

Nowcasting and Forecasting with Big Data

Time Series Analysis Team
Federal Reserve Bank of New York

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

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.

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**
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Monitoring Economic Conditions | Then and Now

▪ Exploring the Data

- It's always been a **big data** problem:
 - *"Only by analyzing numerous time series, each of restricted significance, can business cycles be made to reveal themselves definitively enough to permit close observation."*
(Burns and Mitchell, *Measuring Business Cycles*, 1946)

▪ Statistical Measurement

- National Accounts and GDP (Kuznets, 1930s)
 - One of the great inventions of the 20th century
 - *"Without measures of economic aggregates like GDP, policymakers would be adrift in a sea of unorganized data."*
(Nordhaus and Samuelson in the 15th edition of their textbook, *Economics*)

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).

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)

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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The Real-Time Data Flow



The Real-Time Data Flow (United States)

1) Calendars		2) Alerts		3) Export		4) Settings		Economic Calendars					
United States		6) Browse		17:12:51		10/04/19 - 10/11/19							
Economic Releases		View <input checked="" type="radio"/> Agenda <input type="radio"/> Weekly											
Date	Time	R	Event	Period	Surv(M)	Actual	Prior	S	Flag				
21)	10/04 08:30	■	Change in Nonfarm Payrolls	Sep	145k	136k	130k	99.21					
22)	10/04 08:30	-	Two-Month Payroll Net Revision	Sep	--	45k	--	17.32					
23)	10/04 08:30	-	Change in Private Payrolls	Sep	130k	114k	96k	30.71					
24)	10/04 08:30	■	Change in Manufact. Payrolls	Sep	3k	-2k	3k	69.45					
25)	10/04 08:30	■	Unemployment Rate	Sep	3.7%	3.5%	3.7%	89.29					
26)	10/04 08:30	-	Average Hourly Earnings MoM	Sep	0.2%	0.0%	0.4%	31.50					
27)	10/04 08:30	-	Average Hourly Earnings YoY	Sep	3.2%	2.9%	3.2%	32.28					
28)	10/04 08:30	-	Average Weekly Hours All Employees	Sep	34.4	34.4	34.4	25.98					
29)	10/04 08:30	-	Labor Force Participation Rate	Sep	63.2%	63.2%	63.2%	18.90					
30)	10/04 08:30	-	Underemployment Rate	Sep	--	6.9%	7.2%	22.05					
31)	10/04 08:30	■	Trade Balance	Aug	-\$54.5b	-\$54.9	-\$54.0b	84.25					
32)	10/07 15:00	-	Consumer Credit	Aug	\$15.000b	--	\$23.294b	39.37					
33)	10/07-10/11		Monthly Budget Statement	Sep	\$82.5b	--	\$119.1b	75.59					
34)	10/08 06:00	■	NFIB Small Business Optimism	Sep	102.5	--	103.1	62.20					
35)	10/08 08:30	■	PPI Final Demand MoM	Sep	0.1%	--	0.1%	86.61					
36)	10/08 08:30	■	PPI Ex Food and Energy MoM	Sep	0.2%	--	0.3%	66.93					
37)	10/08 08:30	-	PPI Ex Food, Energy, Trade MoM	Sep	0.2%	--	0.4%	11.02					
38)	10/08 08:30	■	PPI Final Demand YoY	Sep	1.8%	--	1.8%	68.50					
39)	10/08 08:30	■	PPI Ex Food and Energy YoY	Sep	2.3%	--	2.3%	66.14					
40)	10/08 08:30	-	PPI Ex Food, Energy, Trade YoY	Sep	--	--	1.9%	10.24					
41)	10/09 07:00	■	MBA Mortgage Applications	Oct 4	--	--	8.1%	92.31					
42)	10/09 10:00	-	JOLTS Job Openings	Aug	7265	--	7217	24.41					
43)	10/09 10:00	-	Wholesale Trade Sales MoM	Aug	--	--	0.3%	14.96					
44)	10/09 10:00	■	Wholesale Inventories MoM	Aug F	0.4%	--	0.4%	81.10					
45)	10/09 14:00	-	FOMC Meeting Minutes	Sep 18	--	--	--	21.26					
46)	10/10 08:30	-	Real Avg Weekly Earnings YoY	Sep	--	--	1.2%	9.45					
47)	10/10 08:30	■	CPI MoM	Sep	0.1%	--	0.1%	96.06					
			GDP Ex Food and Energy MoM	Sep	0.2%	--	0.2%	76.25					

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)

1) Calendars		2) Alerts		3) Export		4) Settings		Economic Calendars					
World		6) Browse		17:14:14		10/04/19 - 10/11/19							
Economic Releases		All Economic Releases						View					
Date	Time	R	Event	Period	Surv(M)	Actual	Prior	S	Flag				
21) 10/04 00:00	+		Exports YoY	Aug	2.7%	-0.8%	1.7%	53.85	MY				
22) 10/04 00:00	-		Imports YoY	Aug	-8.0%	-12.5%	-5.9%	38.46	MY				
23) 10/04 00:00	+		Trade Balance MYR	Aug	10.70b	10.92b	14.27b	46.15	MY				
24) 10/04 01:00	+		Markit India PMI Services	Sep	--	48.7	52.4	70.00	IN				
25) 10/04 01:00	+		Markit India PMI Composite	Sep	--	49.8	52.6	70.00	IN				
26) 10/04 02:06	-		Consumer Confidence Index	Sep	--	121.8	123.1	26.32	IN				
27) 10/04 02:15	■		RBI Repurchase Rate	Oct 4	5.15%	5.15%	5.40%	94.74	IN				
28) 10/04 02:15	■		RBI Reverse Repo Rate	Oct 4	4.90%	4.90%	5.15%	68.42	IN				
29) 10/04 02:15	■		RBI Cash Reserve Ratio	Oct 4	4.00%	4.00%	4.00%	63.16	IN				
30) 10/04 02:32	■		Money Supply M3 YoY	Aug	--	12.84%	10.09%	66.67	IN				
31) 10/04 02:45	-		Budget Balance YTD	Aug	--	123.1	-109.7b	40.00	FR				
32) 10/04 03:30	+		Markit Germany Construction PMI	Sep	--	50.1	46.3	50.00	DE				
33) 10/04 03:30	■		Foreign Reserves	Sep 27	--	\$220.4	\$221.7b	80.77	DE				
34) 10/04 03:30	-		Forward Contracts	Sep 27	--	\$33.1b	\$32.0b	26.92	DE				
35) 10/04 04:00	-		Money Supply Narrow Def	Sep 27	--	10.56t	10.63t	33.33	DE				
36) 10/04 04:00	-		Deficit to GDP YTD	2Q	--	4.0%	4.1%	16.22	IT				
37) 10/04 04:00	-		New Car Registrations YoY	Sep	--	1.3%	-1.6%	36.78	UK				
38) 10/04 04:20	+		Foreign Reserves	Sep	--	\$469.4	\$468.17t	42.11	IN				
39) 10/04 04:26	-		CPI YoY	Sep	--	6.7%	6.7%	0.00	IN				
40) 10/04 04:30			WIFO Quarterly Economic Forecasts						DE				
41) 10/04 04:45	-		Markit/Stanbic IBTC Bank PMI	Sep	--	57.1	56.4	0.00	IN				
42) 10/04 05:00	■		Trade Balance	Sep P	--	-1710c	-12030m	83.33	DE				
43) 10/04 05:00			Istat Releases Revised Quarterly National Account Series						DE				
44) 10/04 06:00	-		Industrial Output MoM	Aug	--	3.0%	-2.1%	6.67	IN				
45) 10/04 06:00	-		Industrial Output WDA YoY	Aug	--	2.0%	-1.3%	20.00	IN				
46) 10/04 07:00	-		Vehicle Production	Sep	--	31890t	337462	35.00	MX				
47) 10/04 07:00	-		Vehicle Exports	Sep	--	28424t	281811	30.00	MX				
48) 10/04 07:30			Effective Exchange Rate	Sep	--	75.66	75.72	25.81	MX				

The Real-Time Data Flow

- Macro releases make front-page news.

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



Reuters

Nov. 15, 2017, 11:50 AM 21

US stock futures trade higher after jobs report disappoints

Alexandra Gibbs | @alexgibbsy

Published 6:04 AM ET Fri, 3 Nov 2017 | Updated 8:38 AM ET Fri, 3 Nov 2017



MARKET NEWS NOVEMBER 3, 2017 / 9:14 AM / 15 DAYS AGO

TREASURIES-Yields fall after wages data for October disappoints

REUTERS

U.S. Treasury Bond Prices Fall on Strong Data

By Akane Otani | Published October 25, 2017 | Features | Dow Jones NewsWire

US Treasury yields climb after stronger industrial production data

Alexandra Gibbs | Thomas Franck

Published 5:45 AM ET Thu, 16 Nov 2017 | Updated 1:50 PM ET Thu, 16 Nov 2017



MARKET NEWS OCTOBER 25, 2017 / 8:48 AM / 23 DAYS AGO

FOREX-Dollar index adds gains on upbeat durable goods data



REUTERS

US Treasury yields fall after strong housing starts data

Alexandra Gibbs | @alexgibbsy

Published 12 Hours Ago | Updated 4 Hours Ago

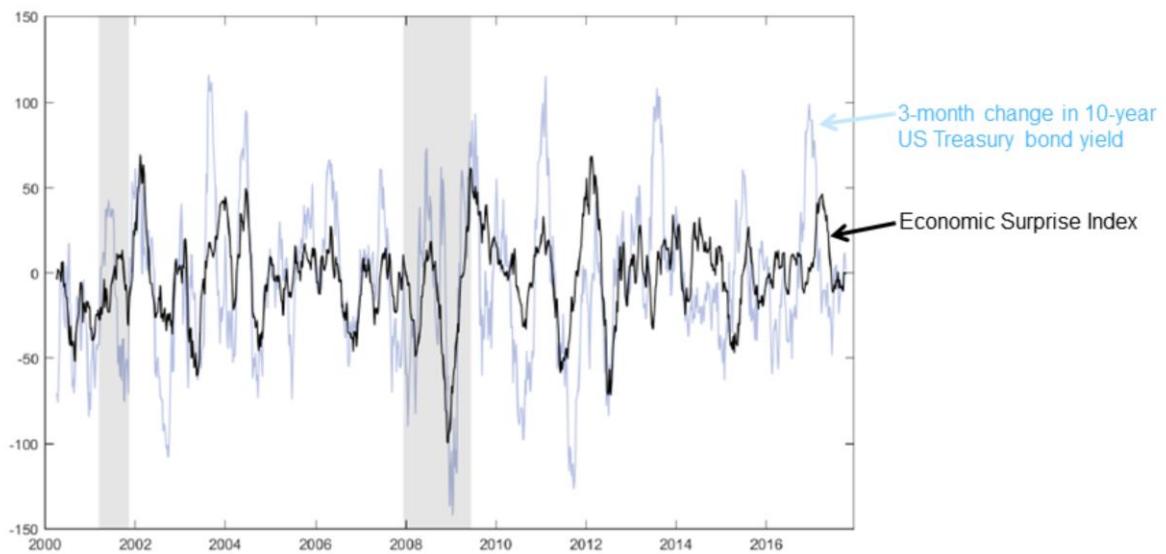


U.S. Stocks Rise On Above Expected U.S. GDP Growth

By IFC Markets | (Ara Zohrabian) | Market Overview | Oct 30, 2017 09:41AM ET

The Real-Time Data Flow

- News moves markets!



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.

Low Frequency Effects of Macroeconomic News on Government Bond Yields
with Carlo Altavilla and Michele Modugno; *Journal of Monetary Economics* (2017)

The Data

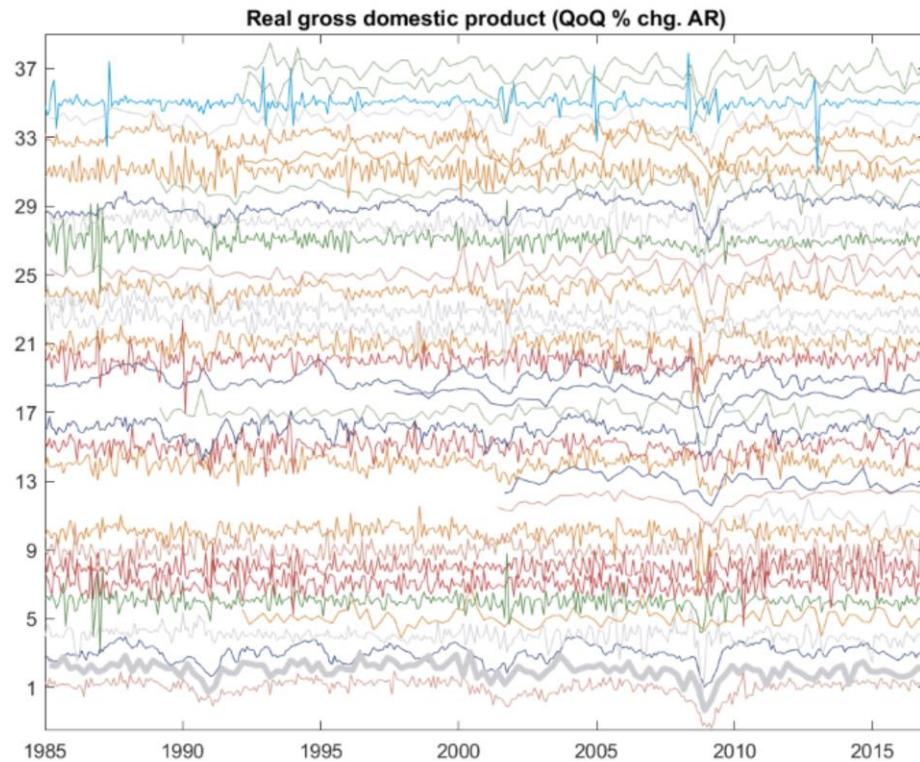
Release	Timing	Delay	Source
■ Construction Spending	first business day of the month, two months prior	33	Census Bureau
■ ISM Manufacturing Report on Business	first business day of the month, one month prior	3	ISM
■ ISM Non-Manufacturing Report on Business	third business day of the month, one month prior	5	ISM
■ U.S. International Trade in Goods and Services	first full week of the month, two months prior	35	BEA, Census Bureau
■ Manufacturers' Shipments, Inventories, and Orders	first week of the month, two months prior	35	Census Bureau
■ ADP National Employment Report	first Wednesday of the month, one month prior	5	ADP
■ Employment Situation	first Friday of the month, one month prior	7	BLS
■ Manufacturing and Trade Inventories	first full week of the month, two months prior	44	Census Bureau
■ Job Openings and Labor Turnover	second week of the month, two months prior	42	BLS
■ U.S. Import and Export Price Indexes	middle of the month, one month prior	13	BLS
■ Retail Trade	ninth business day of the month, one month prior	14	Census Bureau
■ Producer Price Index	middle of the month, one month prior	14	BLS
■ Wholesale Trade	middle of the month, two months prior	37	Census Bureau
■ Empire State Manufacturing Survey	15th of the month, current month	-14	New York Fed
■ Manufacturing Business Outlook Survey	third Thursday of the month, current month	-11	Philadelphia Fed
■ Industrial Production and Capacity Utilization	middle of the month, one month prior	17	Federal Reserve Board
■ Consumer Price Index	middle of the month, one month prior	18	BLS
■ New Residential Construction	12th business day of the month, one month prior	16	Census Bureau
■ Advance Economic Indicators	last week of the month, one month prior	28	Census Bureau
■ New Residential Sales	17th business day of the month, one month prior	26	Census Bureau
■ Advance Durable Goods	third week of the month, one month prior	26	Census Bureau
■ Personal Income and Outlays	last week of the month, one month prior	30	BEA
■ Gross Domestic Product	last week of the month, prior quarter	28	BEA
■ Productivity and Costs	first week of the month, prior quarter	34	BLS

Big Data for Monitoring Macroeconomic Conditions

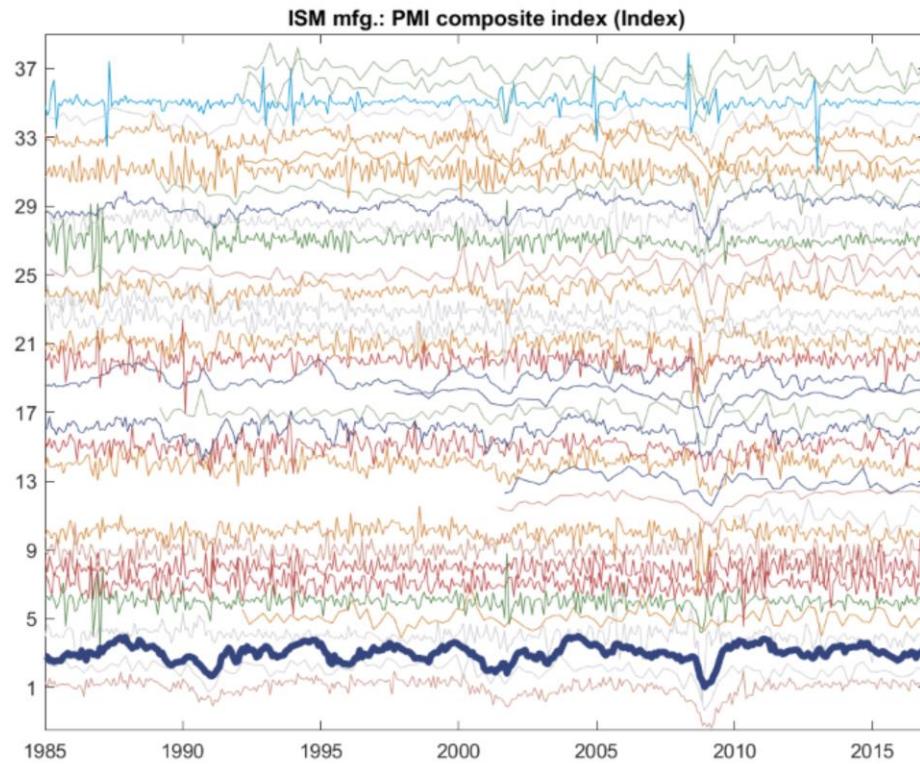


The New York Fed Staff Nowcast employs 37 data series. They are represented in a standardized format (with a mean of zero and a variance of 1) and spaced for visibility. Individual series are bolded in slides 13-49 to emphasize their respective dynamics.

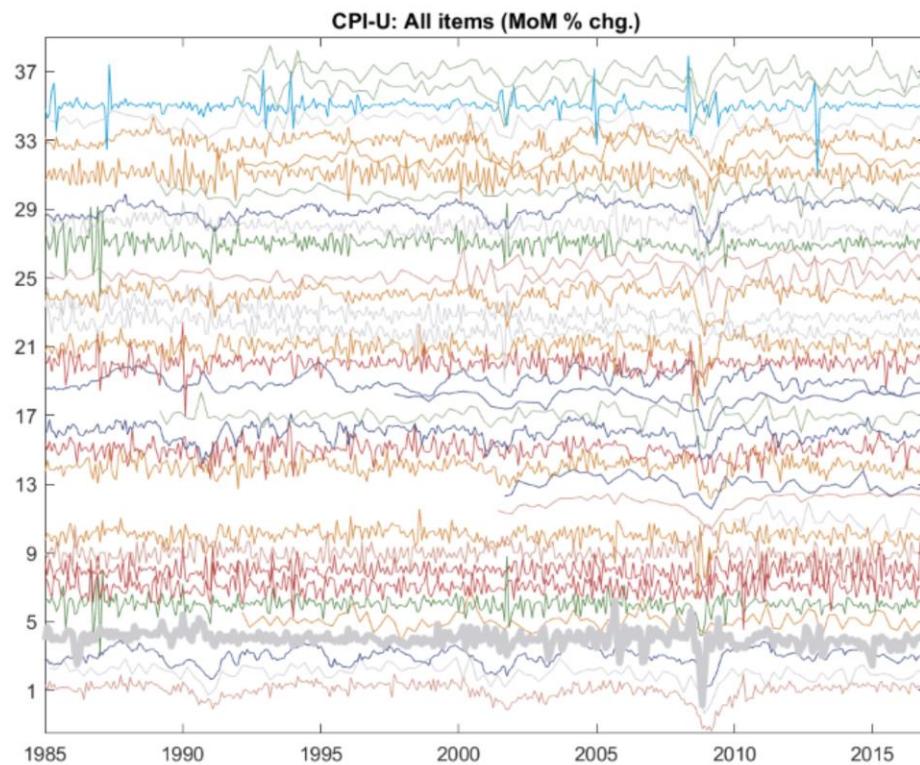
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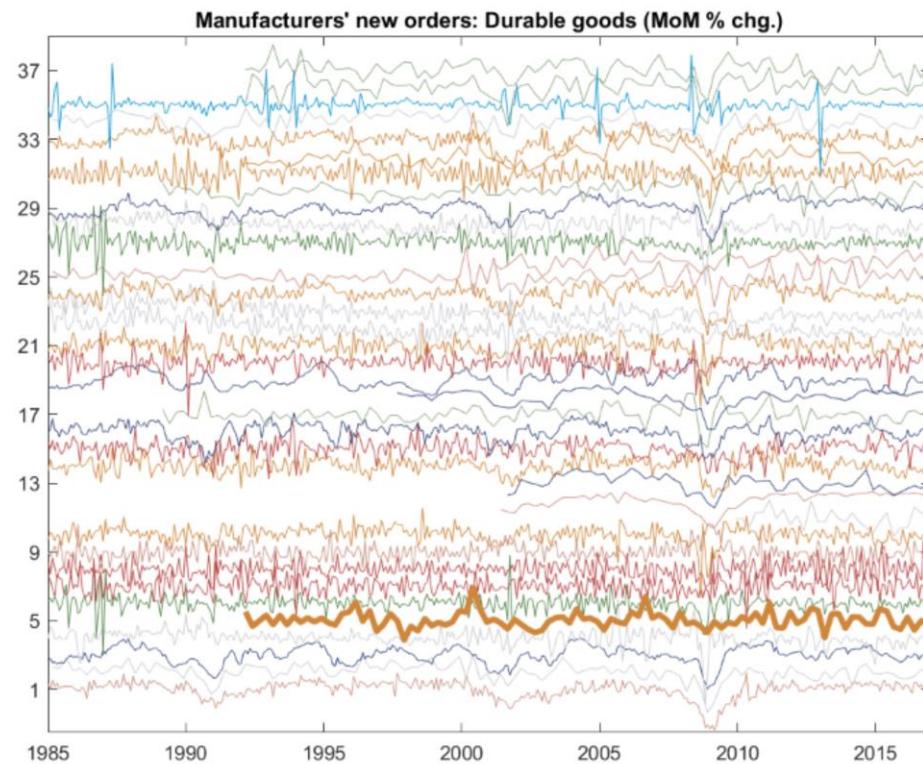
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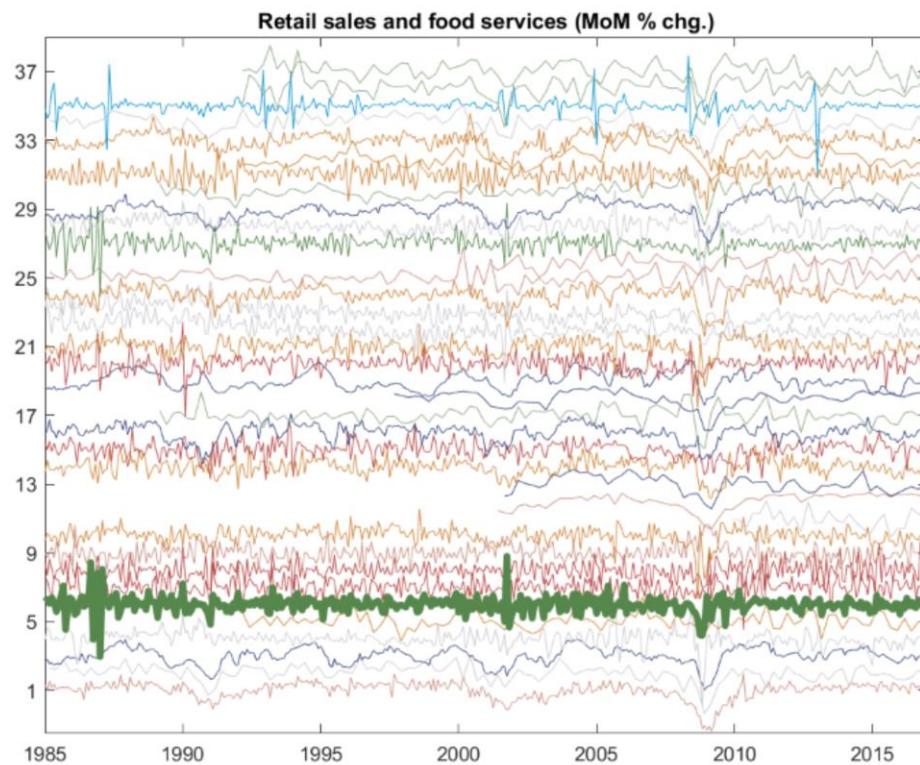
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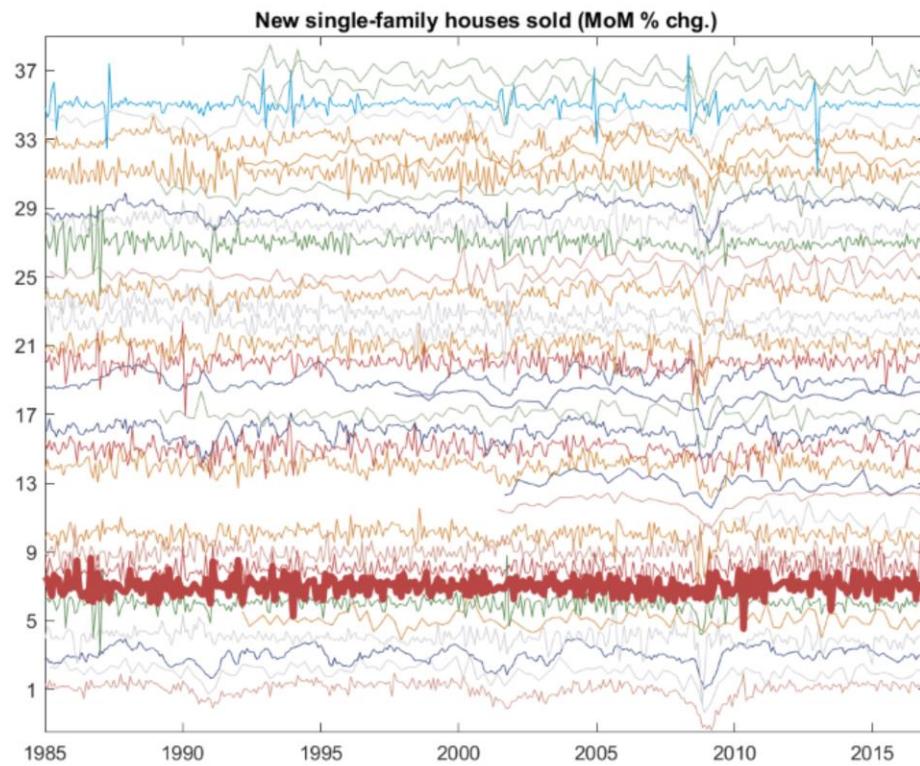
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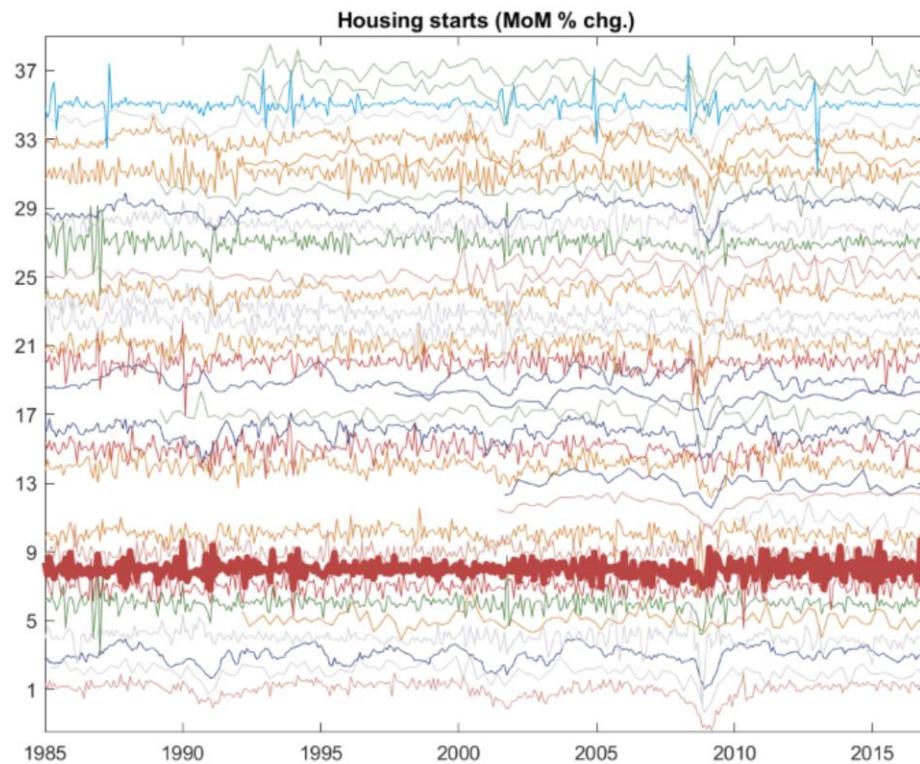
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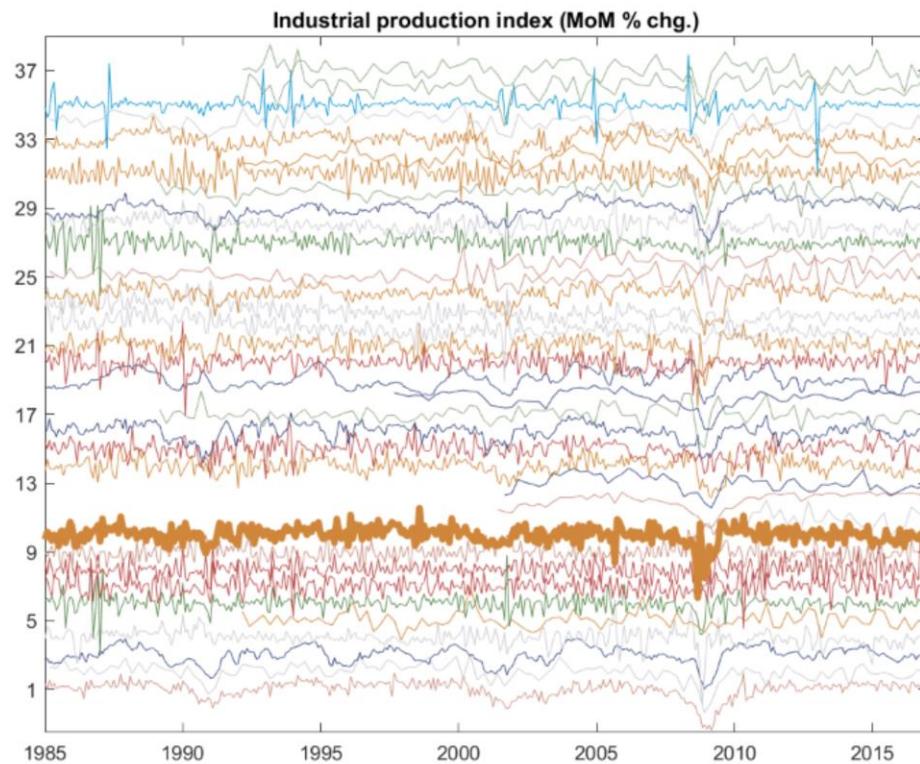
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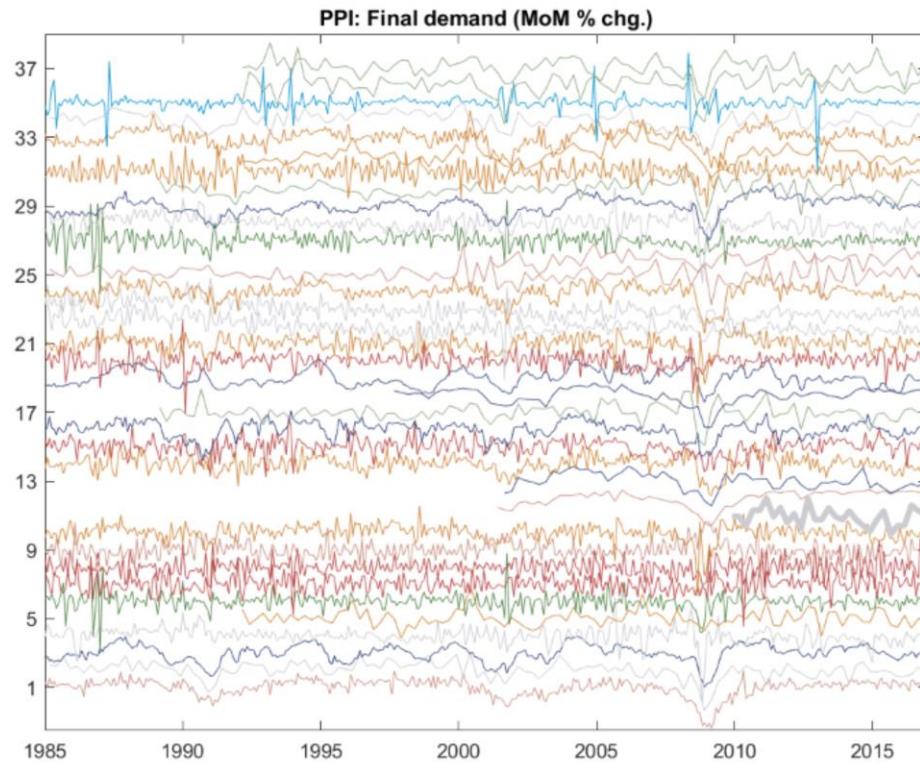
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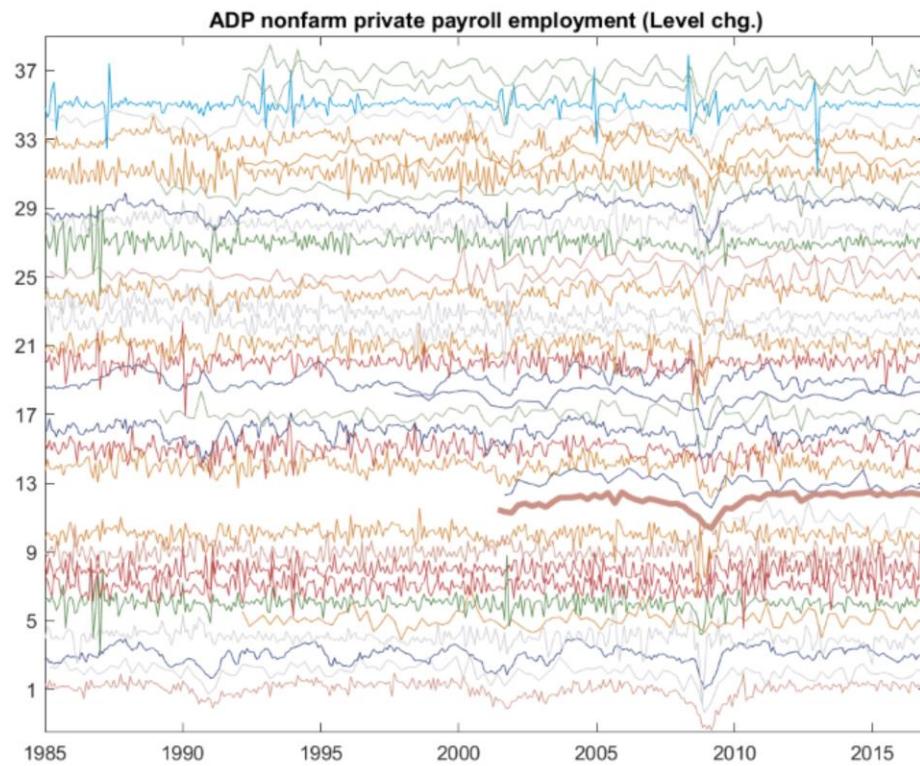
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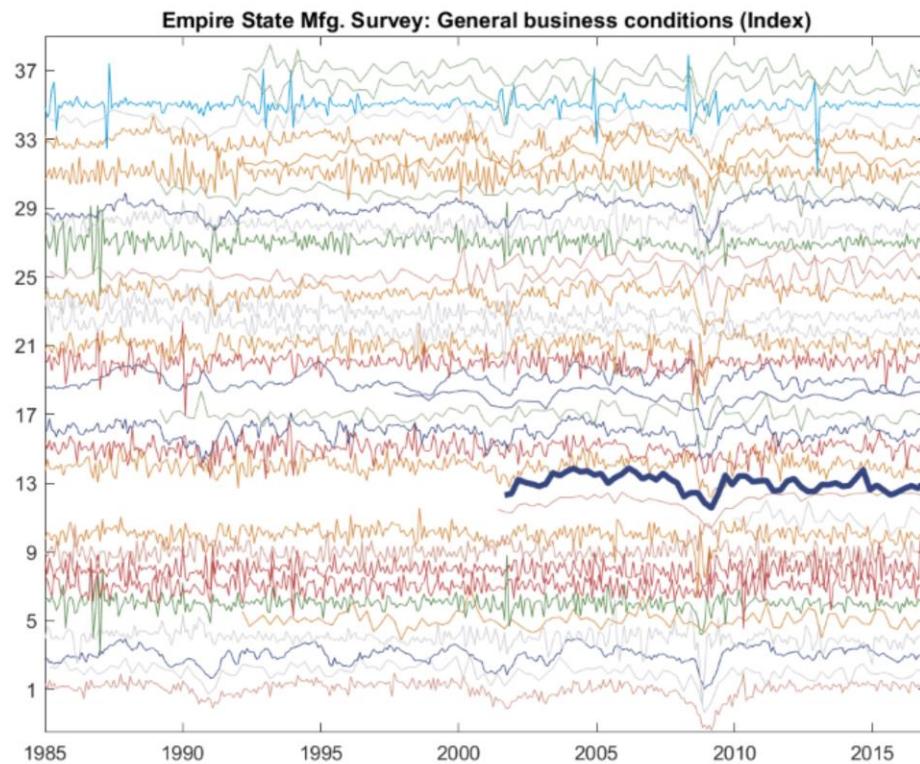
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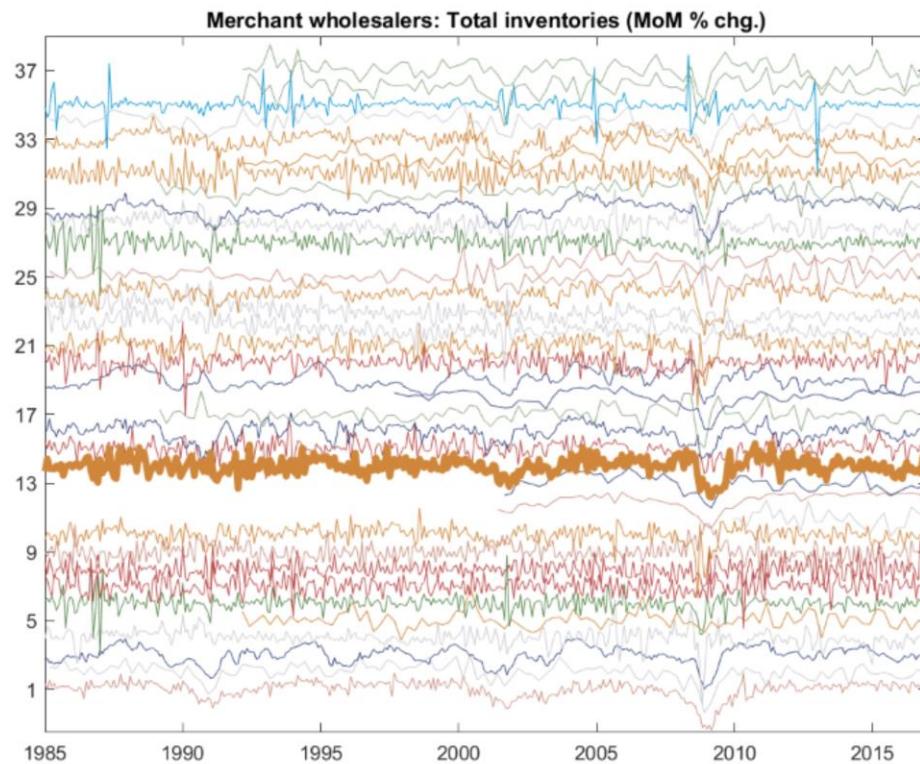
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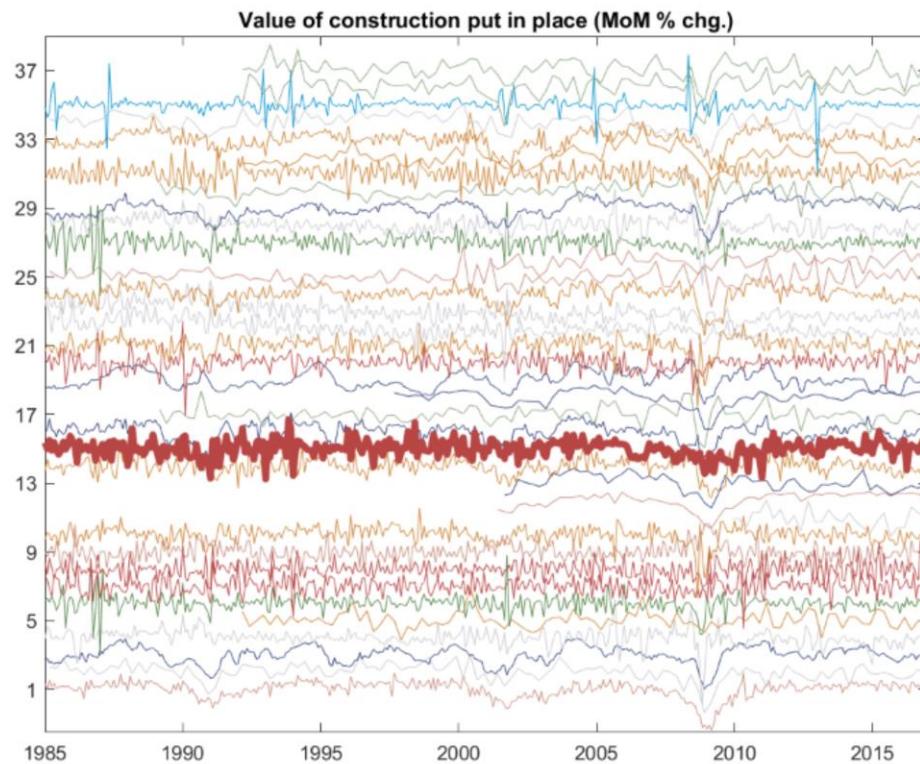
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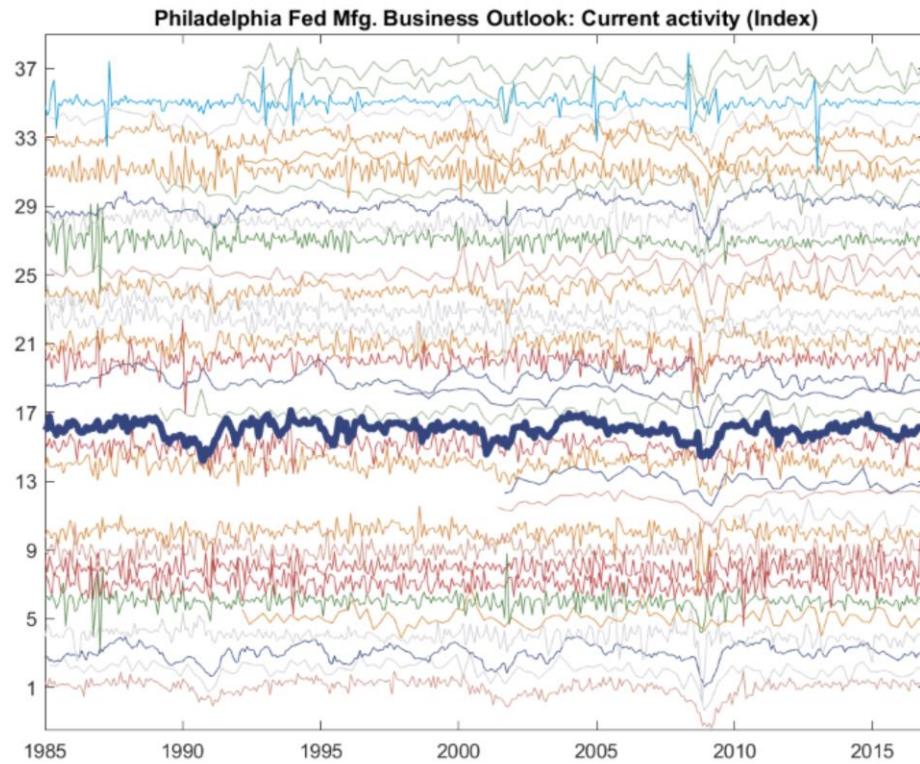
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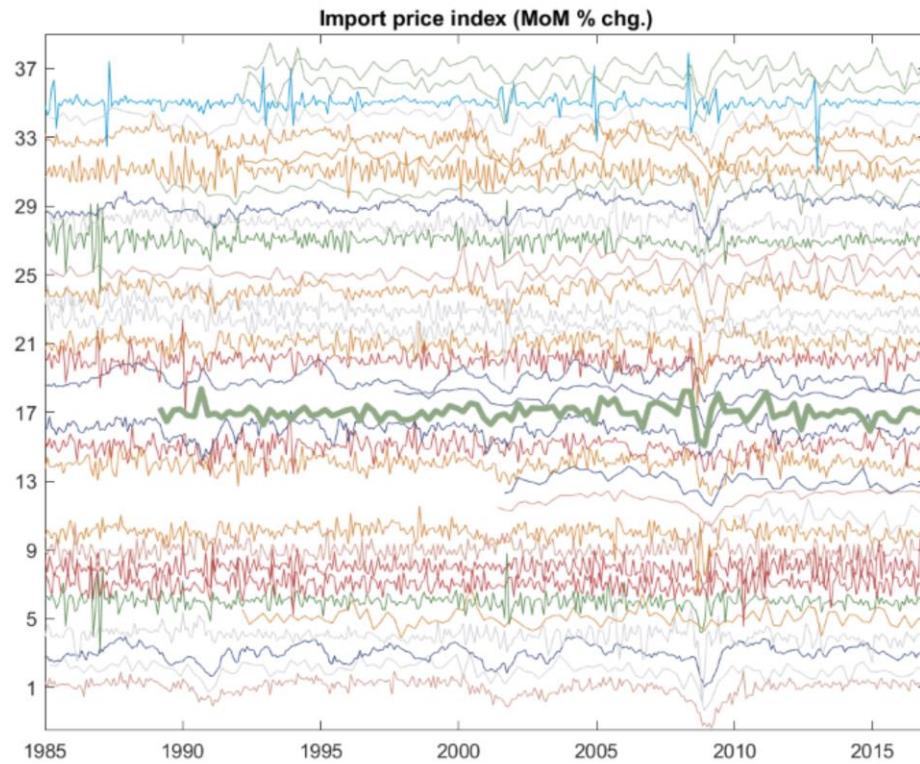
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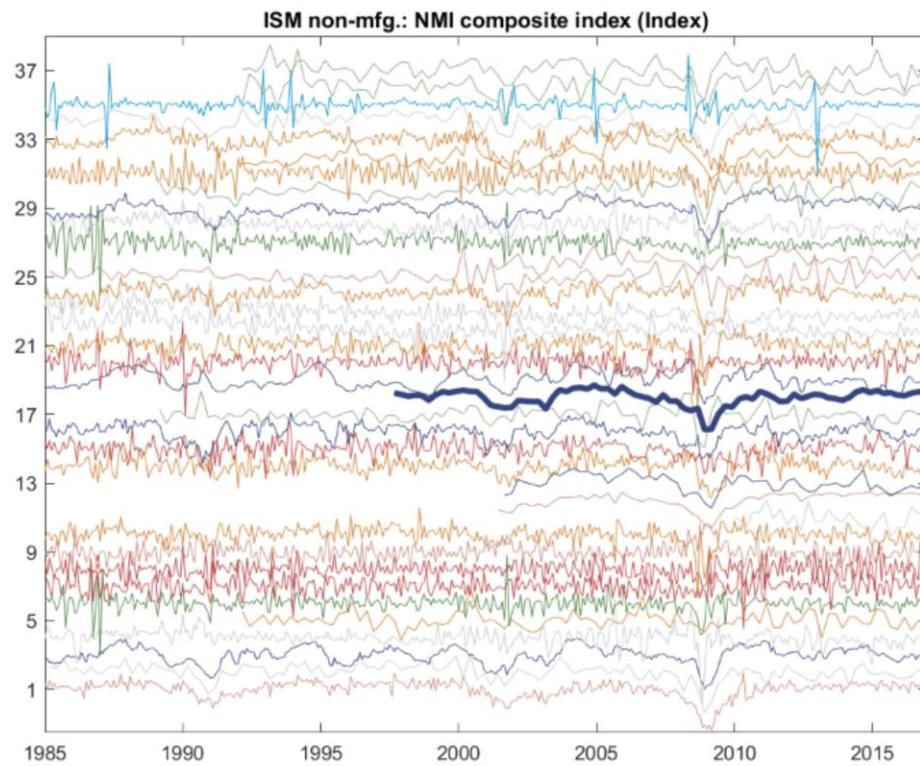
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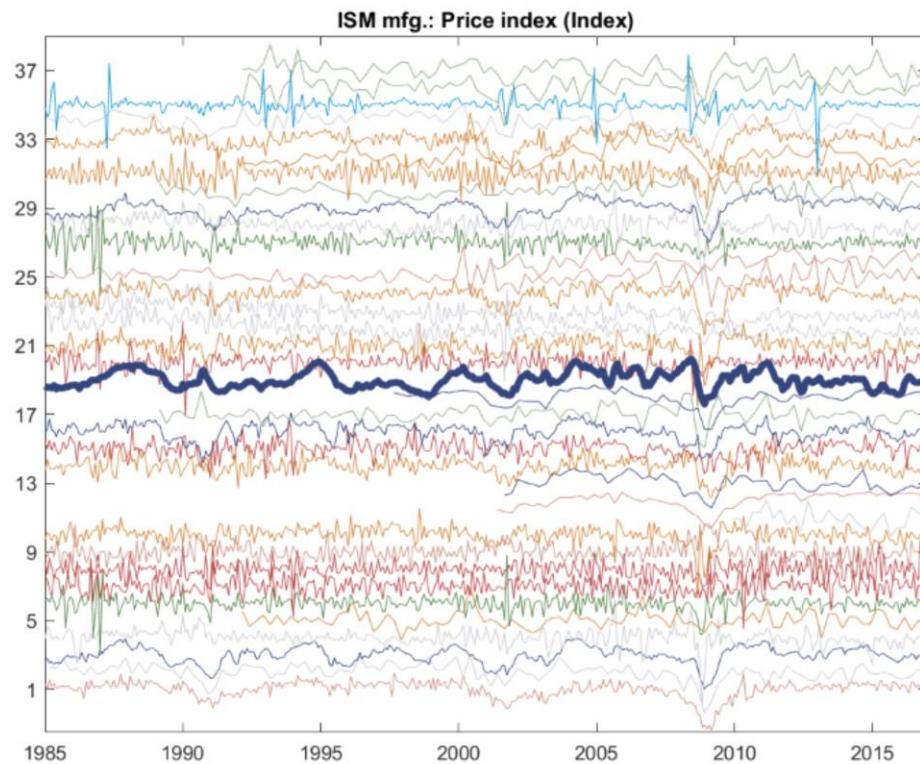
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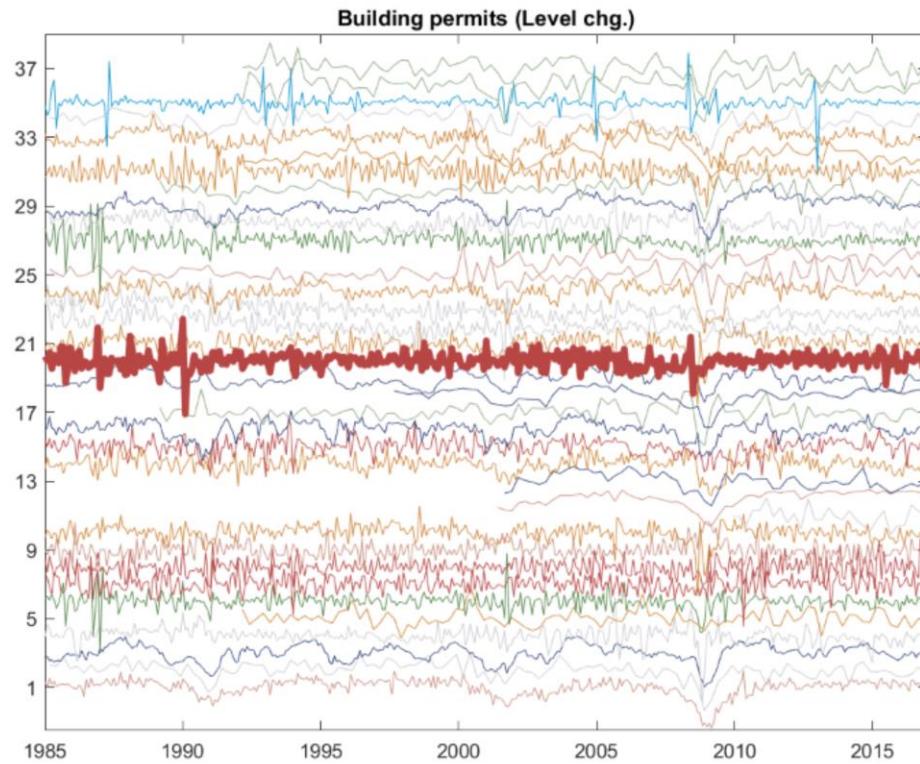
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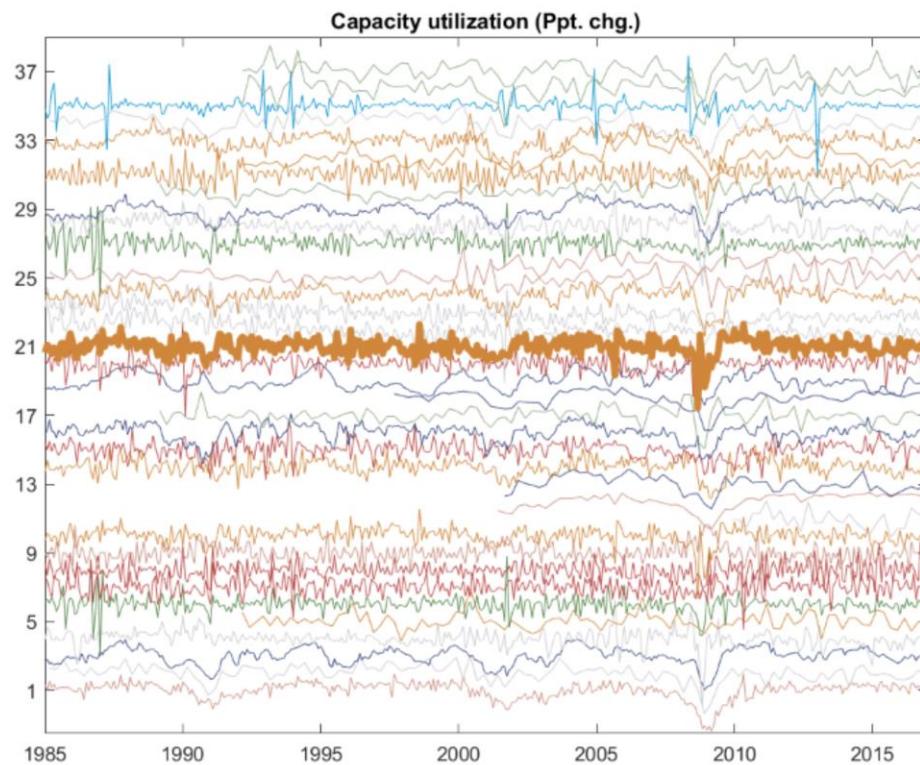
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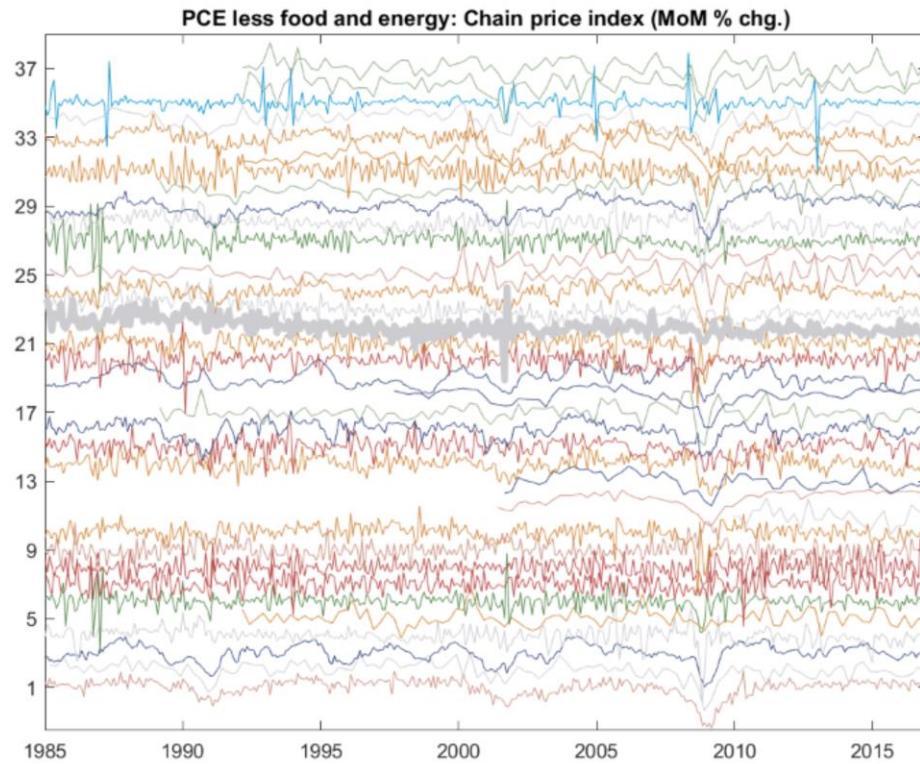
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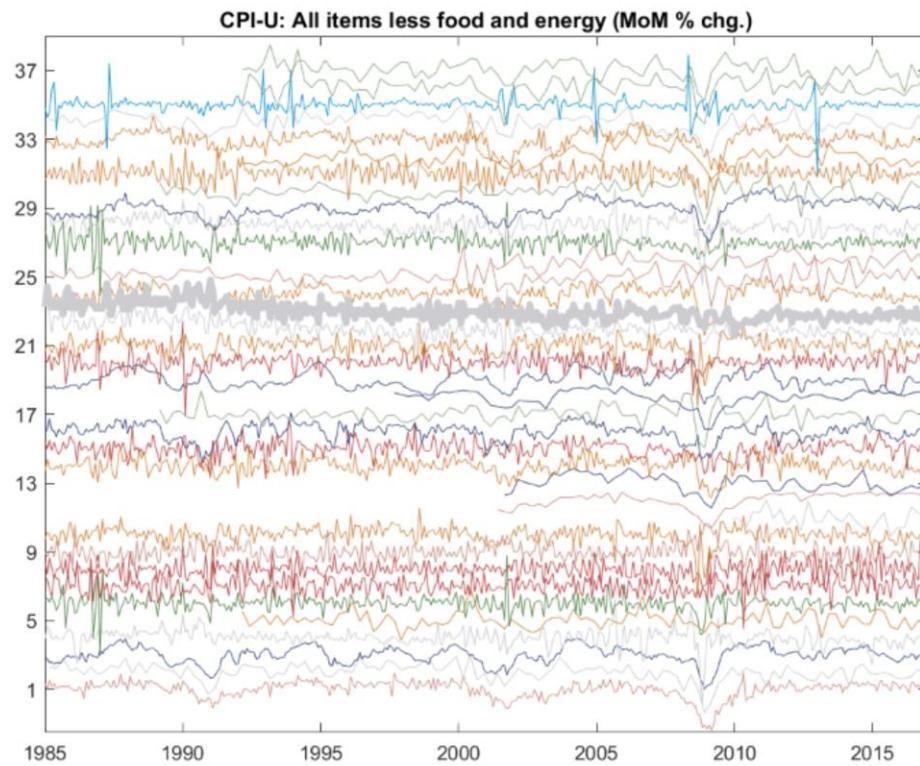
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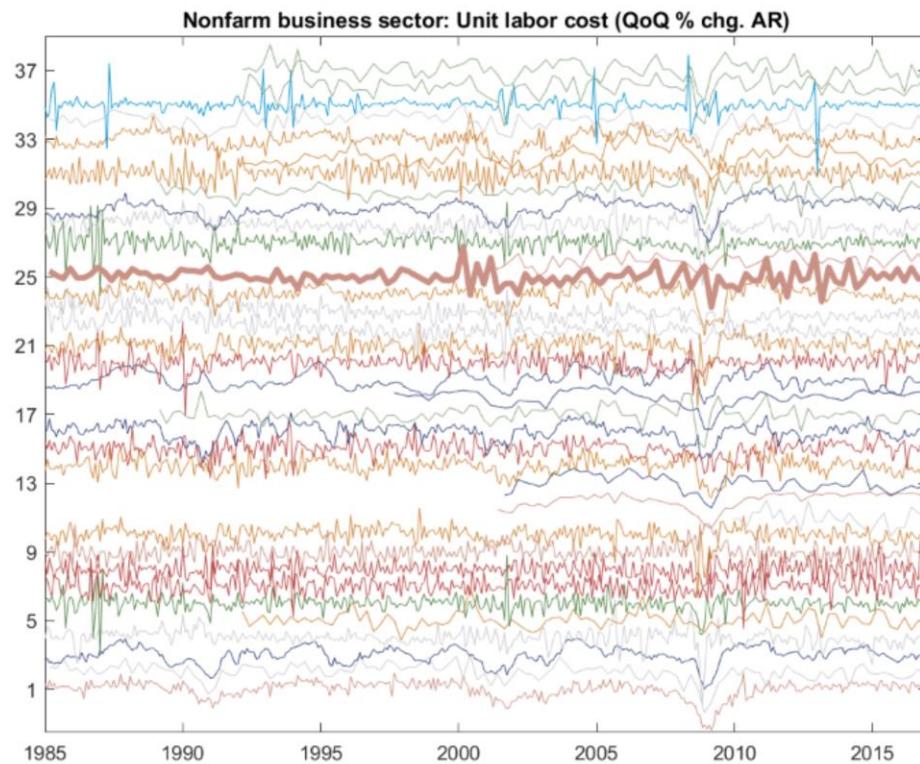
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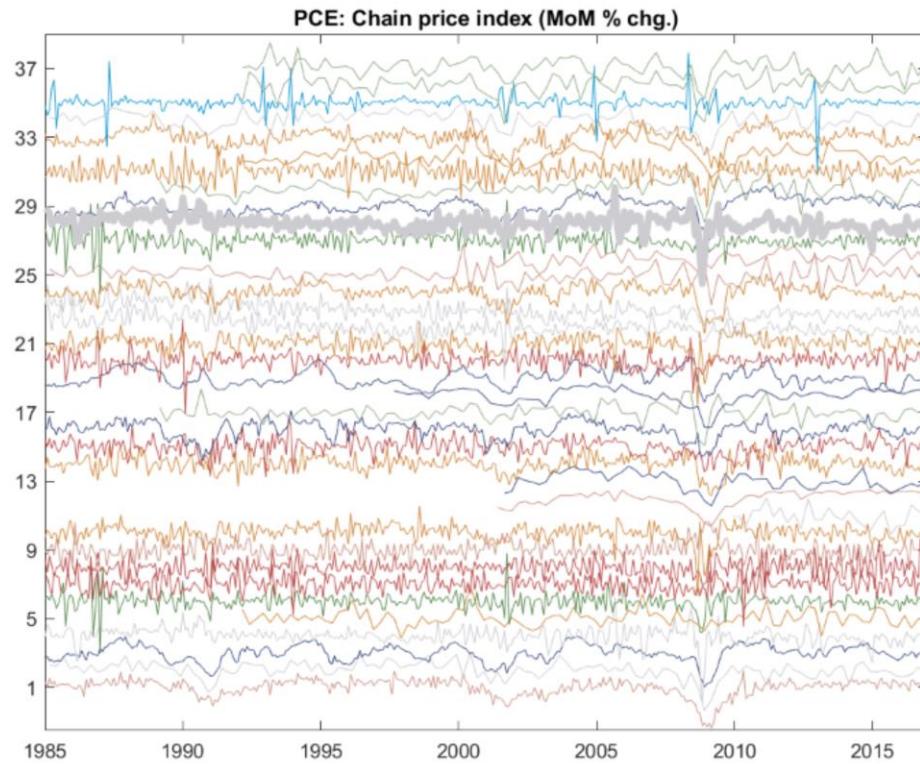
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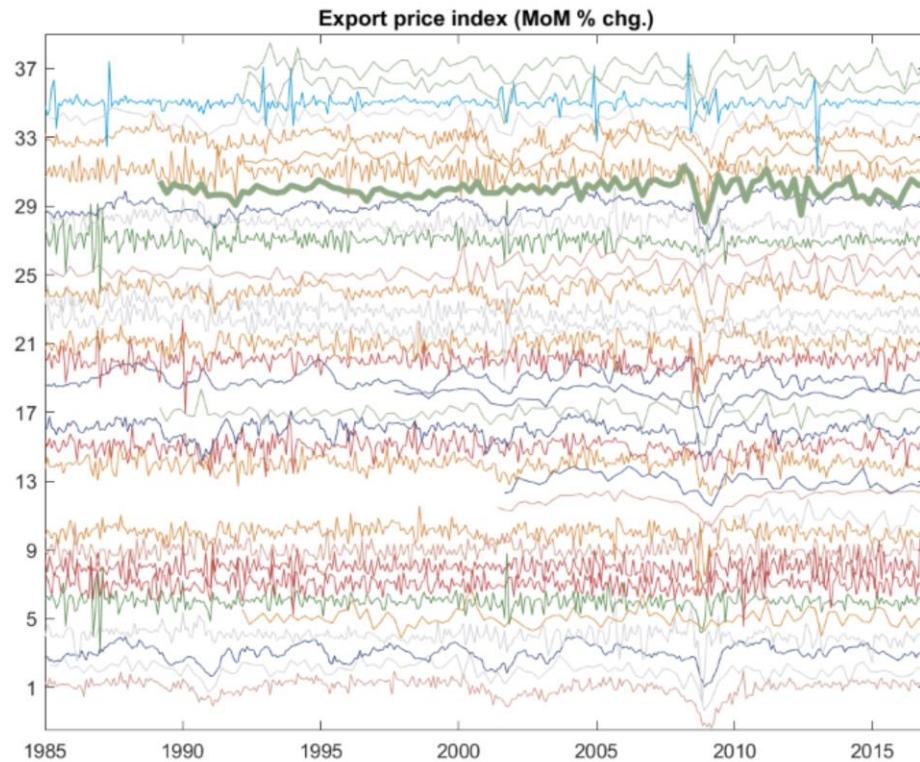
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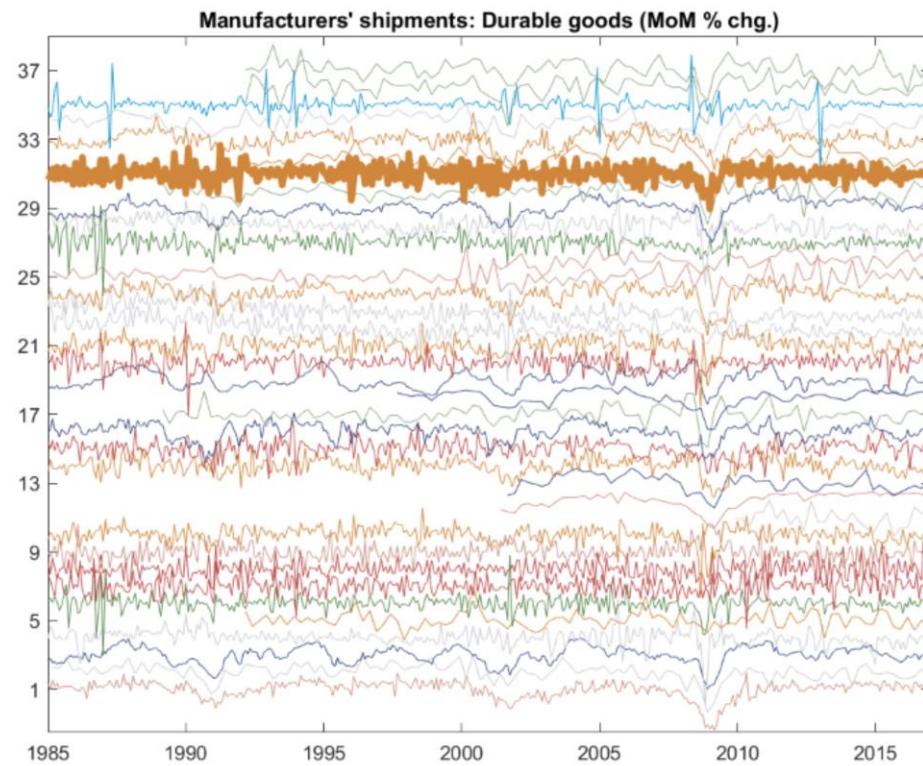
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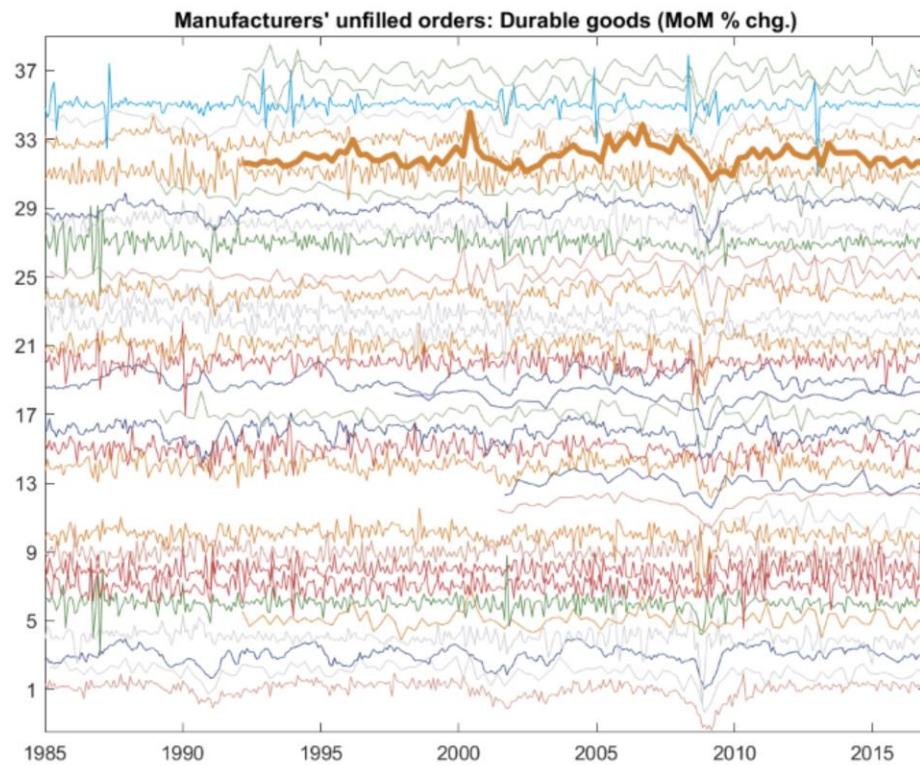
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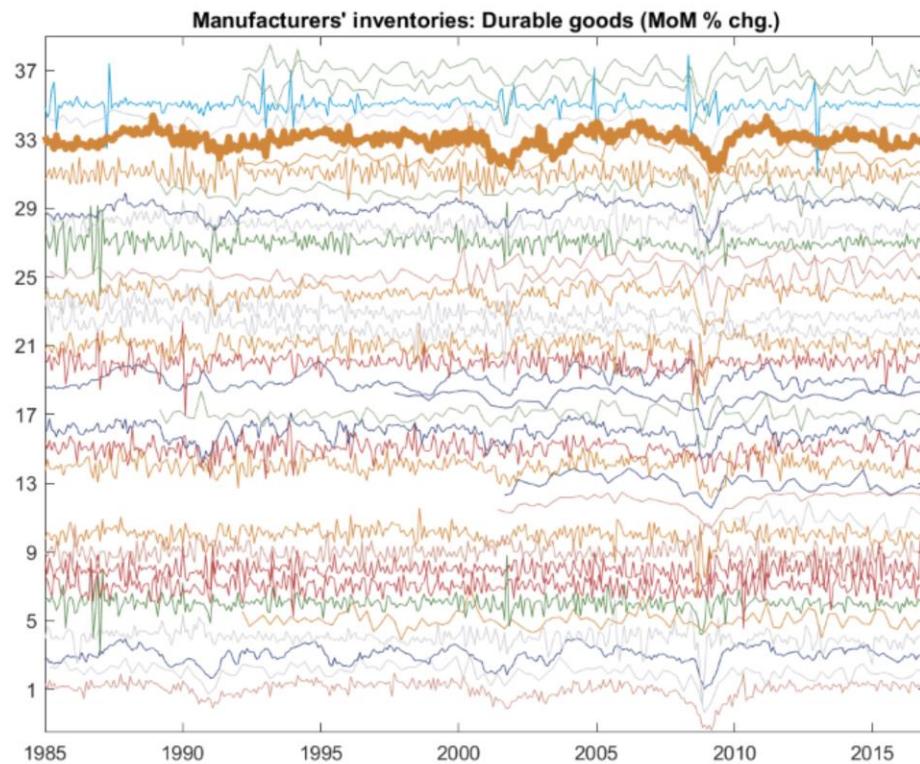
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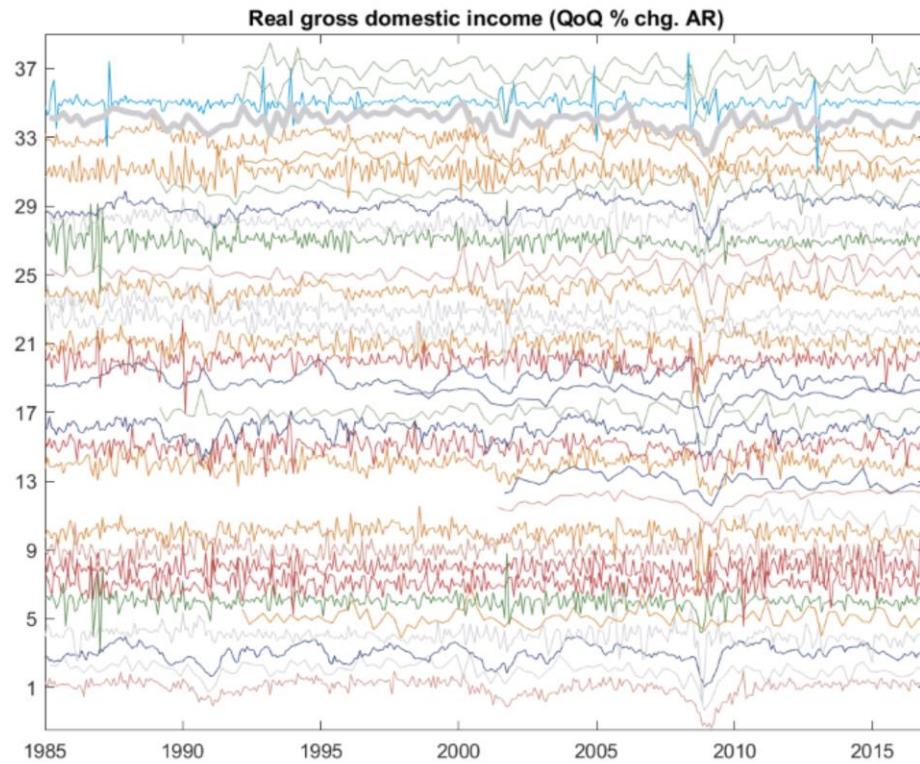
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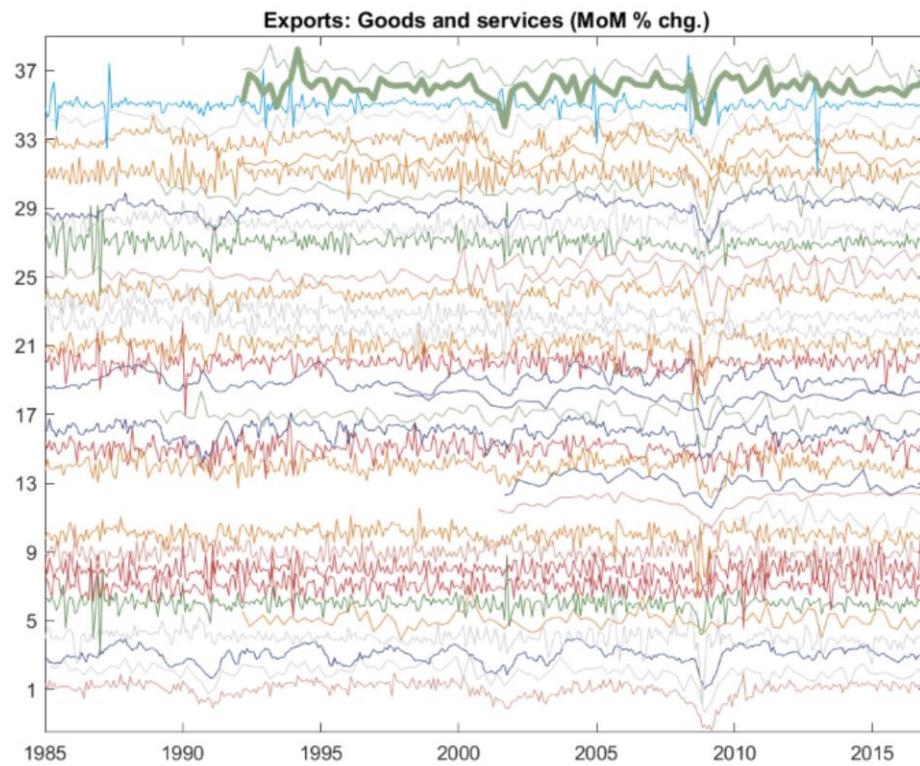
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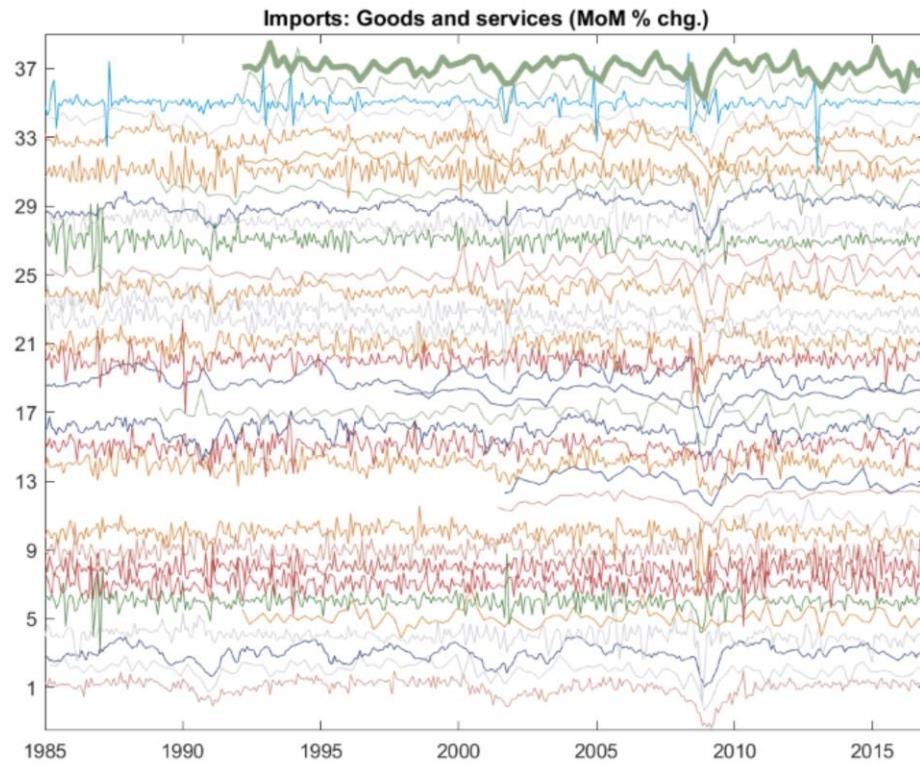
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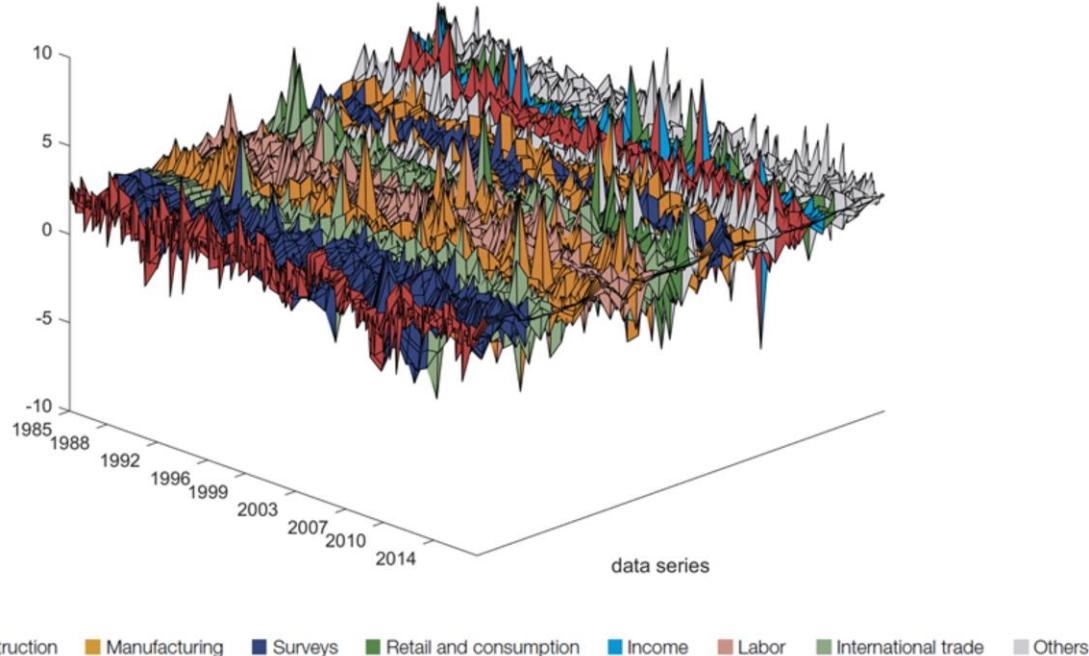
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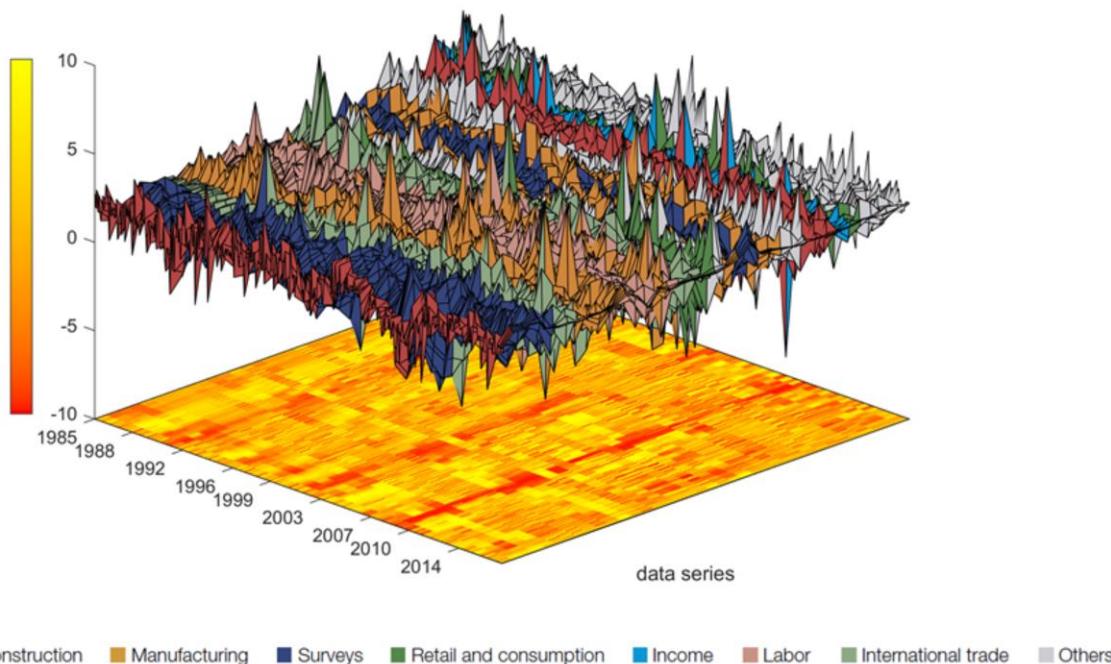
Big Data for Monitoring Macroeconomic Conditions



Big Data for Monitoring Macroeconomic Conditions



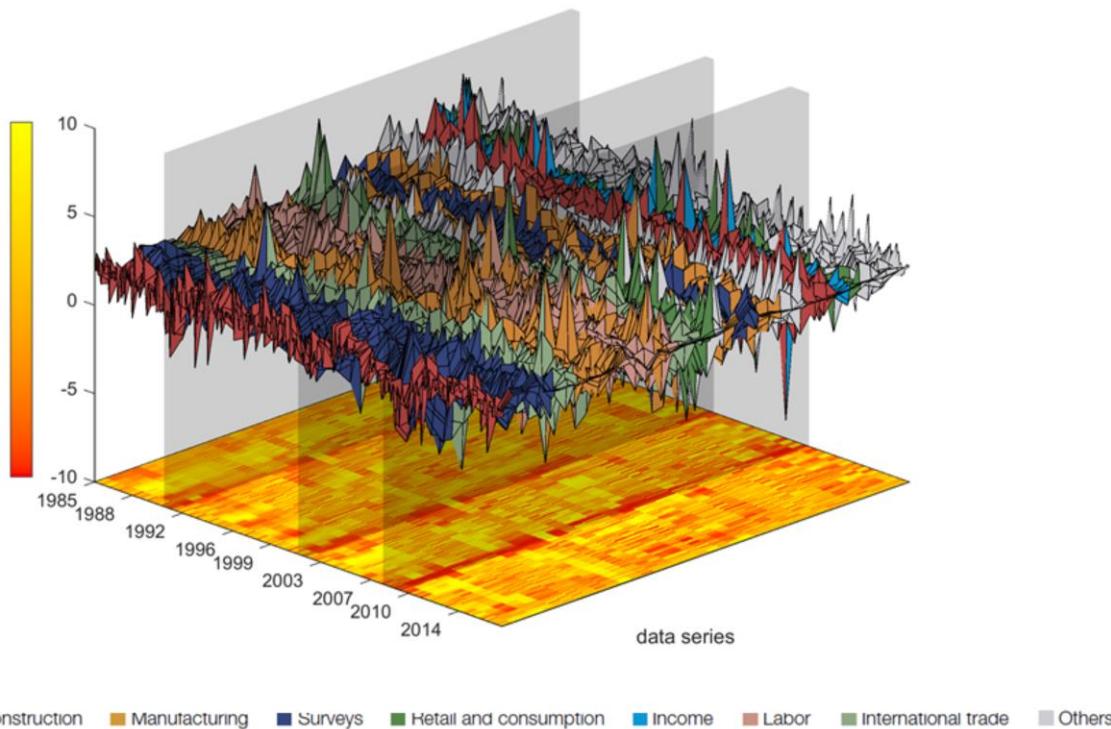
Big Data for Monitoring Macroeconomic Conditions



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.

Big Data for Monitoring Macroeconomic Conditions



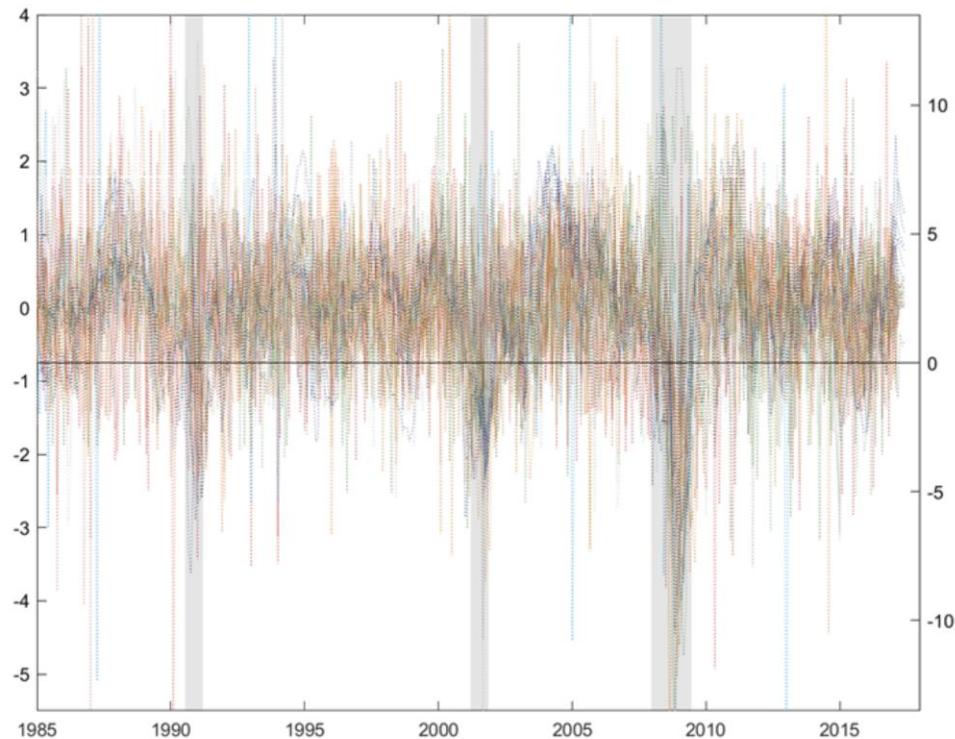
The deep ridge in the 2008-09 period corresponds to the Great Recession, a time when all macroeconomic variables were deeply depressed compared with their historical averages. A similar, but less uniform red ridge is also evident in the early 1990s and early 2000s, periods that correspond to shallower and less widespread recessions.

The gray shaded areas indicate NBER recessions.

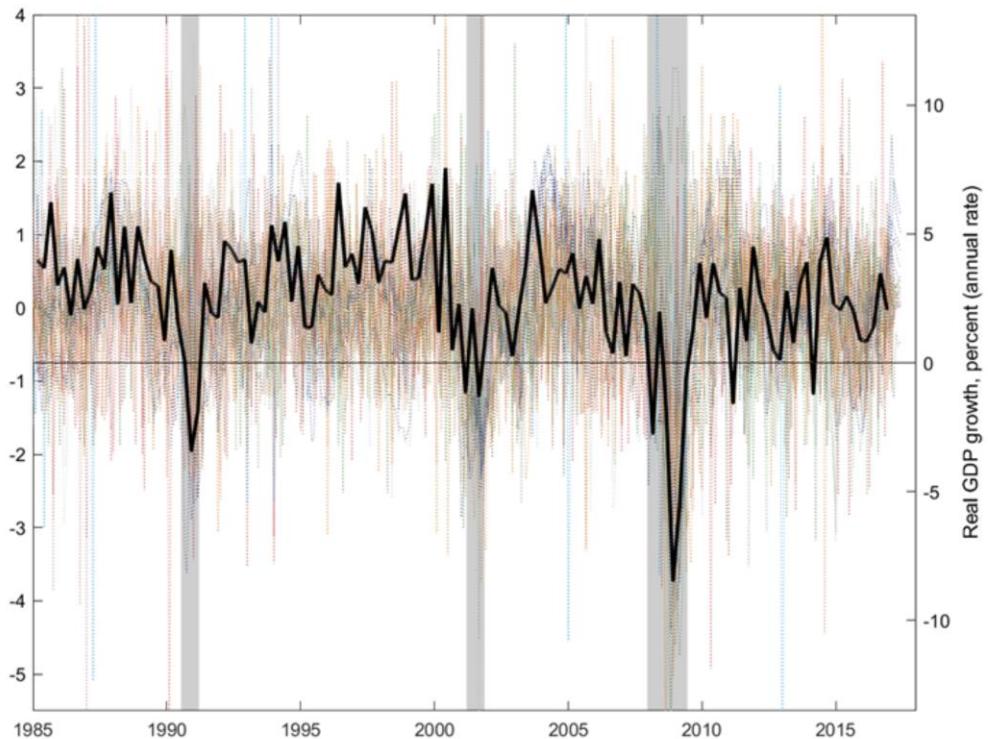
For more discussion, see “Opening the Toolbox: The Nowcasting Code on GitHub,” Federal Reserve Bank of New York *Liberty Street Economics*, August 10, 2018.

Big Data for Monitoring Macroeconomic Conditions

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.



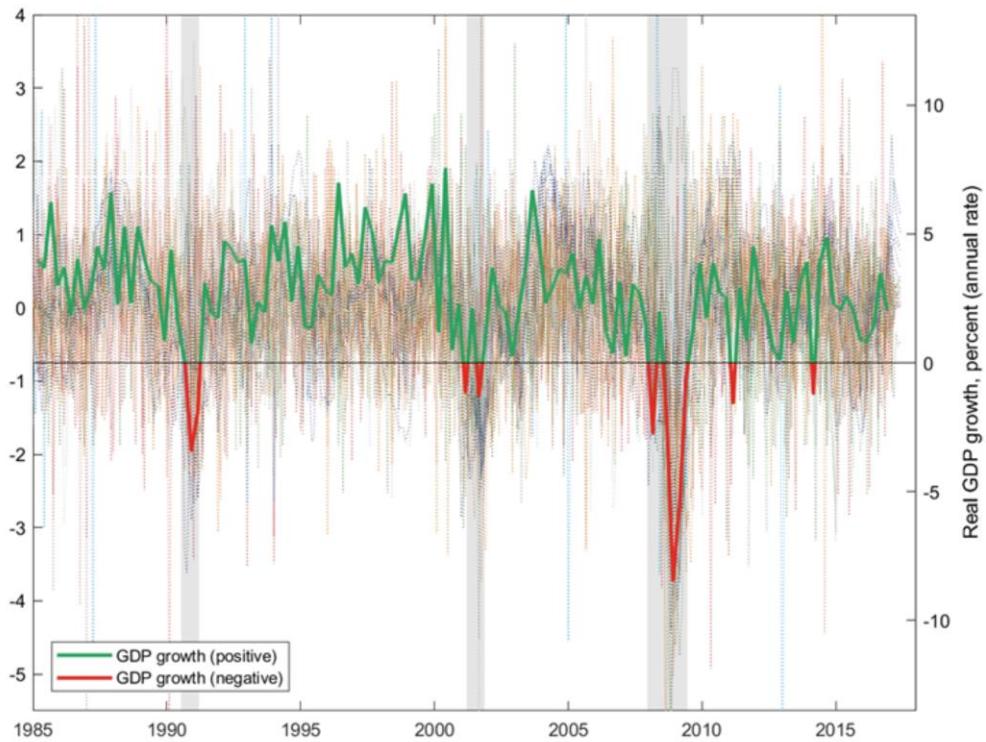
Big Data for Monitoring Macroeconomic Conditions



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.

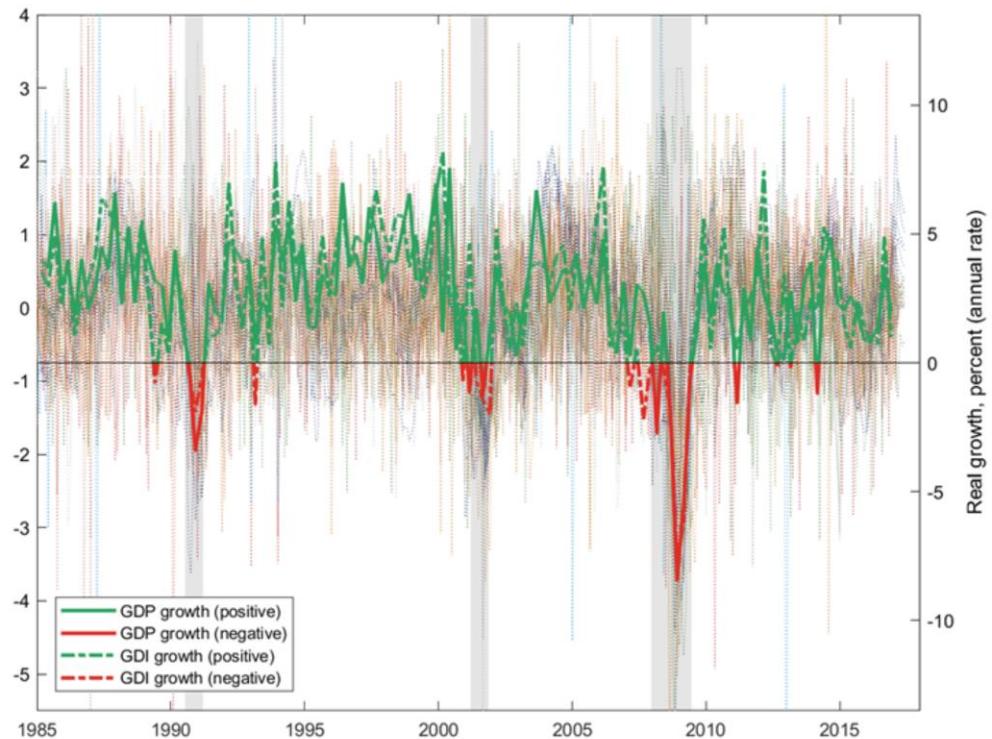
Burns and Mitchell meet Kuznets



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.

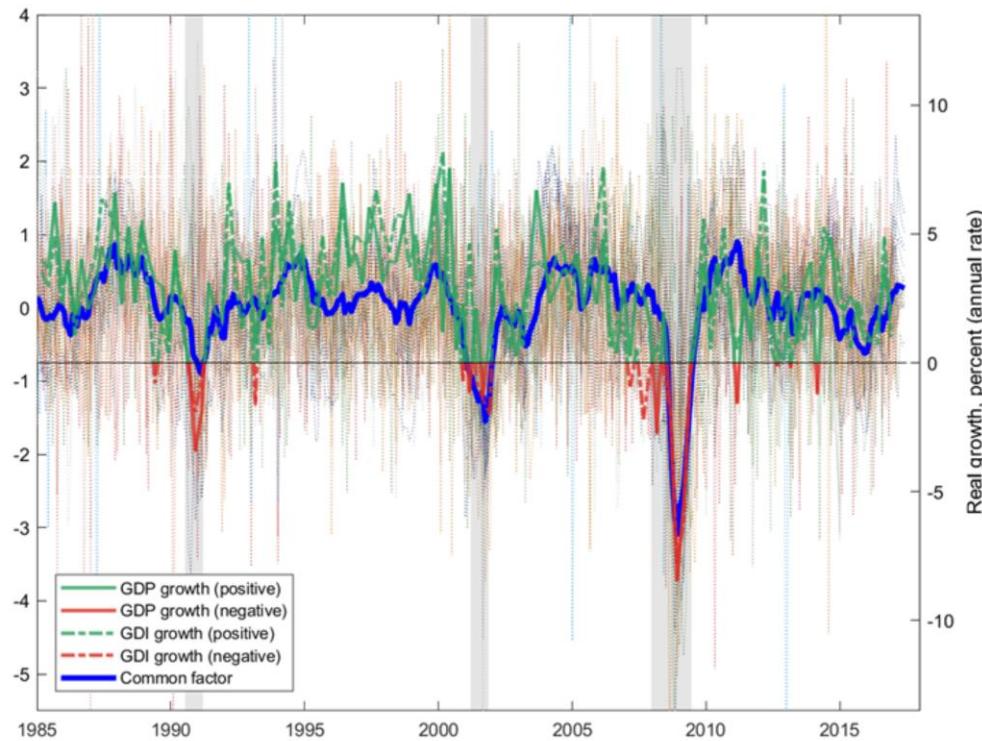
Burns and Mitchell meet Kuznets



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.

Burns and Mitchell meet Kuznets



The blue line gives the common factor estimated from the dynamic factor model.

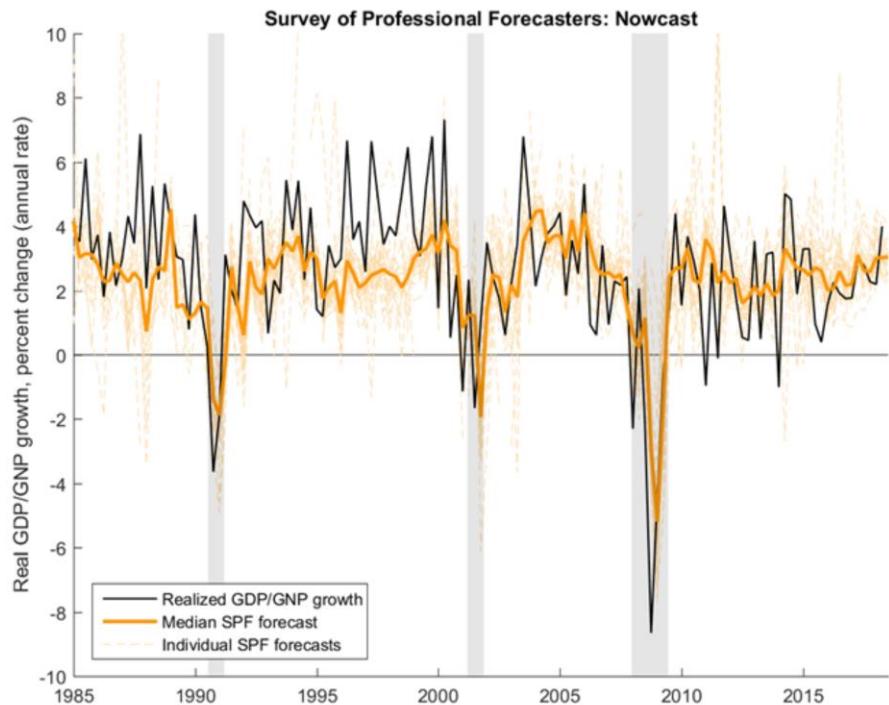
The pervasiveness of common fluctuations across different sectors of the economy implies strong cross-sectional correlations, suggesting that the bulk of fluctuations is essentially driven by a few common sources. Dynamic factor models build on this basic fact to provide a parsimonious and yet suitable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

Outline

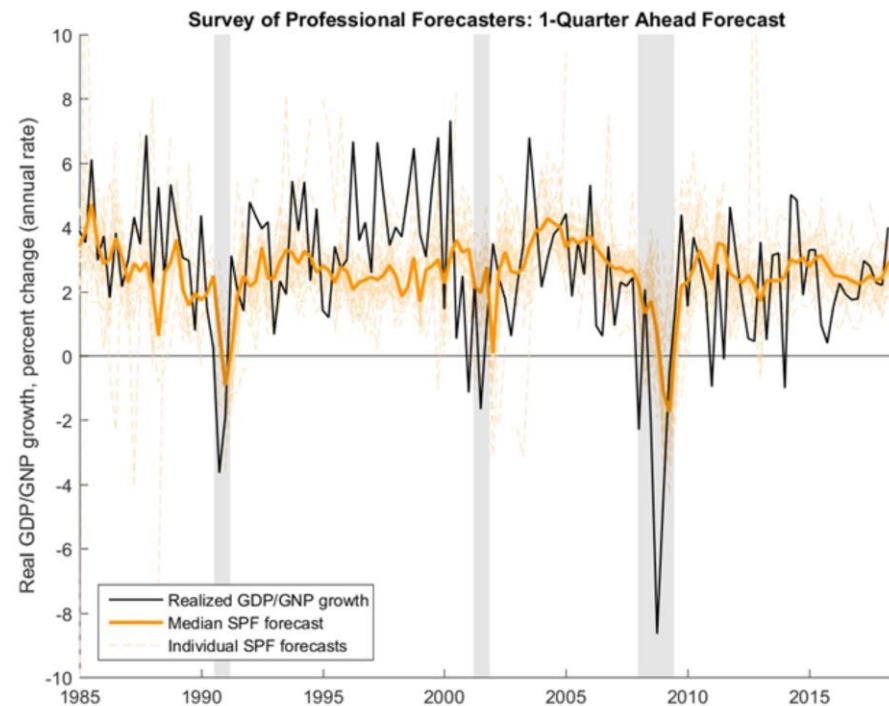
- Monitoring Economic Conditions: Then and Now
- The Real Time Data Flow
- **Forecasting and the Importance of Now**
- The Nowcasting Framework
- Nowcasting in Practice
- Nowcasting during a Government Shutdown
- Nowcasting around the World

Forecasting the Business Cycle

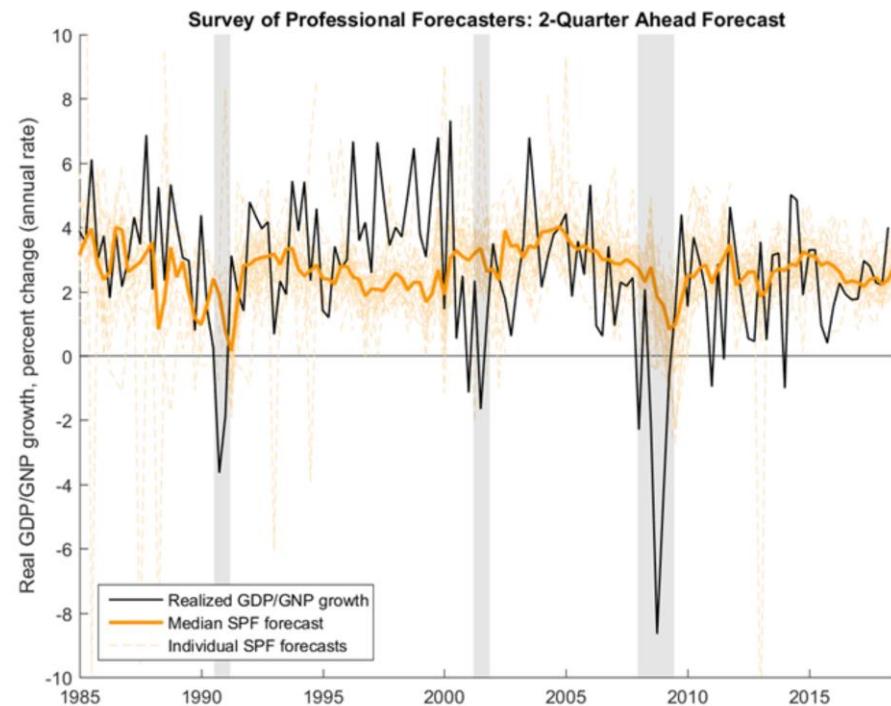


The current quarter predictions (“nowcasts”) from the Survey of Professional Forecasters track closely with observed data. To match historic SPF data, we splice real GDP with real GNP. Professional forecasters find the most success predicting the current and next quarter. There is considerable uncertainty for longer horizons, reflected in the flattening of the orange line in subsequent quarters in the next few slides.

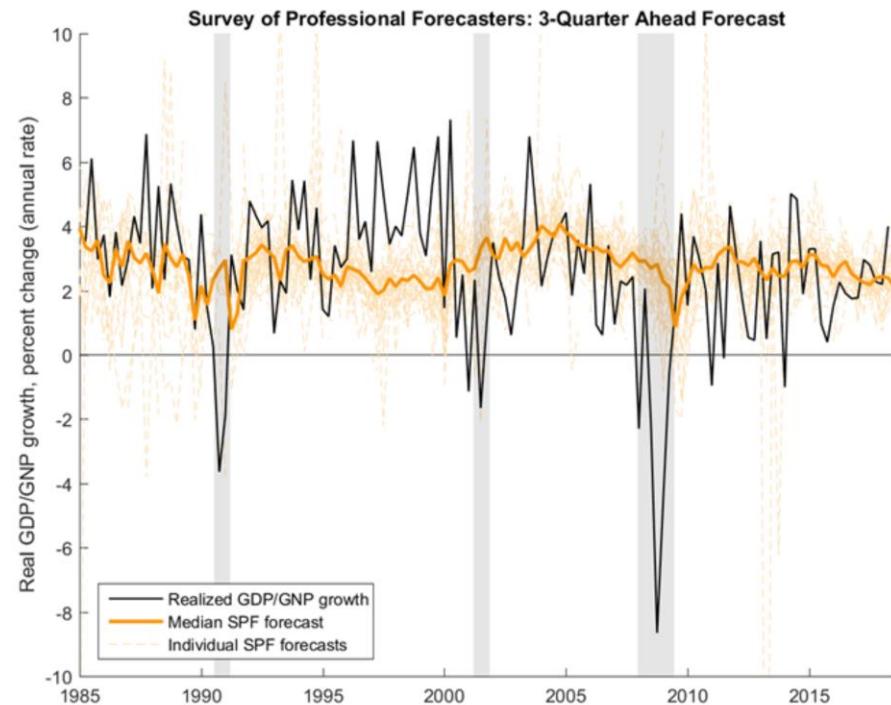
Forecasting the Business Cycle



Forecasting the Business Cycle

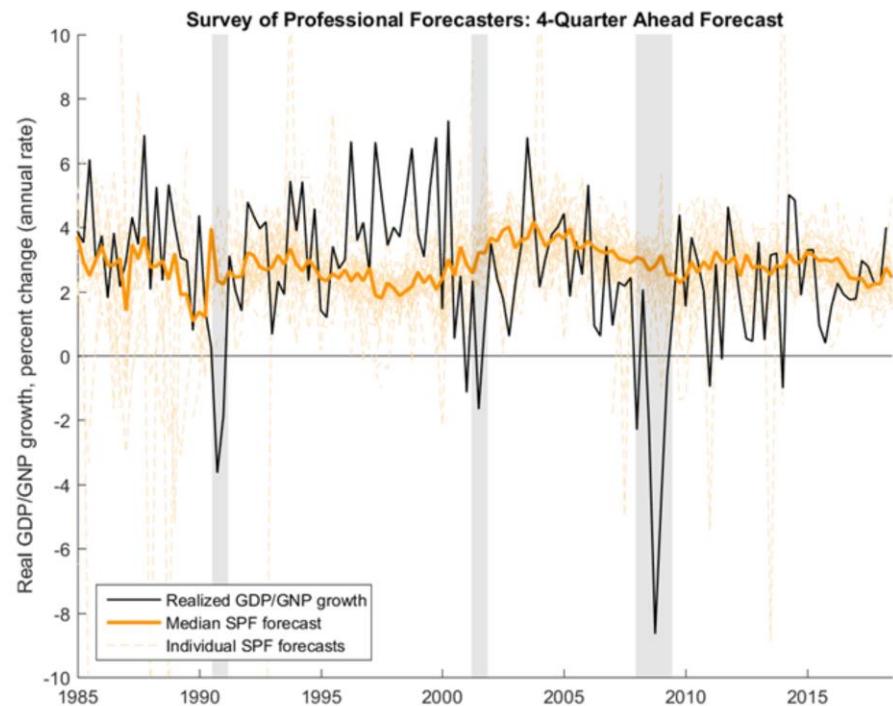


Forecasting the Business Cycle



Forecasting the Business Cycle

Four quarters ahead, the SPF forecast is nearly unchanged.



The Importance of “Now”

Horizons of Predictability

	horizon (h quarters ahead)					
	-1	0	1	2	3	4
BEA	1.61					
Naïve		2.43	2.46	2.55	2.55	2.55
SPF		1.94***	2.21**	2.40	2.47	2.52

Root-mean-square errors for h -quarter ahead forecasts of GDP growth, 1985Q1-2014Q4

- The present is the only horizon of predictability.
 - Unpredictability beyond current quarter
- How can we predict the present?
- Can a machine replicate expert judgment?

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

- Monitoring current economic conditions in real time by predicting the present
 - **Model-based** counterpart to conjectural analysis
 - Real-time reading of the **newsflow**
 - Continuously updated **nowcast** of GDP growth

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.

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

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.

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?

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.

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 engine of the platform is the Dynamic Factor Model, equipped with advanced filtering techniques, of the kind used in robotics.

The Real-Time Data Flow

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

■ Housing and construction ■ Manufacturing ■ Surveys ■ Retail and consumption ■ Income ■ Labor ■ International trade ■ Others

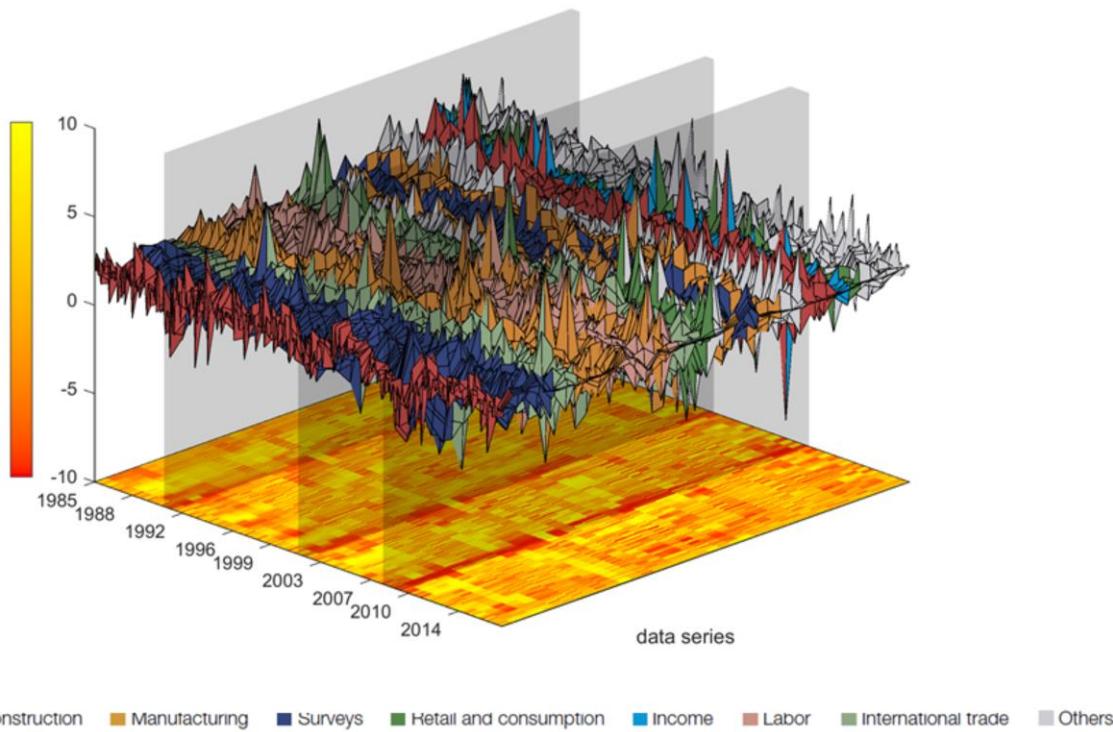
Alternative Data Sources

- 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

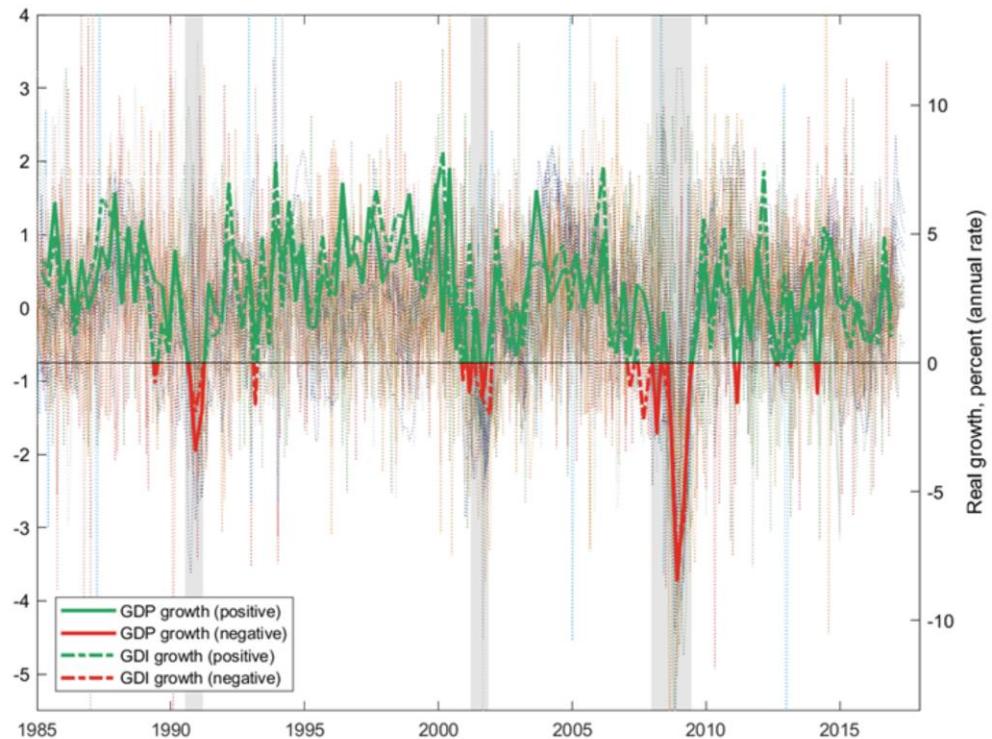
Given the richness of the available macroeconomic information, what might be the role for the ever-growing alternative sources of big data, such as internet search queries, electronic payments, or online prices in monitoring the economy? Choi & Varian (2012) and Askatas (2015), for example, show that 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.

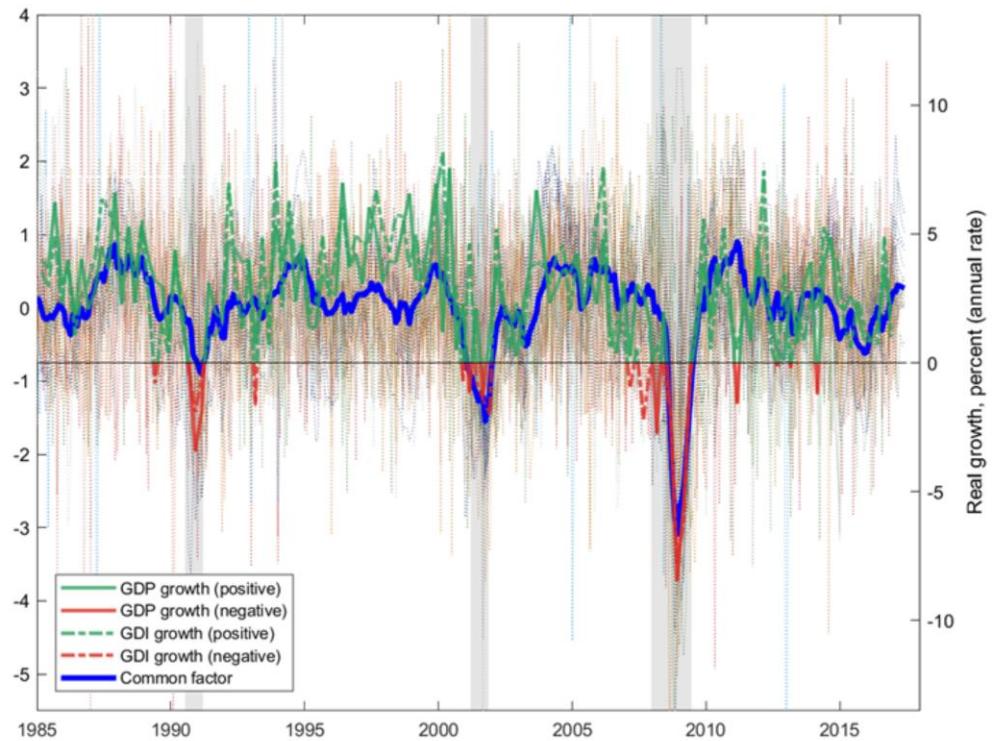
The Machinery | The Data



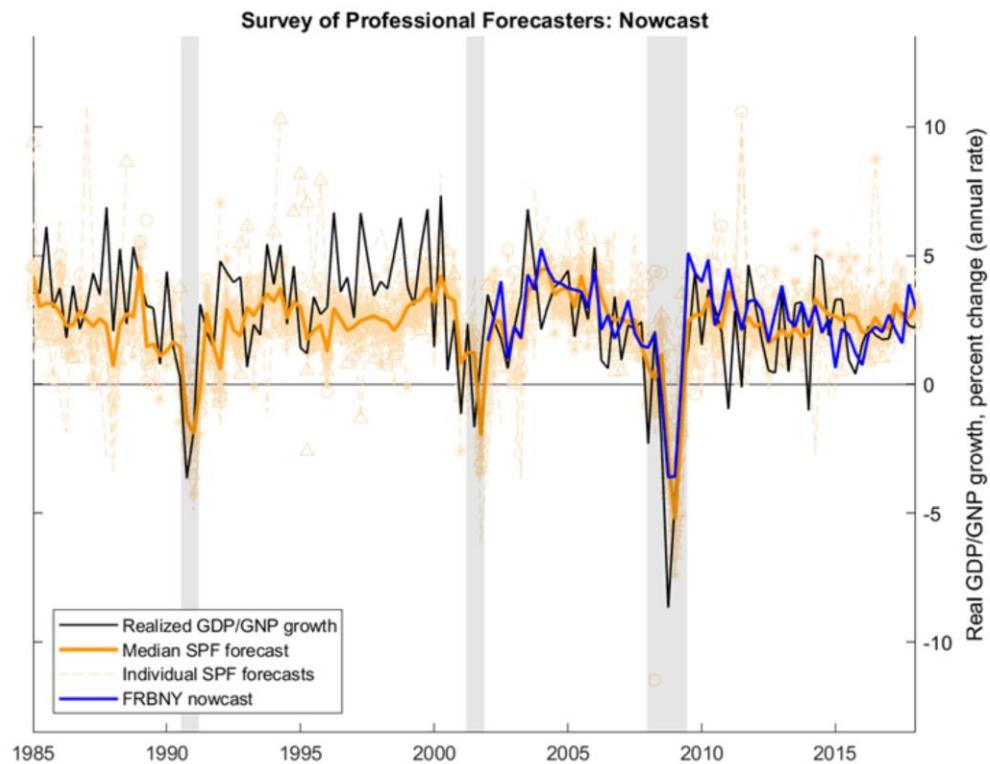
Burns and Mitchell meet Kuznets



Burns and Mitchell meet Kuznets



Forecasting the Business Cycle



Outline

- Monitoring Economic Conditions: Then and Now
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New York Fed Staff Nowcast

2019:Q4 | 2019:Q3 | 2019:Q2 | 2019:Q1

Last Release 11:15am EST Oct 04, 2019

ARCHIVE

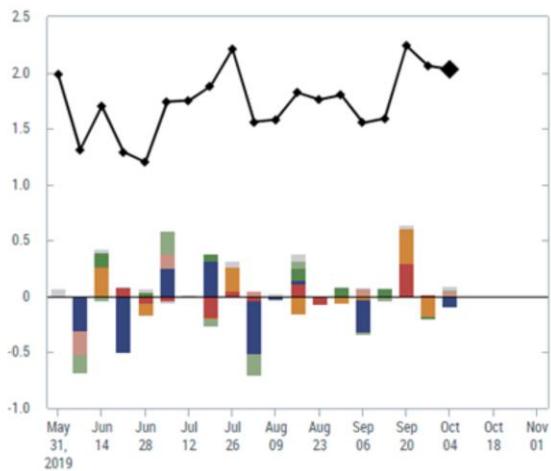
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LAYOUT

◆ The New York Fed Staff Nowcast ○ Advance GDP estimate □ Latest GDP estimate

■ Housing and construction ■ Manufacturing ■ Surveys ■ Retail and consumption ■ Income ■ Labor ■ International trade ■ Others

Percent (annual rate)

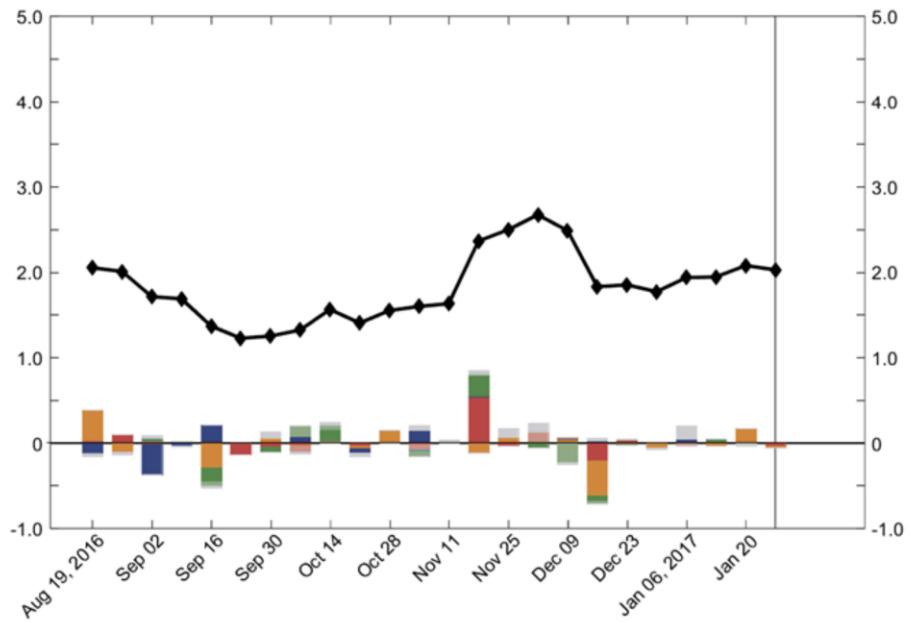


Data Flow (Oct 04, 2019)					
Model Update	Release Date	Data Series	Actual	Impact	Nowcast GDP Growth
Oct 04					2.03
	8:30AM Oct 04	Civilian unemployment rate	-0.20	0.03	
	8:30AM Oct 04	Imports: Goods and services	0.50	0.01	
	8:30AM Oct 04	Exports: Goods and services	0.22	-0.00	
	8:30AM Oct 04	All Employees: Total nonfarm	136.00	0.01	
	10:00AM Oct 03	Total business inventories	0.15	-0.00	
	10:00AM Oct 03	ISM non-mfg.: NMI composite index	52.60	-0.00	
	8:10AM Oct 02	ADP nonfarm private payroll employment	135.00	0.01	
	10:00AM Oct 01	ISM mfg.: Employment index	46.30	-0.04	
	10:00AM Oct 01	ISM mfg.: Prices index	49.70	0.01	
	10:00AM Oct 01	Value of construction put in place	0.13	0.00	
	10:00AM Oct 01	ISM mfg.: PMI composite index	47.80	-0.06	
		Data revisions		-0.00	
		Parameter revisions		0.03	
	Sep 27				2.06

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.

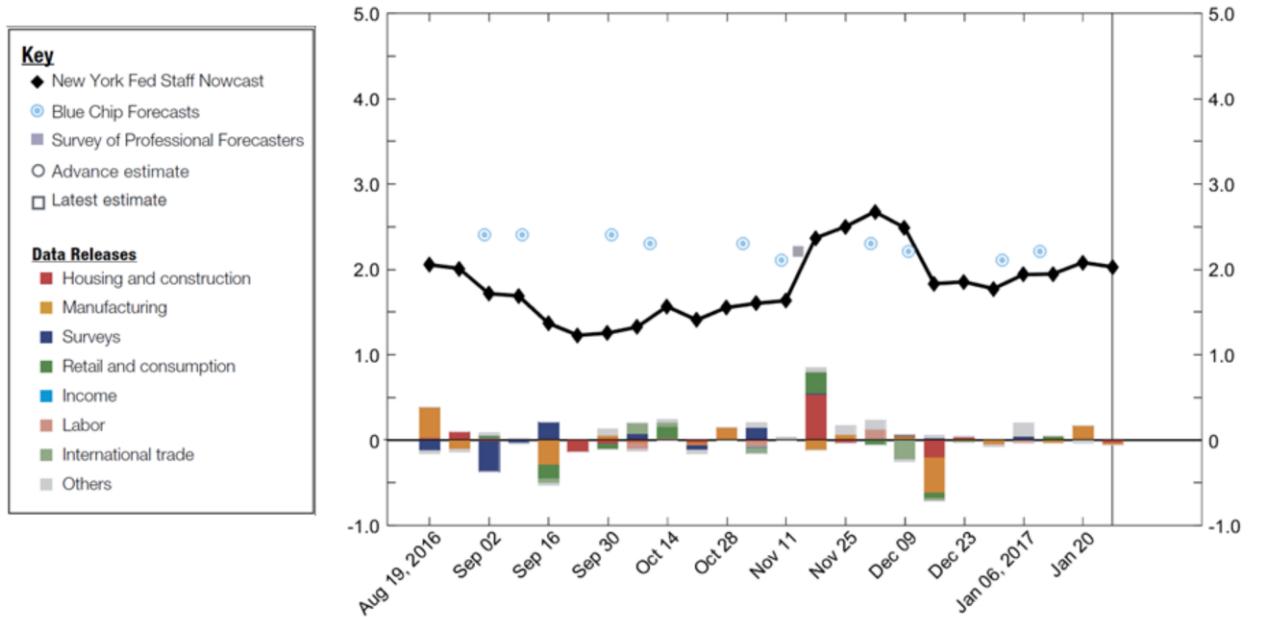
<https://www.newyorkfed.org/research/policy/nowcast>

Nowcasting GDP Growth in 2016:Q4

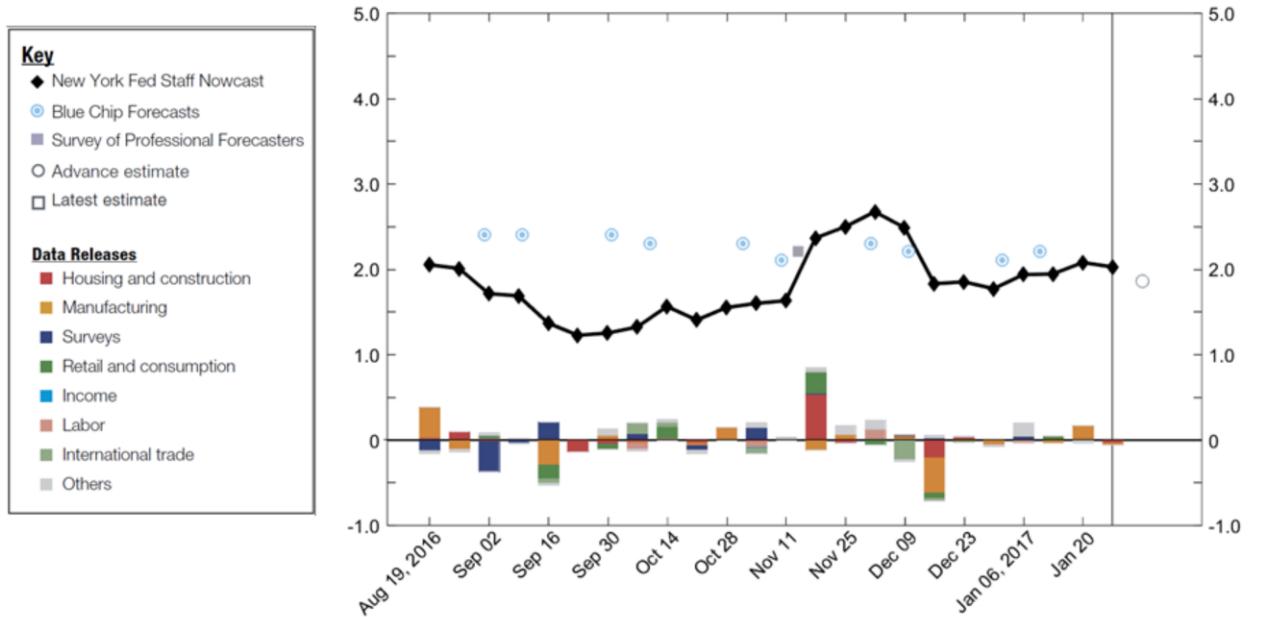


The figure shows the weekly updates of the nowcast, i.e., the predictions of the model based on the information available at the dates indicated on the horizontal axis. The progression reflects how the news in the data released each week changes the nowcast for that week. The colored bars illustrate 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.

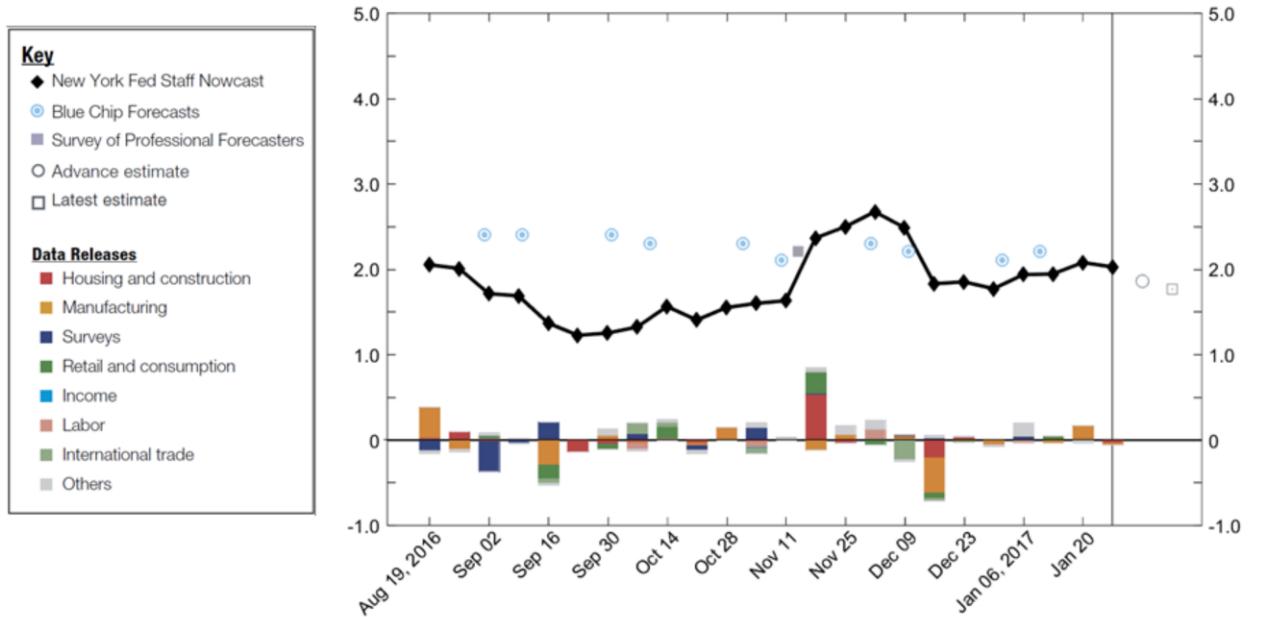
Nowcasting GDP Growth in 2016:Q4



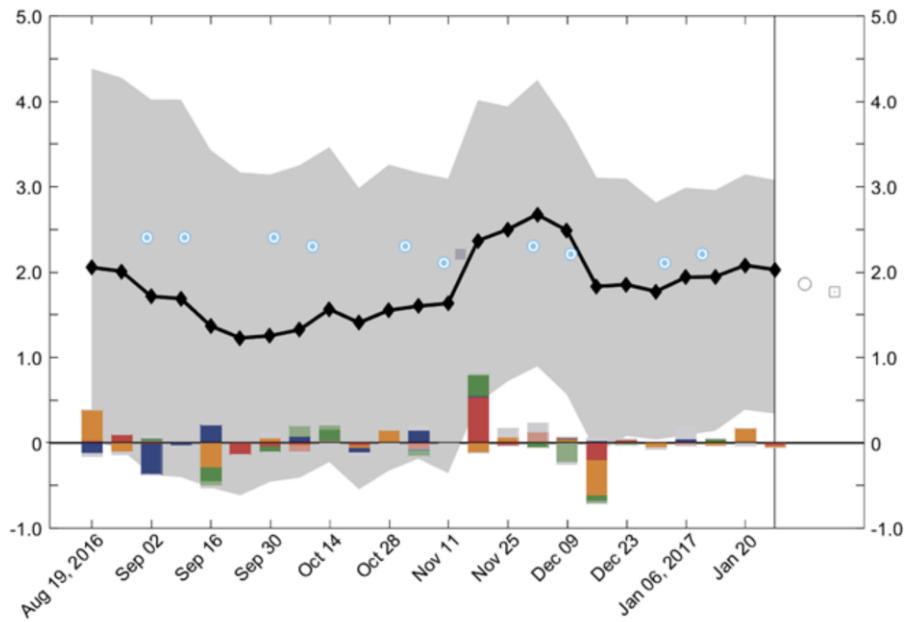
Nowcasting GDP Growth in 2016:Q4



Nowcasting GDP Growth in 2016:Q4

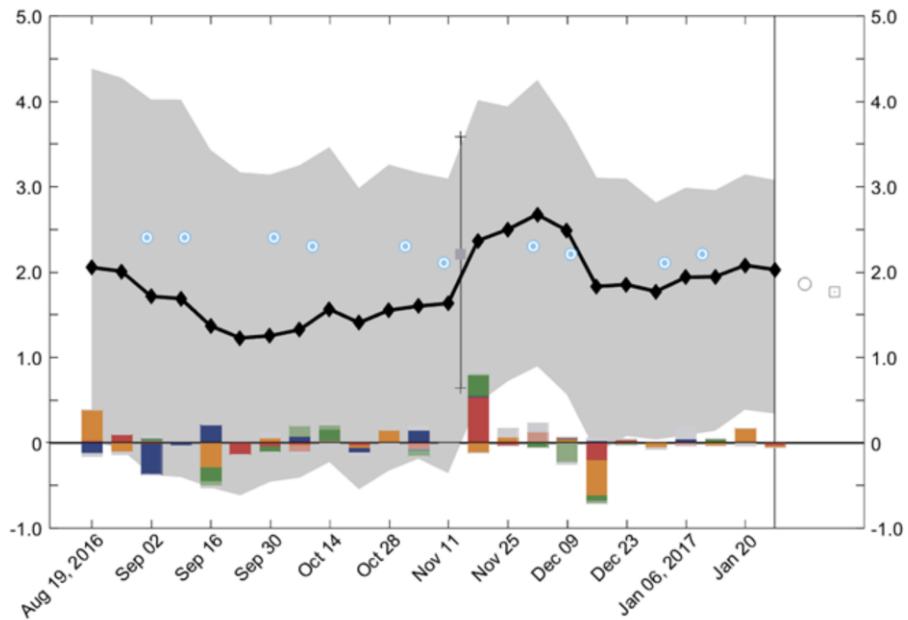


Nowcasting GDP Growth in 2016:Q4



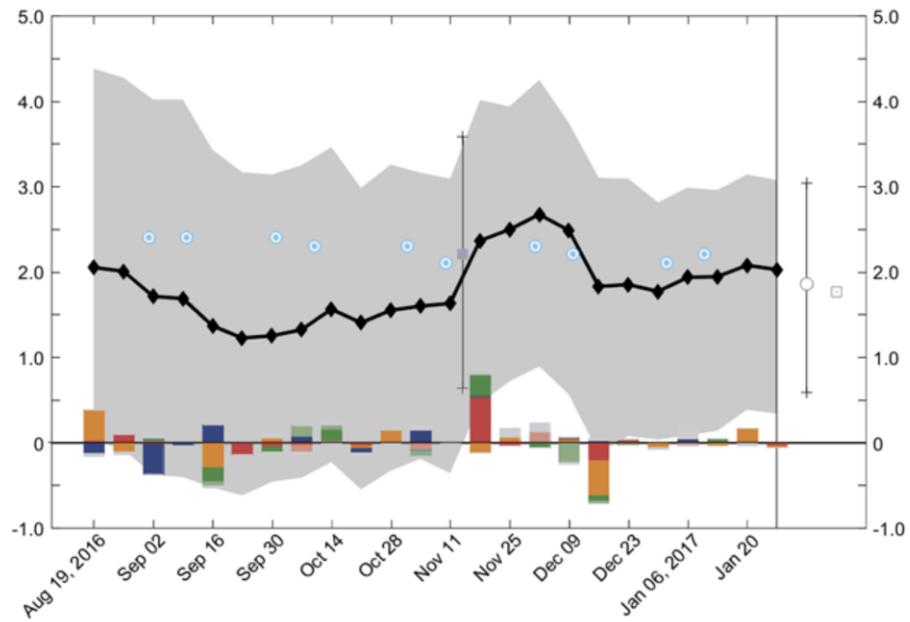
The figure reports the evolution of the nowcast of real GDP growth in 2016:Q4, but with added shading to provide information about forecasting uncertainty. In particular, the shaded area represents the 68% probability interval constructed using the empirical distribution of the forecast errors. We discuss 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.

Nowcasting GDP Growth in 2016:Q4



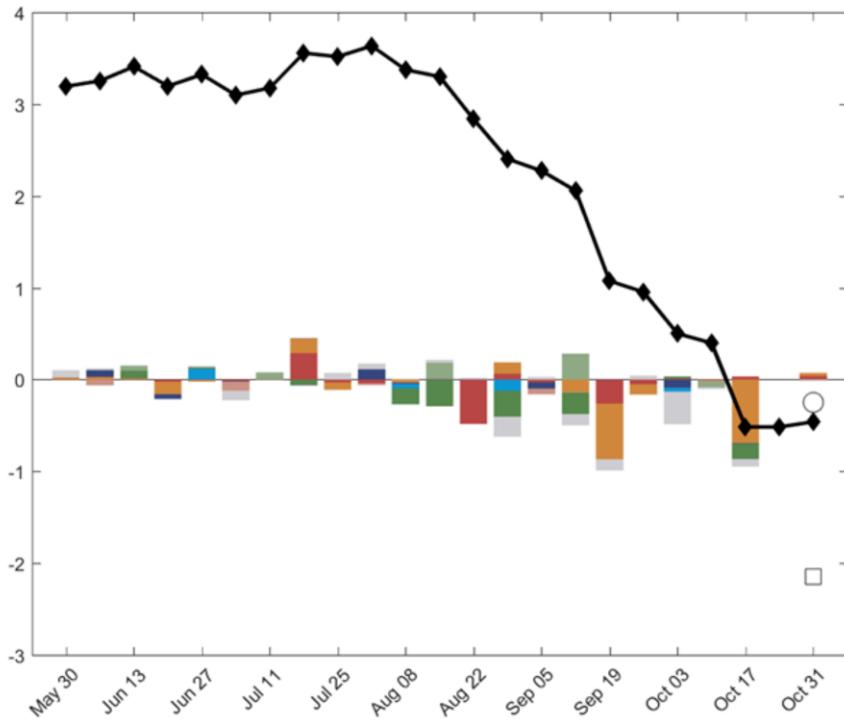
Notice, too, the substantial uncertainty also present in the Bureau of Economic Analysis official release of GDP, as illustrated in the above figure by the error bar around the release, which reflects data revisions. This uncertainty is similar in magnitude to that of the model forecast, suggesting that 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



Nowcasting the Great Recession and Recovery

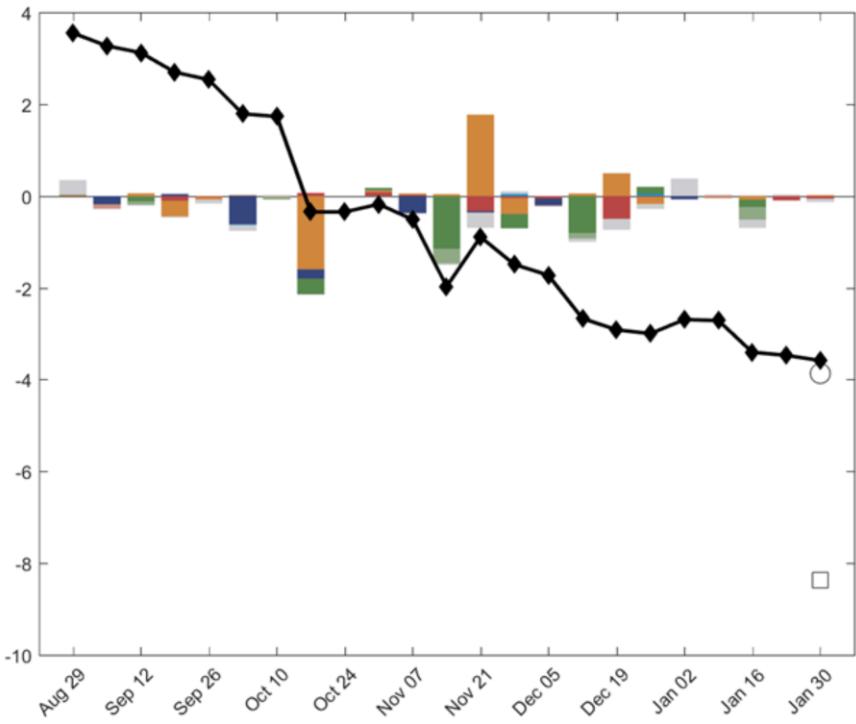
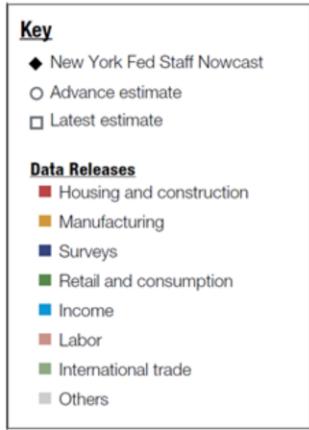
2008:Q3



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.

Nowcasting the Great Recession and Recovery

2008:Q4

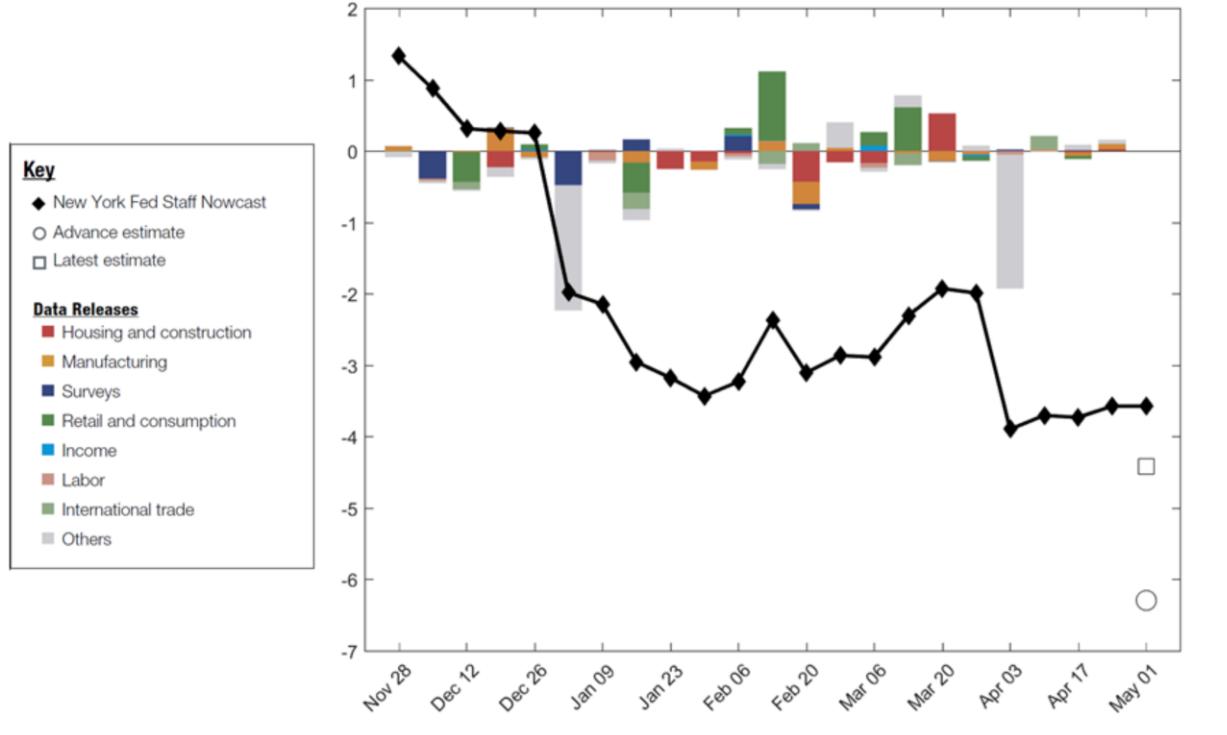


An accompanying *Liberty Street Economics* post discussed the evolution of the nowcast at critical points during the Great Recession in 2008-09. For example, the nowcast first dropped into negative territory in mid-October 2008, roughly one month after the failure of Lehman Brothers and six weeks before 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).

See Adams et al., "Just Released: Historical Reconstruction of the New York Fed Staff Nowcast, 2002-15."

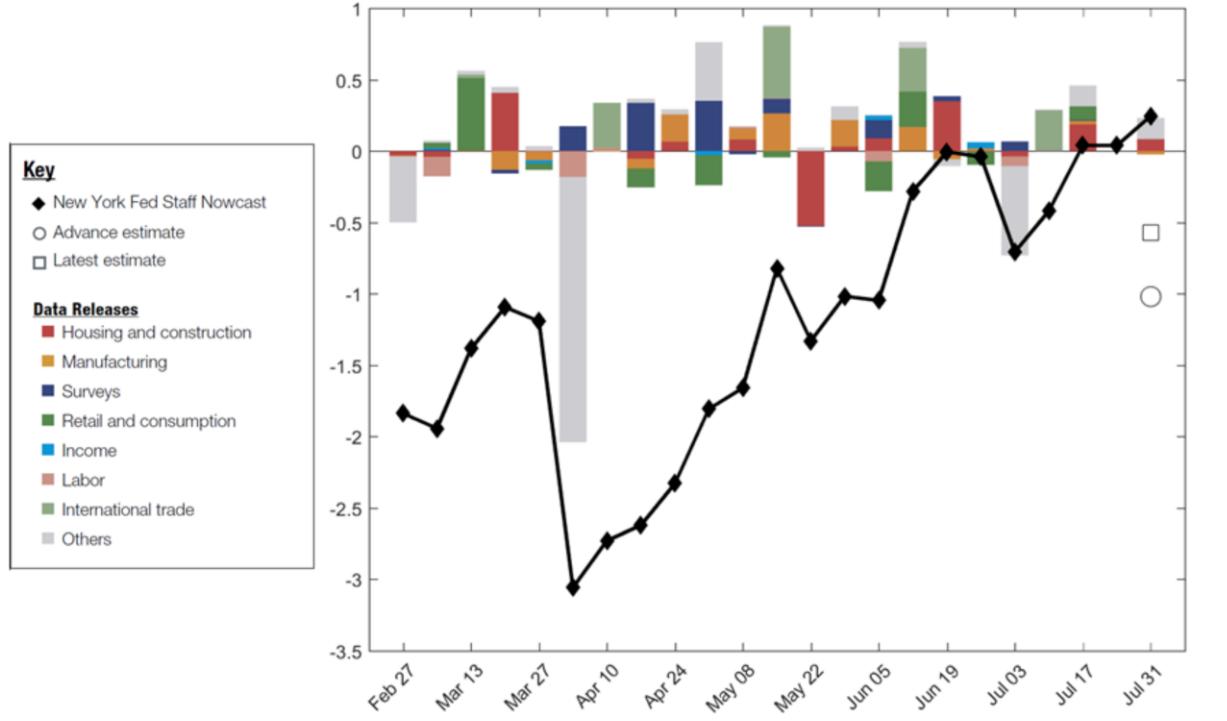
Nowcasting the Great Recession and Recovery

2009:Q1



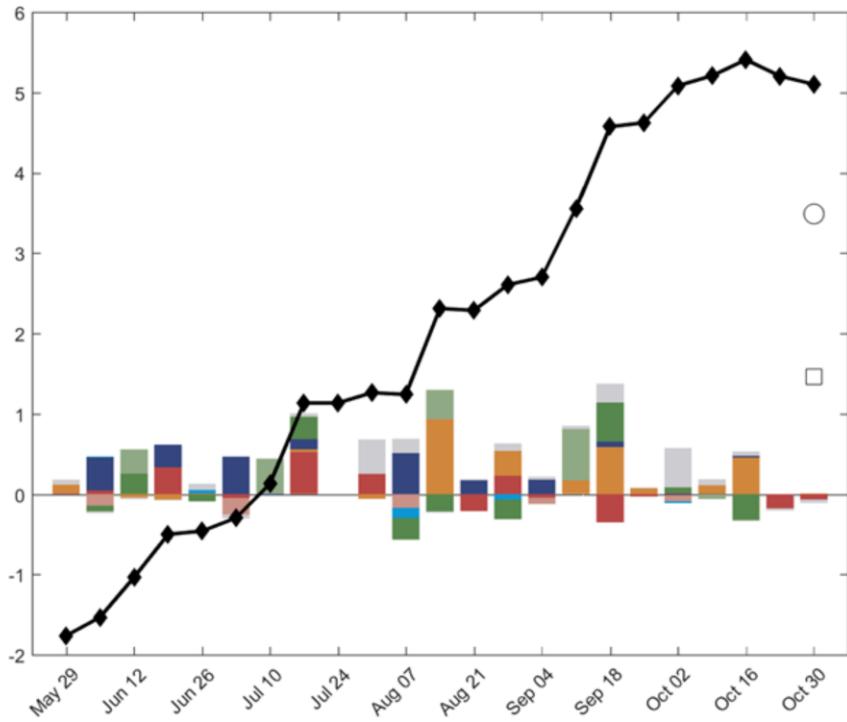
Nowcasting the Great Recession and Recovery

2009:Q2



Nowcasting the Great Recession and Recovery

2009:Q3

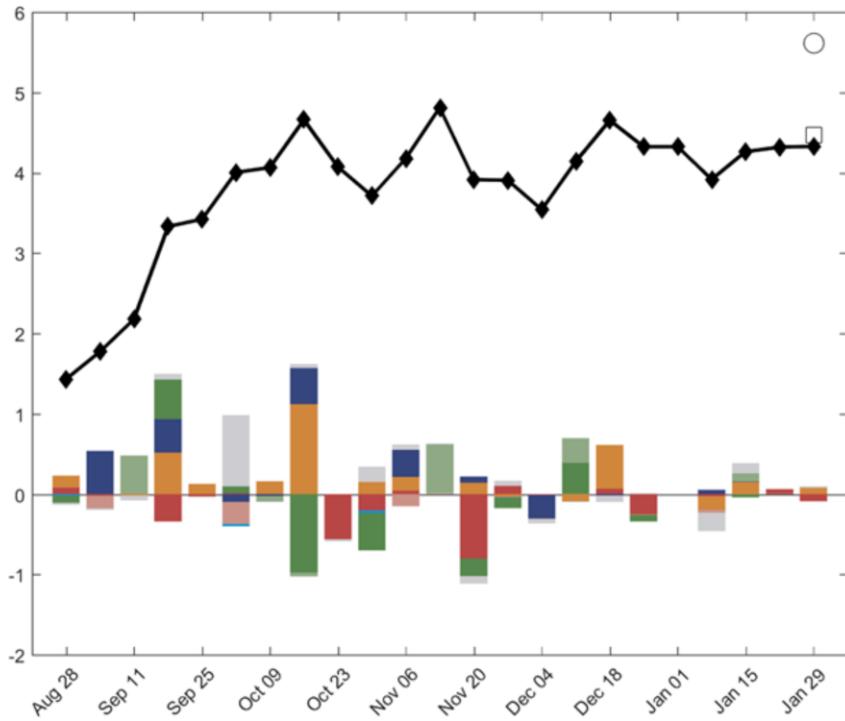
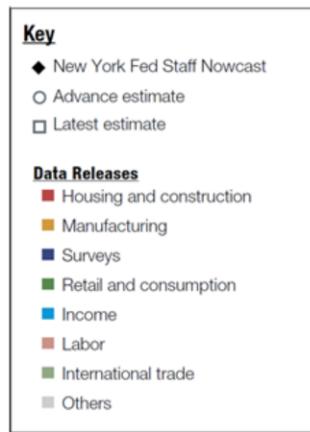


The summer of 2009 marked the end of the recession. At the start of the third quarter in July, the nowcast still predicted negative GDP growth (see the figure above). However, over the next few months, a wide variety of better-than-expected data was released, especially for manufacturing, international 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.

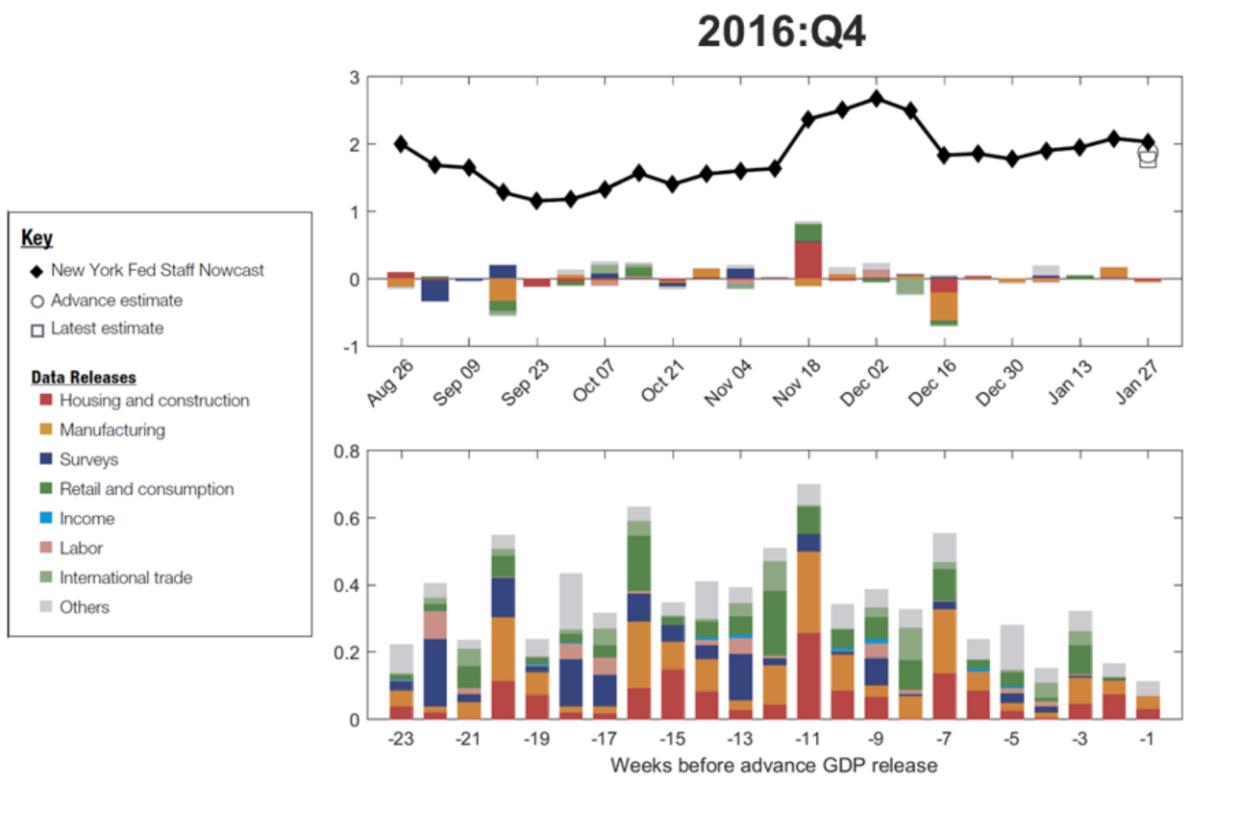
See Adams et al., "Just Released: Historical Reconstruction of the New York Fed Staff Nowcast, 2002-15."

Nowcasting the Great Recession and Recovery

2009:Q4



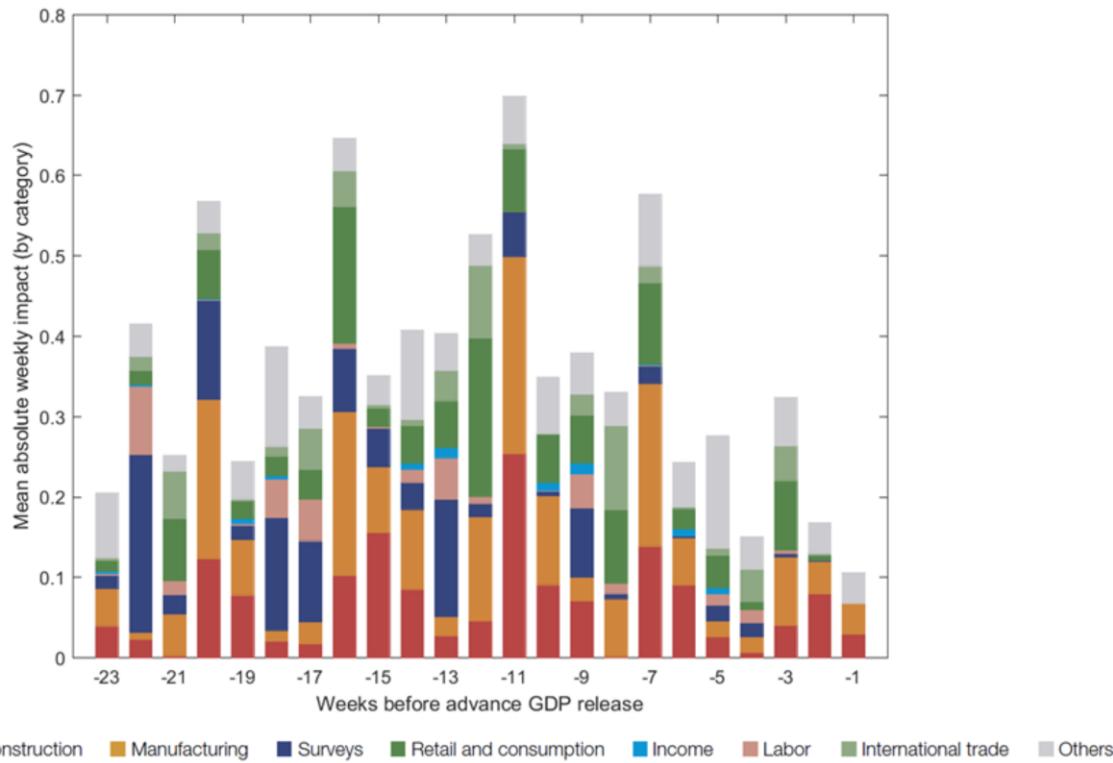
The Impact of Macroeconomic Data Releases



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.

The Impact of Macroeconomic Data Releases



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

New York Fed Staff Nowcast

2019:Q4 | 2019:Q3 | 2019:Q2 | 2019:Q1

Last Release 11:15am EST Oct 04, 2019

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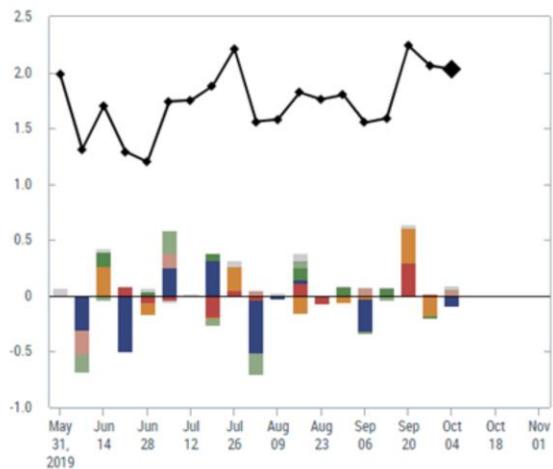
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◆ The New York Fed Staff Nowcast ○ Advance GDP estimate □ Latest GDP estimate

■ Housing and construction ■ Manufacturing ■ Surveys ■ Retail and consumption ■ Income ■ Labor ■ International trade ■ Others

Percent (annual rate)



Expand

Data Flow (Oct 04, 2019)

Model Update	Release Date	Data Series	Actual	Impact	Nowcast GDP Growth
Oct 04					2.03
8:30AM Oct 04		Civilian unemployment rate	-0.20	0.03	
8:30AM Oct 04		Imports: Goods and services	0.50	0.01	
8:30AM Oct 04		Exports: Goods and services	0.22	-0.00	
8:30AM Oct 04		All Employees: Total nonfarm	136.00	0.01	
10:00AM Oct 03		Total business inventories	0.15	-0.00	
10:00AM Oct 03		ISM non-mfg.: NMI composite index	52.60	-0.00	
8:10AM Oct 02		ADP nonfarm private payroll employment	135.00	0.01	
10:00AM Oct 01		ISM mfg.: Employment index	46.30	-0.04	
10:00AM Oct 01		ISM mfg.: Prices index	49.70	0.01	
10:00AM Oct 01		Value of construction put in place	0.13	0.00	
10:00AM Oct 01		ISM mfg.: PMI composite index	47.80	-0.06	
		Data revisions		-0.00	
		Parameter revisions		0.03	
	Sep 27				2.06

<https://www.newyorkfed.org/research/policy/nowcast>

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

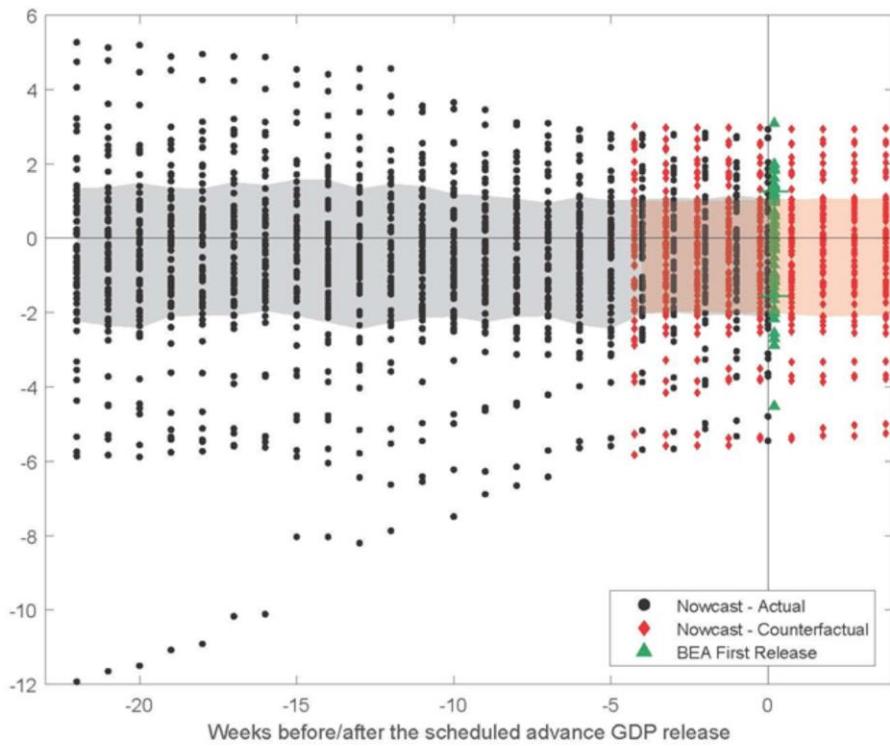
For more discussion, see
“Monitoring Economic Conditions
during a Government Shutdown,”
Federal Reserve Bank of New York
Liberty Street Economics, February 5,
2019.

Series Delayed by the Shutdown

Series	Release	Scheduled Date	Reference Period
New single-family houses sold	▪ New Residential Sales	12/27/2018	Nov 2018
Merchant wholesalers: Total inventories	▪ Advance Economic Indicators	12/28/2018	Nov 2018
Value of construction put into place	▪ Construction Spending	1/3/2019	Nov 2018
Manufacturers' new orders: Durable goods			
Manufacturers unfilled orders: All manufacturing industries	▪ Full Report - Manufacturers' Shipments, Inventories, and Orders	1/7/2019	Nov 2018
Manufacturers shipments: Durable goods			
Manufacturers inventories: Durable goods			
Exports: Goods and services	▪ U.S. International Trade in Goods and Services	1/8/2019	Nov 2018
Imports: Goods and Services			
Merchant wholesalers: Total inventories	▪ Monthly Wholesale Trade	1/10/2019	Nov 2018
Inventories: Total business	▪ Manufacturing, Trade Inventories, and Sales	1/16/2019	Nov 2018
Retail sales	▪ Advance Monthly Sales for Retail and Food Services	1/16/2019	Dec 2018
Housing starts			
Building permits	▪ New Residential Construction	1/17/2019	Dec 2018
Manufacturers' new orders: Durable goods			
Manufacturers unfilled orders: All manufacturing industries	▪ Advance Report - Manufacturers' Shipments, Inventories, and Orders	1/25/2019	Dec 2018
Manufacturers shipments: Durable goods			
Manufacturers inventories: Durable goods			
New single-family houses sold	▪ New Residential Sales	1/29/2019	Dec 2018
Merchant wholesalers: Total inventories			
Exports: Goods and services	▪ Advance Economic Indicators	1/29/2019	Dec 2018
Imports: Goods and services			
Real gross domestic product	▪ Gross Domestic Product	1/30/2019	2018Q4
Real gross domestic income			
PCE less food and energy: Chain price index			
Real disposable personal income	▪ Personal Income and Outlays	1/31/2019	Dec 2018
PCE: Chain price index			
Real PCE			

█ Housing and construction
 █ Manufacturing
 █ Surveys
 █ Retail and consumption
 █ Income
 █ Labor
 █ International trade
 █ Others

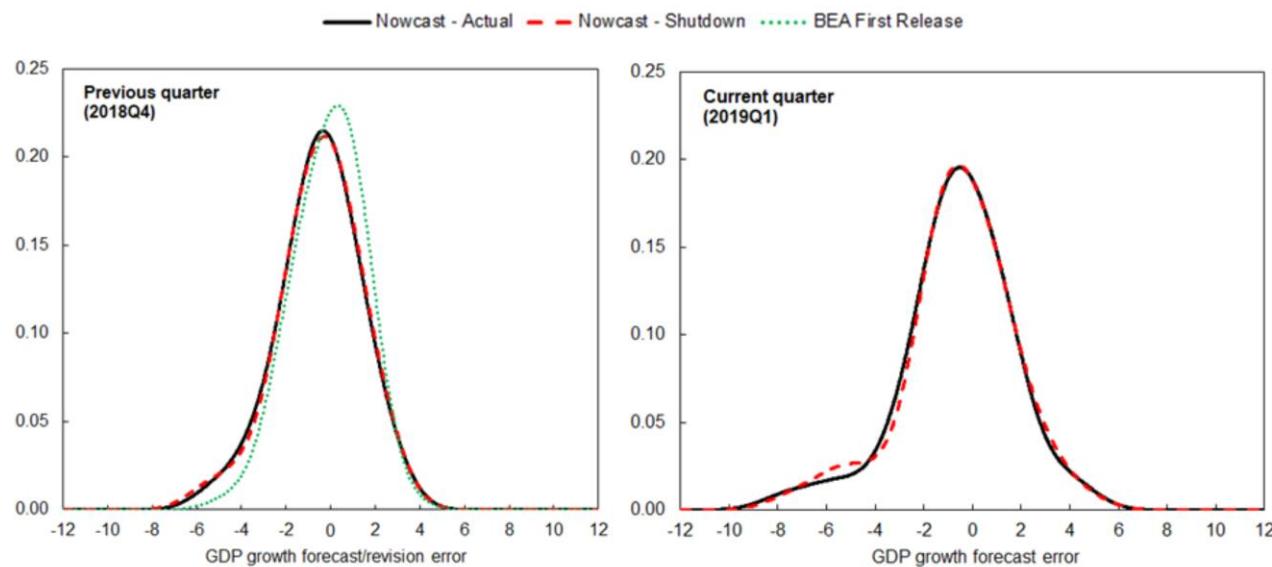
Forecast Error Distribution Comparison



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.

Nowcasting during a Government Shutdown



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.

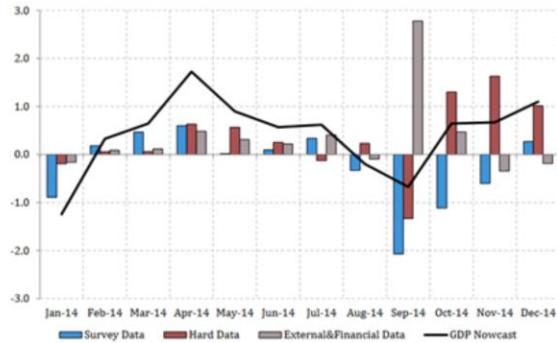
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Nowcasting around the World

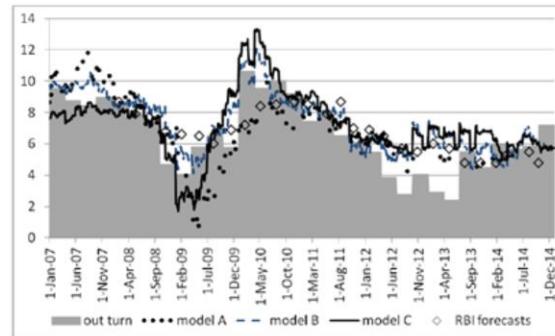
Russia 

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



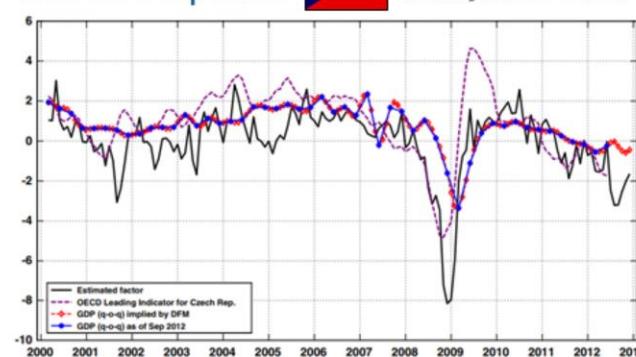
China 

Giannone, Miranda Agrippino, and Modugno (2013)
"Nowcasting China Real GDP"



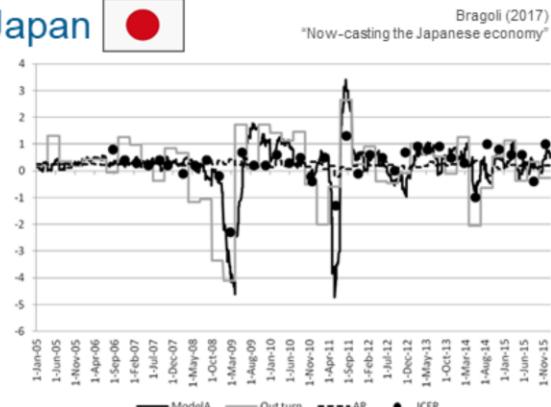
Czech Republic 

Rusnák (2016)
"Nowcasting Czech GDP in real time"



Nowcasting around the World

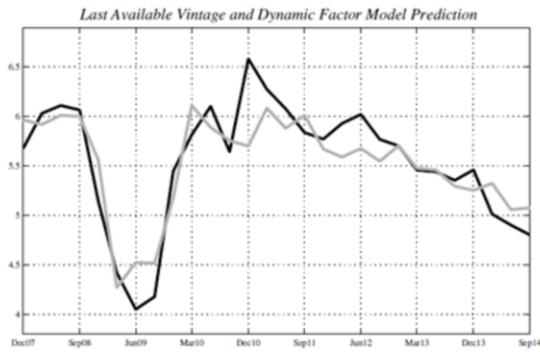
Japan 



Indonesia 

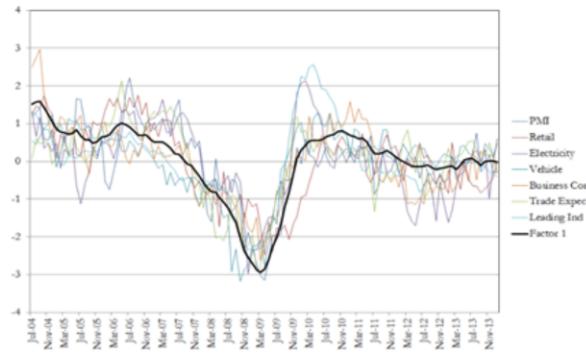
Luciani, Pundit, Ramayandi, and Veronese (2015)

"Nowcasting Indonesia"



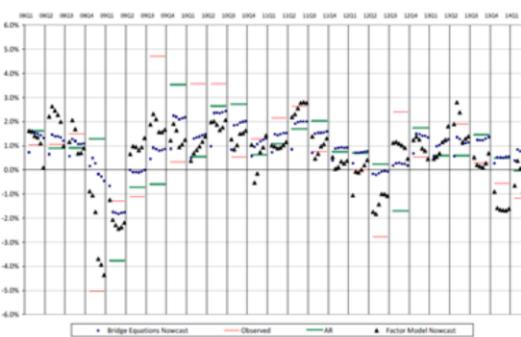
South Africa 

Kabundi, Nel, and Ruch (2016)
"Nowcasting Real GDP growth in South Africa"



Argentina 

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

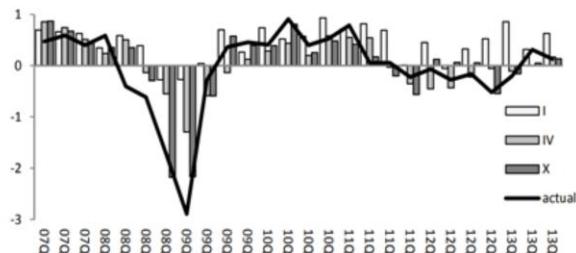


Nowcasting around the World

Euro Area



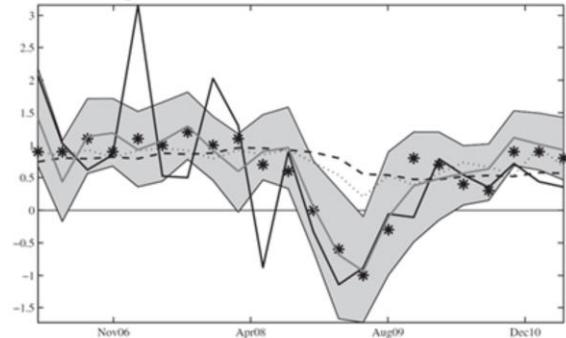
Gayer, Girardi, and Reuter (2014)
"The Role of Survey Data in
Nowcasting Euro Area GDP Growth"



Source: European Commission, DataInsight

Norway

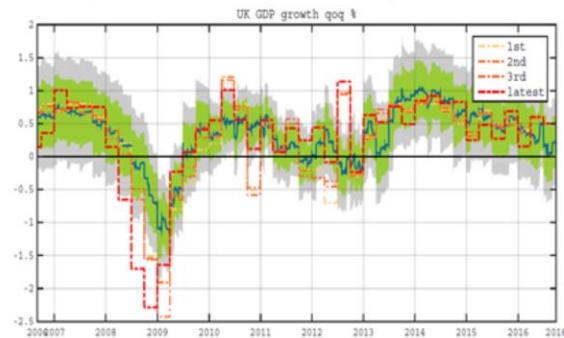
Luciani and Ricci (2014)
"Nowcasting Norway"



UK



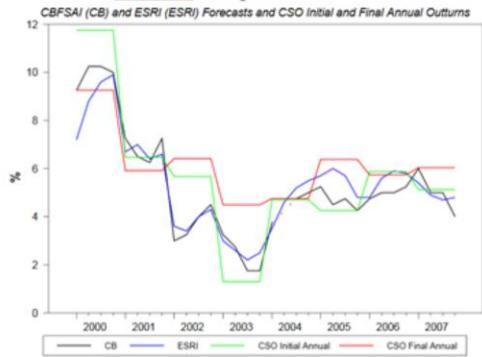
Anesti, Beatriz Galvão, and Miranda-Agrippino (2017)
"Uncertain Kingdom: A Framework for
Nowcasting GDP and its Revisions"



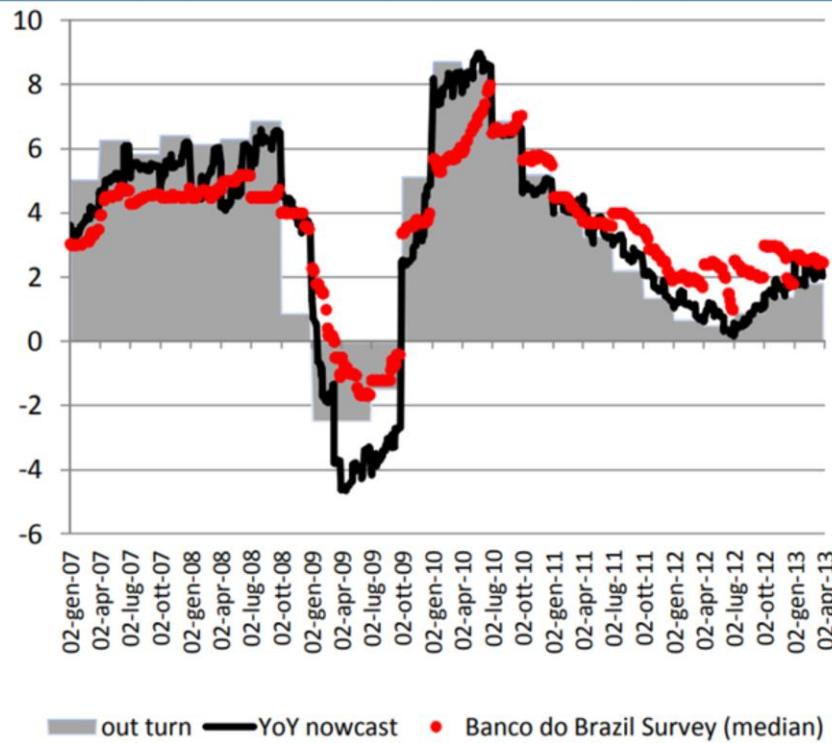
Ireland



D'Agostino, McQuinn, and O'Brien (2008)
"Now-casting Irish GDP"

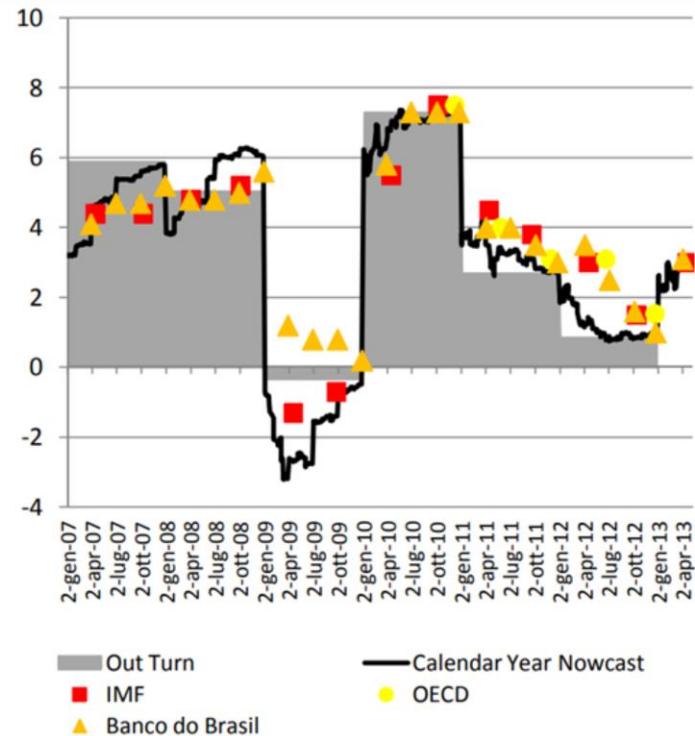


Nowcasting Brazil



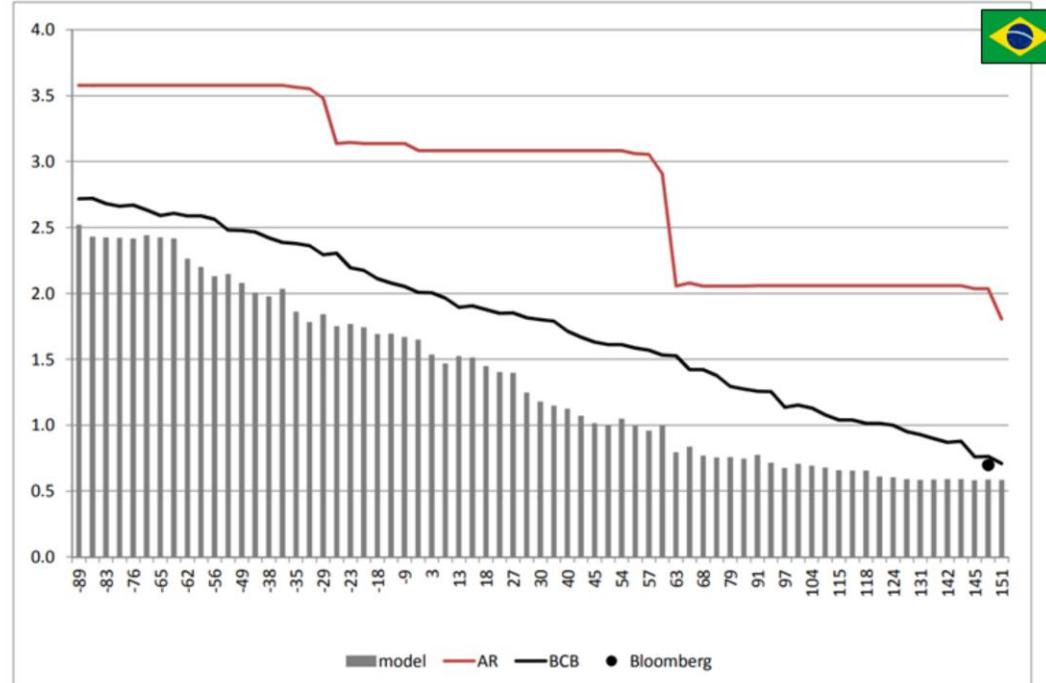
Daniela Bragoli, Luca Metelli and Michele Modugno (2015),
"The importance of updating: Evidence from a Brazilian nowcasting model",
OECD Journal: Journal of Business Cycle Measurement and Analysis, Vol. 2015/1.

Nowcasting Brazil



Daniela Bragoli, Luca Metelli and Michele Modugno (2015),
"The importance of updating: Evidence from a Brazilian nowcasting model",
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Nowcasting Brazil

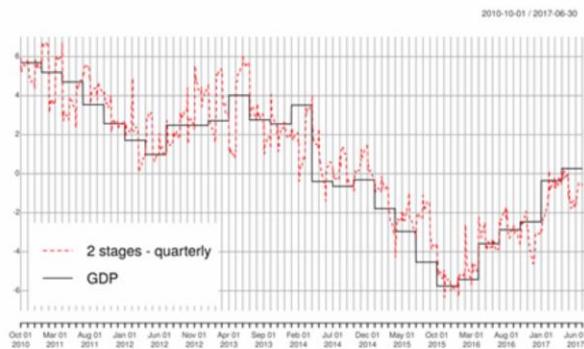
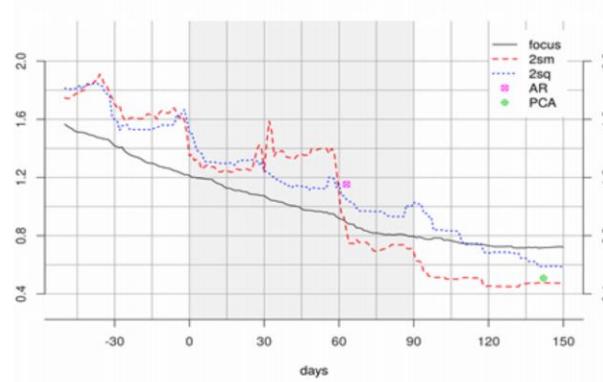


Figure 6: RMSFE: all models comparison



G. Branco Gomes and J. V. Issler

"Nowcasting Brazilian GDP: a performance assessment of dynamic factor models"

Nowcasting Brazil

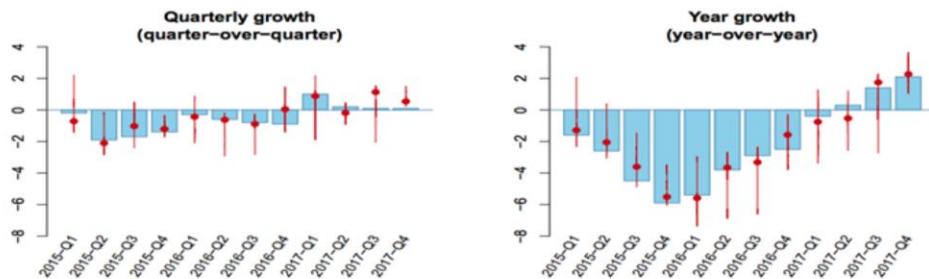


Figure 1: Forecast of Brazilian GDP from 2015-Q1 to 2017-Q4

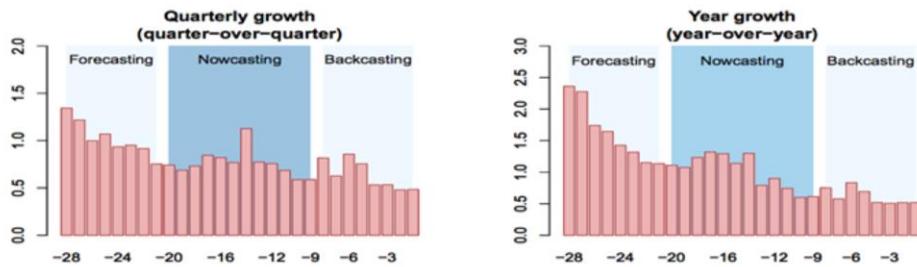


Figure 2: RMSE of forecasts of Brazilian GDP during 28 weeks prior to its release

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

Blogs

- **Just Released: Historical Reconstruction of the New York Fed Staff Nowcast 2002-15** by P. Adams, D. Giannone, E. Qian, and A. Sbordone, Liberty Street Economics (2019)
- **Monitoring Economic Conditions during a Government Shutdown** by P. Adams, D. Giannone, E. Qian, and A. Sbordone, Liberty Street Economics (2019)
- **Opening the Toolbox: The Nowcasting Code on GitHub** by P. Adams, D. Giannone, B. Bok, D. Caratelli, E. Qian, A. Sbordone C. Schneier, and A. Tambalotti, Liberty Street Economics (2018)
- **Just Released: Introducing the New York Fed Staff Nowcast** by G. Aarons, D. Caratelli, D. Giannone, M. Cocci, A. Sbordone and A. Tambalotti, Liberty Street Economics (2016)

Other Materials

- **Macroeconomic Nowcasting and Forecasting with Big Data**
by B. Bok, D. Caratelli, D. Giannone, A. Sbordone and A. Tambalotti
Annual Review of Economics (2018)
- **New York Fed Staff Nowcasting Report**
(updated every Friday at 11:15 a.m. EST)