated on the horizontal axis. The progression reflects how the news in the data released each week changes the nowcast for that week. The colored bars illustrate the impact on the nowcast of news from a week’s data releases (color coded by category). The distance between the diamonds is the difference between the positive and negative portions of the bars.
Nowcasting GDP Growth in 2016:Q4
Nowcasting GDP Growth in 2016:Q4

Key
- New York Fed Staff Nowcast
- Blue Chip Forecasts
- Survey of Professional Forecasters
- Advance estimate
- Latest estimate

Data Releases
- Housing and construction
- Manufacturing
- Surveys
- Retail and consumption
- Income
- Labor
- International trade
- Others
Nowcasting GDP Growth in 2016:Q4

Key
- New York Fed Staff Nowcast
- Blue Chip Forecasts
- Survey of Professional Forecasters
- Advance estimate
- Latest estimate

Data Releases
- Housing and construction
- Manufacturing
- Surveys
- Retail and consumption
- Income
- Labor
- International trade
- Others

![Graph showing nowcasting GDP growth in 2016:Q4 with key data releases and sources marked on the chart.](image-url)
The figure reports the evolution of the nowcast of real GDP growth in 2016:Q4, but with added shading to provide information about forecasting uncertainty. In particular, the shaded area represents the 68% probability interval constructed using the empirical distribution of the forecast errors. We discuss forecasting performance in more detail below, but it should be noted that the bands narrow as the quarter progresses and information accumulates. This suggests that the data contain useful information that the model is able to exploit in real time.
Notice, too, the substantial uncertainty also present in the Bureau of Economic Analysis official release of GDP, as illustrated in the above figure by the error bar around the release, which reflects data revisions. This uncertainty is similar in magnitude to that of the model forecast, suggesting that the model predictions are roughly as accurate as the first release in predicting the latest available estimates of GDP growth.
Nowcasting GDP Growth in 2016:Q4
We shared forecasts of GDP growth using historically reconstructed data from 2002-15 on the New York Fed’s public website. See the “Archive” section of the interactive charts. The values we report for these quarters represent predictions that our nowcasting model would have made in real time, using the data that were available to the public as of the dates noted.
An accompanying Liberty Street Economics post discussed the evolution of the nowcast at critical points during the Great Recession in 2008-09. For example, the nowcast first dropped into negative territory in mid-October 2008, roughly one month after the failure of Lehman Brothers and six weeks before the National Bureau of Economic Research (NBER) Business Cycle Dating Committee officially announced that the economy had been in a recession for the past twelve months. Additional negative news throughout the quarter led to further declines in the nowcast, and our final prediction of -3.6 percent GDP growth was almost exactly in line with the BEA’s advance estimate (denoted with a circle in the figure above). Subsequent official estimates revised the contraction down to more than 8 percent (denoted by the square in the figure).

Nowcasting the Great Recession and Recovery

2009:Q1

Key
- New York Fed Staff Nowcast
- Advance estimate
- Latest estimate

Data Releases
- Housing and construction
- Manufacturing
- Surveys
- Retail and consumption
- Income
- Labor
- International trade
- Others

Graph showing the nowcasting of the Great Recession and recovery with data releases and key indicators.
Nowcasting the Great Recession and Recovery

Key:
- New York Fed Staff Nowcast
- Advance estimate
- Latest estimate

Data Releases:
- Housing and construction
- Manufacturing
- Surveys
- Retail and consumption
- Income
- Labor
- International trade
- Others

2009:Q2
The summer of 2009 marked the end of the recession. At the start of the third quarter in July, the nowcast still predicted negative GDP growth (see the figure above). However, over the next few months, a wide variety of better-than-expected data was released, especially for manufacturing, international trade, and business sentiment. Those promising signals quickly brought the nowcast into positive territory, providing a first indication that recovery was on the way. The turning point out of the recession was confirmed at the end of October by the BEA's official release of positive GDP growth for 2009:Q3 and one year later by the NBER Business Cycle Dating Committee's official announcement, indicating the recession's end in June 2009.

Nowcasting the Great Recession and Recovery

2009:Q4

Key
- New York Fed Staff Nowcast
- Advance estimate
- Latest estimate

Data Releases
- Housing and construction
- Manufacturing
- Surveys
- Retail and consumption
- Income
- Labor
- International trade
- Others
The top panel tracks the evolution of the New York Fed Staff Nowcast for a reference quarter (2016:Q4). The bars in the lower panel indicate the average absolute impact of each data series on the nowcast. The x axis indicates the point in the quarter when the nowcasts were made, measured in terms of weeks before the first official GDP release.

There is a trade-off between timeliness and quality; as evident from the inverted-U shape traced by the bar heights in the bottom panel, the impact of data release categories varies depending on the timing within the quarter.
Focusing on the bottom panel in the previous slide, surveys move the nowcast early in the quarter, but become less important as hard data arrive. Later on, manufacturing, housing, and retail sales data tend to have a larger impact on the nowcast.

- Business Tendency Surveys are very relevant because of their timeliness
Outline

- Monitoring Economic Conditions: Then and Now
- The Real Time Data Flow
- Forecasting and the Importance of Now
- The Nowcasting Framework
- Nowcasting in Practice
- Nowcasting during a Government Shutdown
- Nowcasting around the World
Nowcasting during a Government Shutdown

- The 2019 partial shutdown of the U.S. federal government disrupted the Census Bureau and BEA release schedules
  - How does this affect forecasters’ ability to monitor economic conditions in real-time?

- Run counterfactual scenarios from 2002:Q2 to 2017:Q4
  - For each quarter, we mimic the pattern of data unavailability from the 2019 government shutdown
  - We compare counterfactual forecasts to those produced with all data available

# Series Delayed by the Shutdown

<table>
<thead>
<tr>
<th>Series</th>
<th>Release</th>
<th>Scheduled Date</th>
<th>Reference Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>New single-family houses sold</td>
<td>New Residential Sales</td>
<td>12/27/2018</td>
<td>Nov 2018</td>
</tr>
<tr>
<td>Merchant wholesalers: Total inventories</td>
<td>Advance Economic Indicators</td>
<td>12/28/2018</td>
<td>Nov 2018</td>
</tr>
<tr>
<td>Value of construction put into place</td>
<td>Construction Spending</td>
<td>1/3/2019</td>
<td>Nov 2018</td>
</tr>
<tr>
<td>Manufacturers’ new orders: Durable goods</td>
<td>Full Report - Manufacturers’ Shipments,</td>
<td>1/7/2019</td>
<td>Nov 2018</td>
</tr>
<tr>
<td>Manufacturers unfilled orders: All</td>
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<tr>
<td>manufacturing industries</td>
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<tr>
<td>Manufacturers shipments: Durable goods</td>
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<tr>
<td>Manufacturers inventories: Durable goods</td>
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<tr>
<td>Exports: Goods and services</td>
<td>U.S. International Trade in Goods and</td>
<td>1/8/2019</td>
<td>Nov 2018</td>
</tr>
<tr>
<td>Imports: Goods and Services</td>
<td>Services</td>
<td></td>
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<tr>
<td>Merchant wholesalers: Total inventories</td>
<td>Monthly Wholesale Trade</td>
<td>1/10/2019</td>
<td>Nov 2018</td>
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<tr>
<td>Inventories: Total business</td>
<td>Manufacturing, Trade Inventories, and Sales</td>
<td>1/16/2019</td>
<td>Nov 2018</td>
</tr>
<tr>
<td>Retail sales</td>
<td>Advance Monthly Sales for Retail and Food</td>
<td>1/16/2019</td>
<td>Dec 2018</td>
</tr>
<tr>
<td>Housing starts</td>
<td>New Residential Construction</td>
<td>1/17/2019</td>
<td>Dec 2018</td>
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<tr>
<td>Building permits</td>
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<tr>
<td>Manufacturers’ new orders: Durable goods</td>
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<tr>
<td>Manufacturers inventories: Durable goods</td>
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<tr>
<td>New single-family houses sold</td>
<td>New Residential Sales</td>
<td>1/29/2019</td>
<td>Dec 2018</td>
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<td>Merchant wholesalers: Total inventories</td>
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<tr>
<td>Exports: Goods and services</td>
<td>Advance Economic Indicators</td>
<td>1/29/2019</td>
<td>Dec 2018</td>
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<tr>
<td>Imports: Goods and services</td>
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<tr>
<td>Real gross domestic product</td>
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<td>Real gross domestic income</td>
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<td>PCE less food and energy: Chain price index</td>
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<td>Real disposable personal income</td>
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<td>PCE: Chain price index</td>
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<tr>
<td>Real PCE</td>
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<tr>
<td>Housing and construction</td>
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<tr>
<td>Manufacturing</td>
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<td>Surveys</td>
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<tr>
<td>Retail and consumption</td>
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<tr>
<td>Income</td>
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<tr>
<td>Labor</td>
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<tr>
<td>International trade</td>
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<td></td>
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<tr>
<td>Others</td>
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</tbody>
</table>
Errors are computed as the difference between the nowcast computed in real time and observed real GDP growth as of the latest release. The dots indicate errors for individual quarters in the evaluation sample. At week 0 the errors refer to the difference between the advance release of GDP and the latest release, with bars indicating the 16th and 84th percentiles of their empirical distribution. The start of the red band marks the beginning of the government-shutdown scenario.

The error distributions exhibit characteristics of a good forecast. The band narrows in width as time goes on, indicating on average a more accurate prediction of GDP growth over the nowcasting period as more information about the economy is released. Finally, at the end of the nowcast updating period, the band is similar to the error bars for the first GDP release, indicating that the uncertainty surrounding the final nowcast made for each quarter is similar to that of the BEA’s first estimate in predicting the true value of aggregate output growth in the economy.
The charts report kernel-smoothed estimates of forecast error densities as of the scheduled first GDP release (week of Feb 1, 2019). The left panel gives the error distributions for the previous quarter (2018:Q4) and the right panel for the current quarter (2019:Q1).

The black and red error distributions in the left panel are nearly identical, showing that the delay of these data releases would not have substantially affected uncertainty around predictions for the previous quarter. Similarly, the delay of the January 2019 scheduled releases also appears to have little impact on the uncertainty around the model’s nowcast for 2019:Q1 GDP growth.
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Nowcasting around the World

Russia
Porshakov, Deryugina, Ponomarenko, Sinyakov (2015)
"Nowcasting and Short-Term Forecasting of Russian GDP with a Dynamic Factor Model"

India
Bragoli and Fosten (2016)
"Nowcasting Indian GDP"
UEA Working Paper 2016-06

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"Nowcasting China Real GDP"

Czech Republic
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"Nowcasting Czech GDP in realtime"
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Japan

Bragoli (2017)
“Now-casting the Japanese economy”

South Africa

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“Nowcasting Real GDP growth in South Africa”

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Luciani, Pudit, Ramayandi, and Veronesi (2015)
“Now-casting Indonesia”

Argentina

Amato, Garegnani, and Blanco (2015)
“GDP Nowcasting: Assessing business cycle conditions in Argentina”
Nowcasting Brazil

Nowcasting Brazil

Nowcasting Brazil

Nowcasting Brazil

G. Branco Gomes and J. V. Issler
“Nowcasting Brazilian GDP: a performance assessment of dynamic factor models”
Nowcasting Brazil

Figure 1: Forecast of Brazilian GDP from 2015-Q1 to 2017-Q4

Figure 2: RMSE of forecasts of Brazilian GDP during 28 weeks prior to its release

Mattos, Gomes, Ferreira, Martins, S. de Valk
“Forecasting, nowcasting and backcasting Brazilian GDP”
Blogs


Other Materials

- **Macroeconomic Nowcasting and Forecasting with Big Data**
  by B. Bok, D. Caratelli, D. Giannone, A. Sbordone and A. Tambalotti

- **New York Fed Staff Nowcasting Report**
  (updated every Friday at 11:15 a.m. EST)