# Nowcasting techniques

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Centro Studi
CONFINDUSTRIA

# Outline

# Introduction: Nowcasting

**The Nowcasting problem**

What's the state of the business cycle?

First attempt by Burns and Mitchell, pioneers in business cycle analysis at the National Bureau of Economic Research (NBER) in the late 1930s.

They "*attacked their investigation as a big data problem: they scrutinized hundreds of data series in search for patterns and regularities. What they uncovered was a* ***systematic co-movement among the series*** *and pervasiveness of fluctuations across different sectors and different kinds of economic activities*".

"Macroeconomic Nowcasting and Forecasting with Big Data", Brandyn Bok, Daniele Caratelli, Domenico Giannone, Argia Sbordone, and Andrea Tambalotti, Federal Reserve Bank of New York Staff Reports, no. 830, November 2017

# Introduction: Nowcasting

Long tradition on indexes of economic activity such as the leading and coincident indicator indexes (OECD, The Conference Board, ...)

Mainly based on Stock and Watson (1989), see Marcellino (2006) for a review.

Stock, James H. and Mark W. Watson, "New Indexes of Coincident and Leading Economic Indicators," in NBER Macroeconomics Annual 1989, Volume 4" NBER Chapters, 1989, pp. 351-409; Marcellino, Massimiliano, Chapter 16 Leading Indicators," Handbook of Economic Forecasting, 2006, 1, 879-960.

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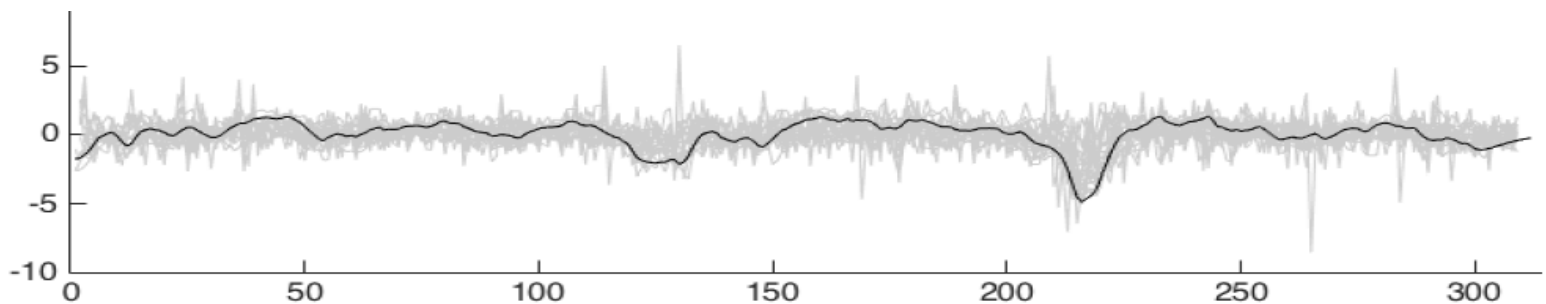
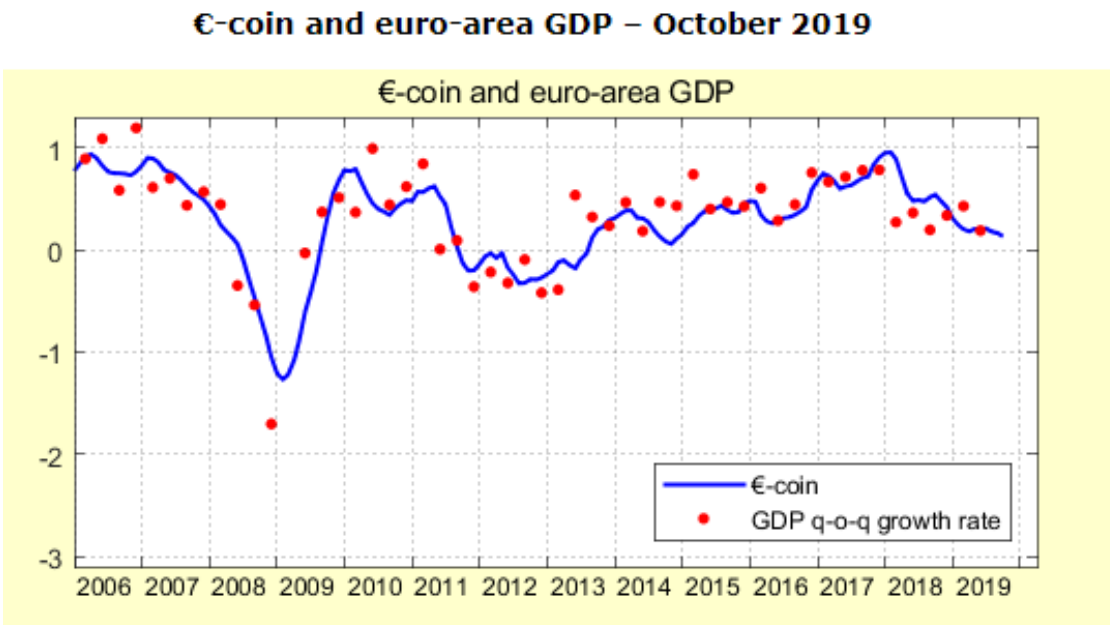
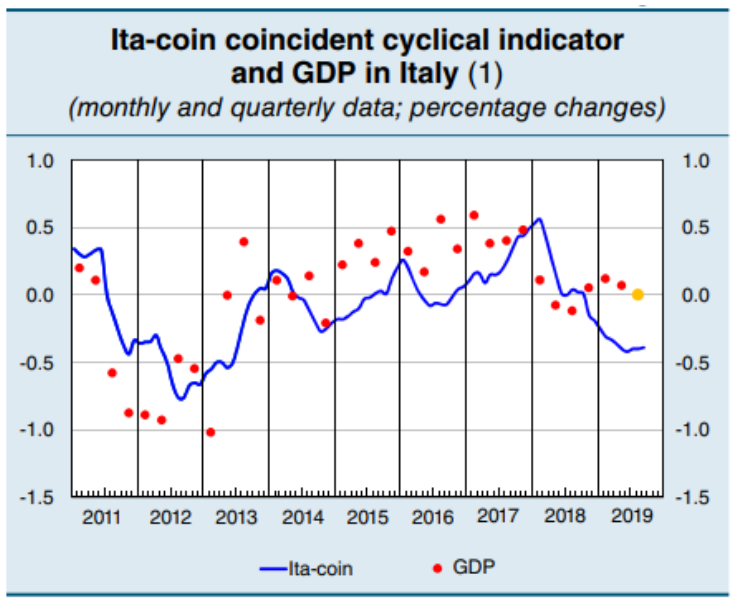


# Examples: factor models in central banks

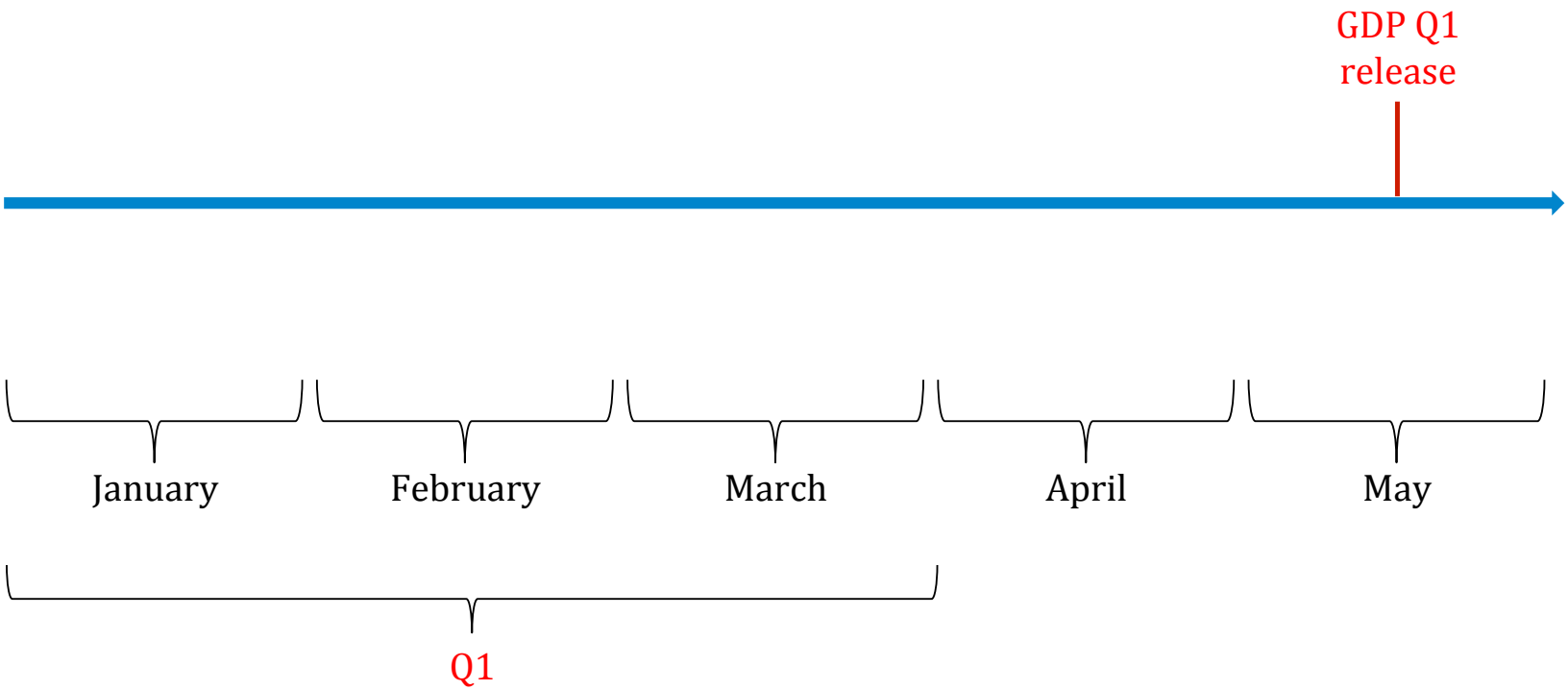



Sources: Bank of Italy and Istat.

The modelling framework is in Altissimo et al. (2010), "New Eurocoin: Tracking economic growth in real time", The Review of Economics and Statistics, No. 92, 1024-1034; Aprigliano, V. and Bencivelli, L. (2013); Ita-coin: a new coincident indicator for the Italian economy. Bank of Italy Temi di Discussione (Working Paper) No, 935.]

# Introduction: The data flow



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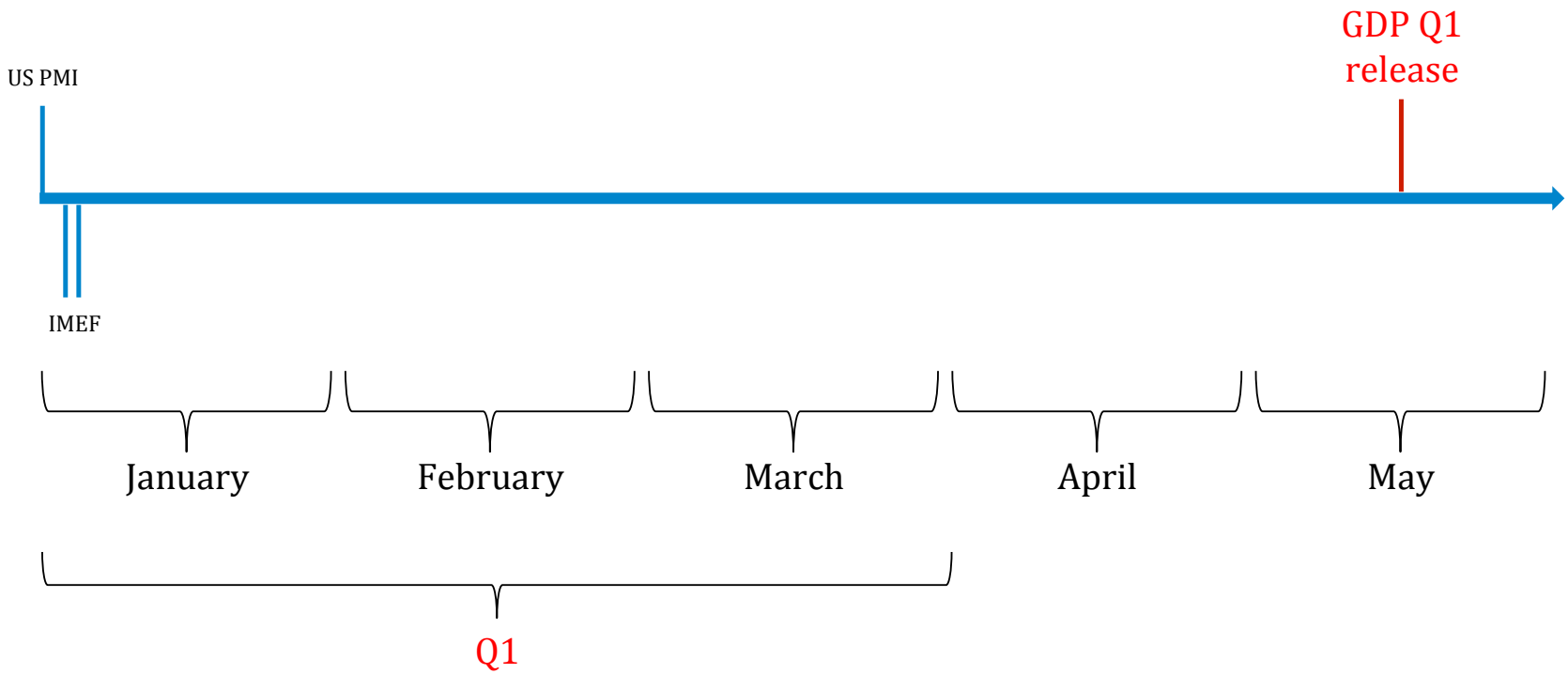

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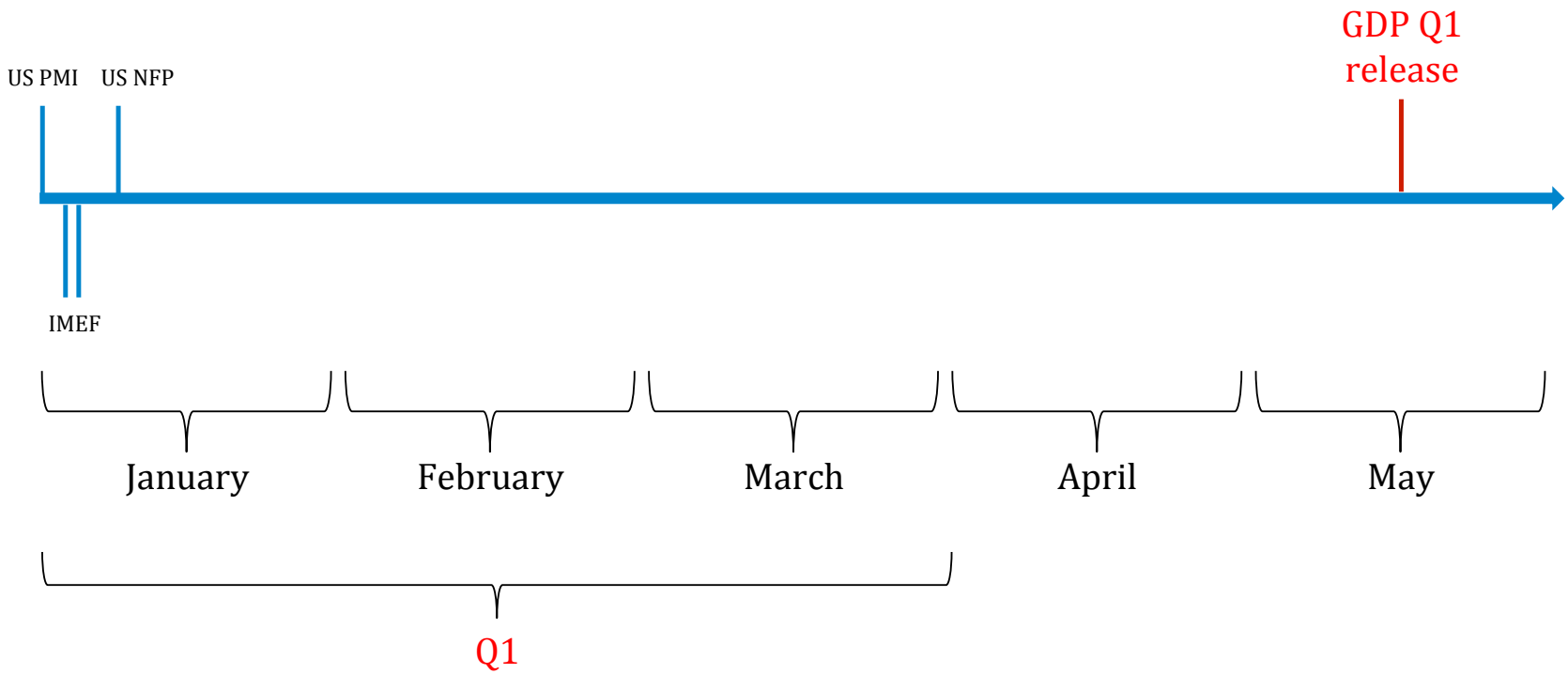

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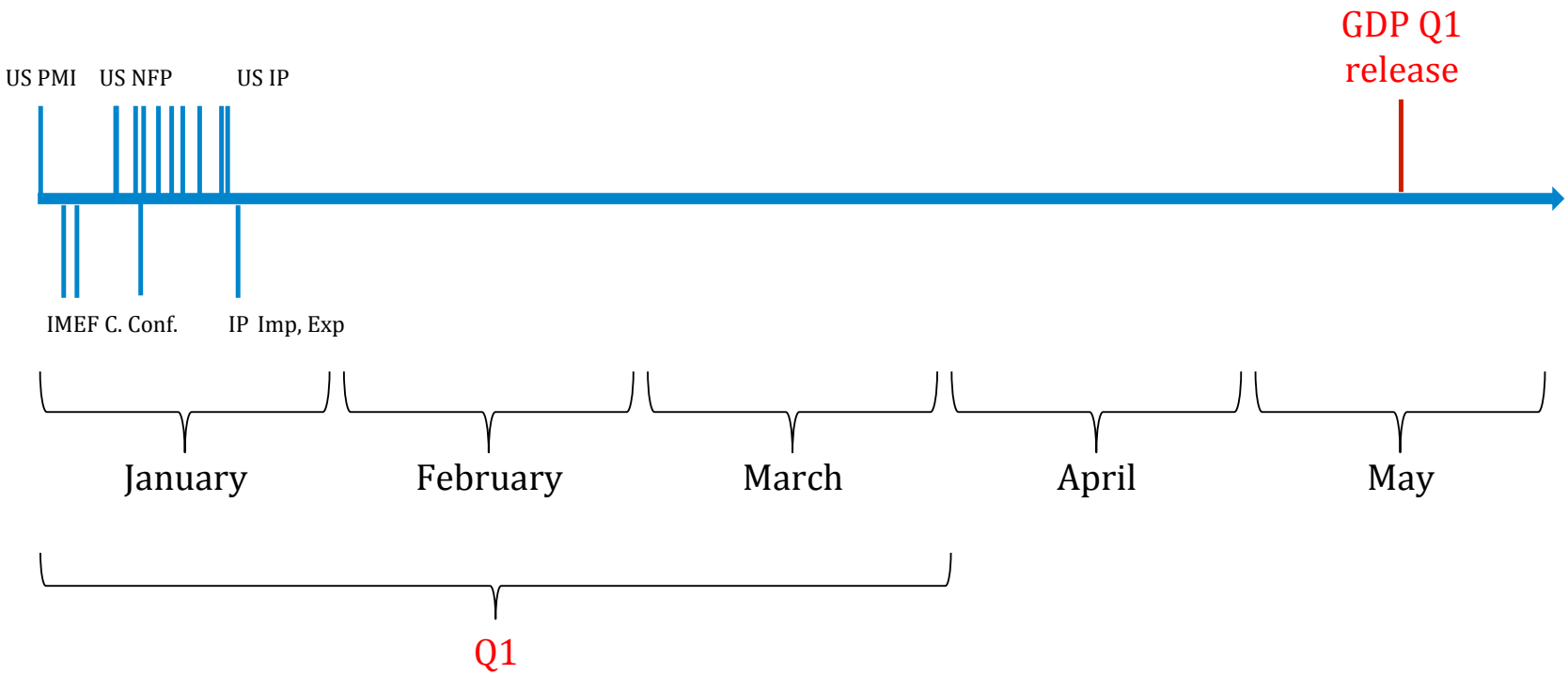

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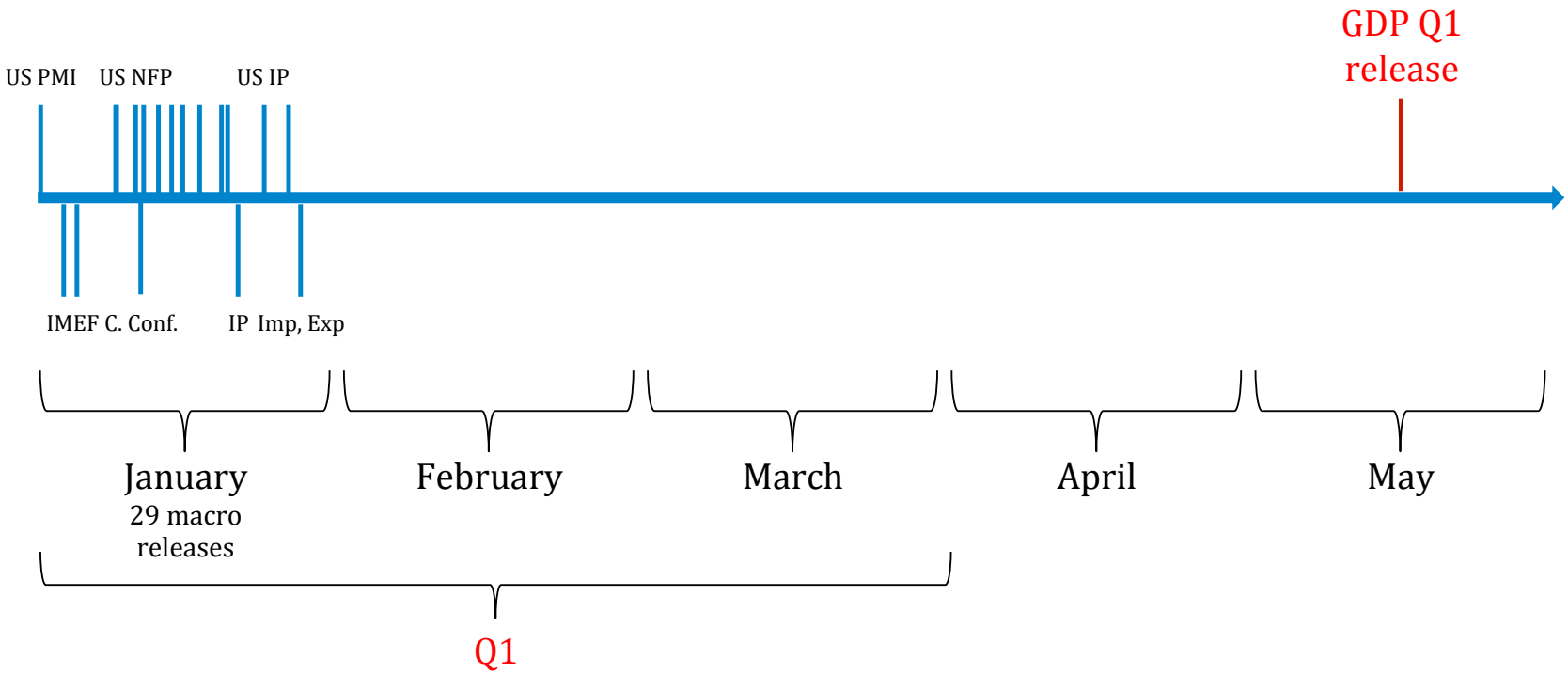

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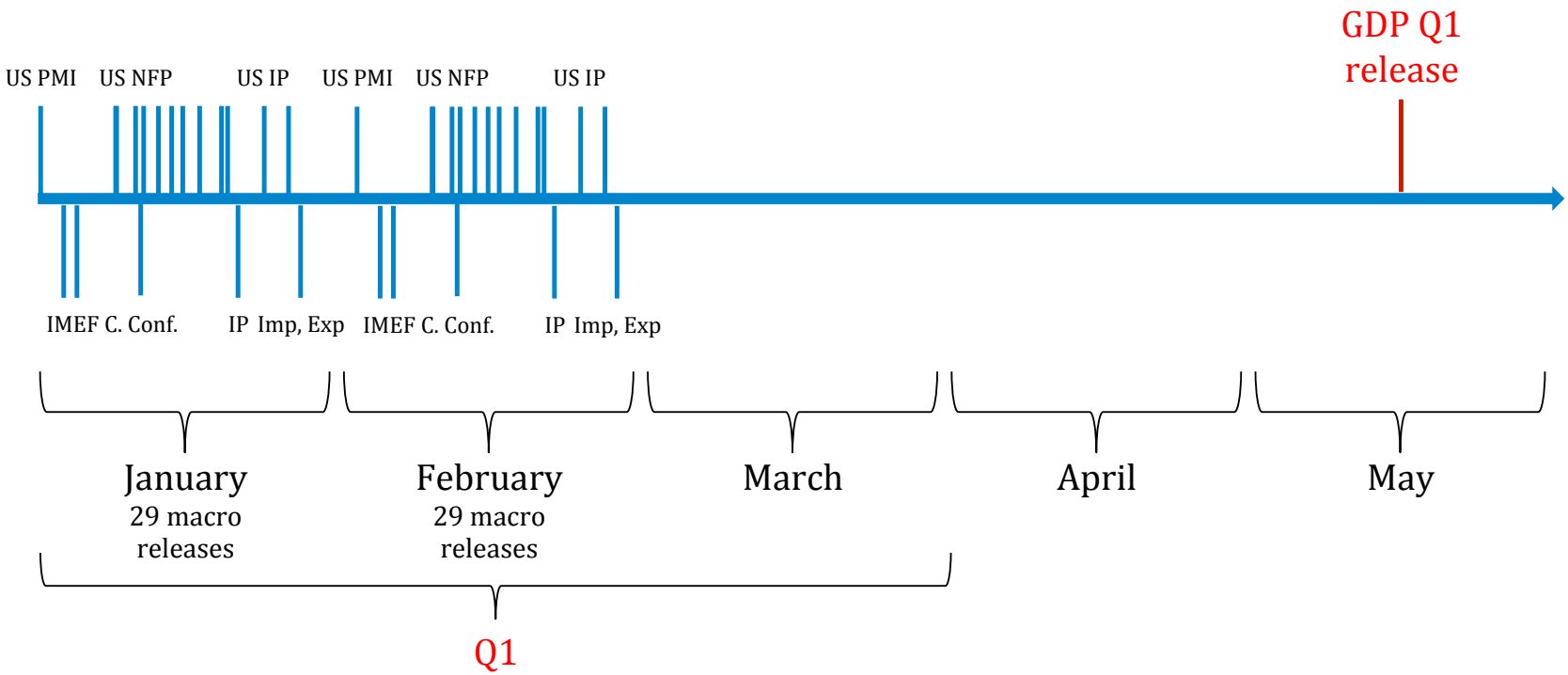

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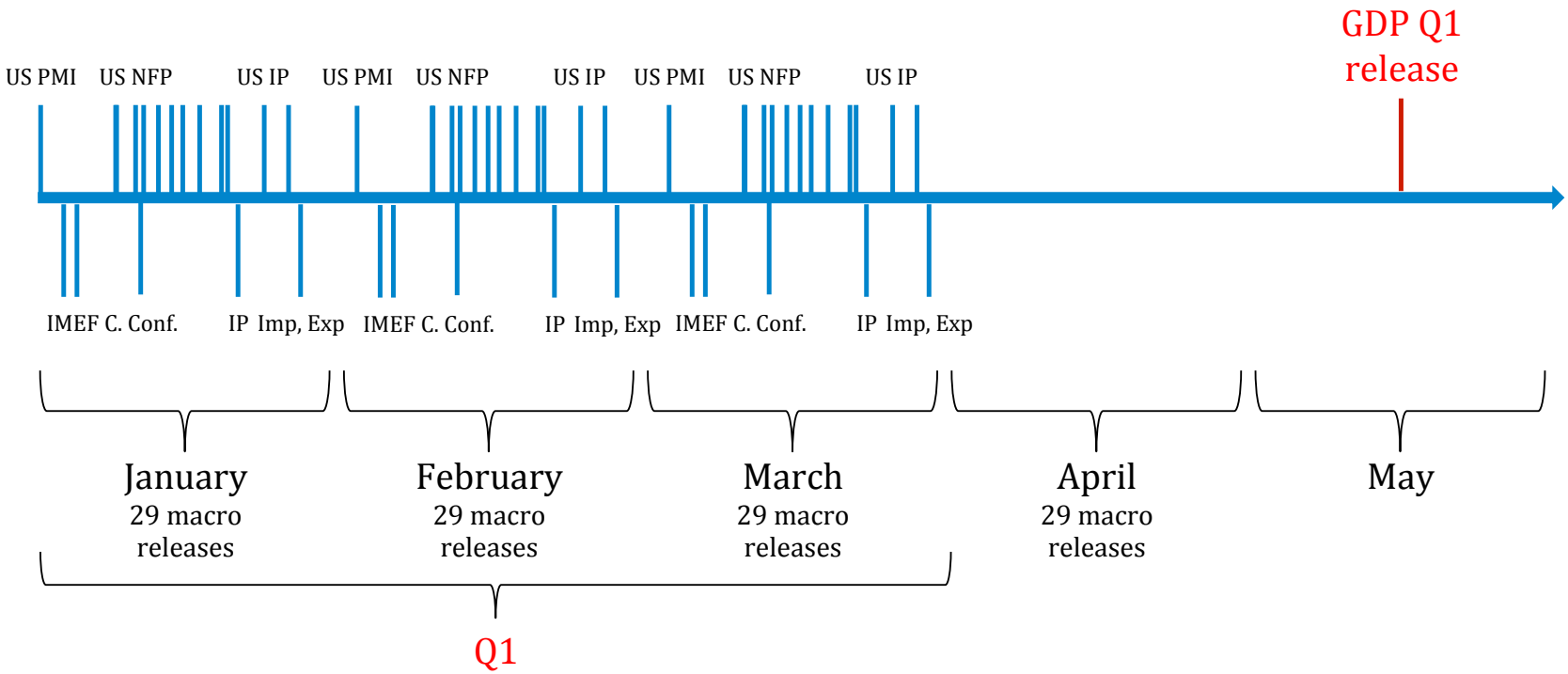

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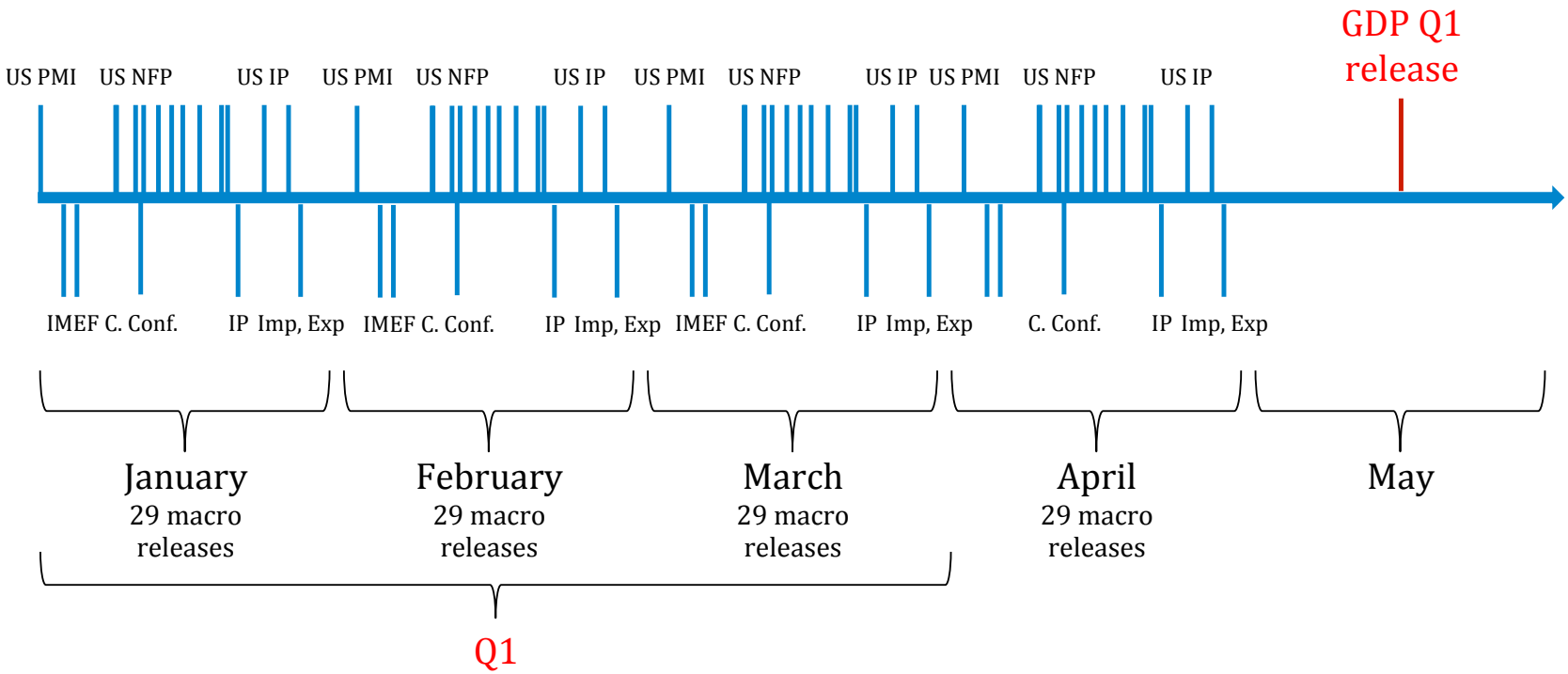

# Introduction: The ragged edge

| **23-Nov** | Employment | Retail Sales | PMI | Nonfarm Payrolls |
|---|---|---|---|---|
| May | X | X | X | X |
| June | X | X | X | X |
| July | X | X | X | X |
| August | X | X | X | X |
| September | X | X | X | X |
| October | X | X | X | X |
| November | NaN | NaN | NaN | NaN |
| December | NaN | NaN | NaN | NaN |

# Introduction: The ragged edge

| **30-Nov** | Employment | Retail Sales | PMI | Nonfarm Payrolls |
|---|---|---|---|---|
| May | X | X | X | X |
| June | X | X | X | X |
| July | X | X | X | X |
| August | X | X | X | X |
| September | X | X | X | X |
| October | X | X | X | X |
| November | NaN | NaN | X | NaN |
| December | NaN | NaN | NaN | NaN |

# Introduction: The ragged edge

| **05-Dec** | Employment | Retail Sales | PMI | Nonfarm Payrolls |
|---|---|---|---|---|
| May | X | X | X | X |
| June | X | X | X | X |
| July | X | X | X | X |
| August | X | X | X | X |
| September | X | X | X | X |
| October | X | X | X | X |
| November | X | NaN | X | NaN |
| December | NaN | NaN | NaN | NaN |

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| **07-Dec** | Employment | Retail Sales | PMI | Nonfarm Payrolls |
|---|---|---|---|---|
| May | X | X | X | X |
| June | X | X | X | X |
| July | X | X | X | X |
| August | X | X | X | X |
| September | X | X | X | X |
| October | X | X | X | X |
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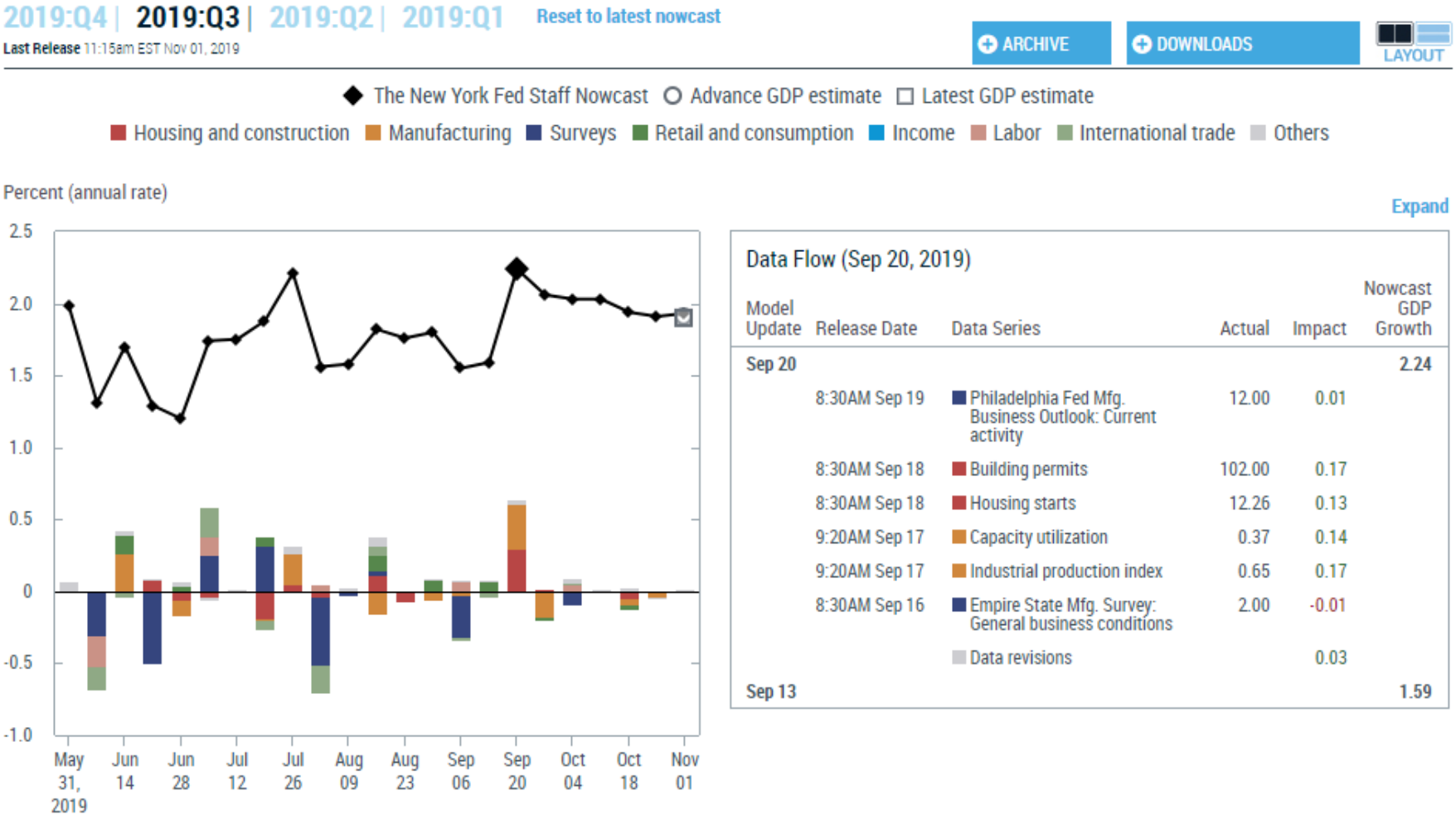
See Giannone, Reichlin and Small (2008), Doz et al. (2011, 2012), Banbura and Modugno (2014), Banbura et al. (2013).

# Examples: the New York Fed experience




[The modelling framework of the NY Fed Staff is the same that I have used for Mexico]

# Nowcasting: applications

**Examples in the literature** (in "Macroeconomic Nowcasting and Forecasting with Big Data", Brandyn Bok, Daniele Caratelli, Domenico Giannone, Argia Sbordone, and Andrea Tambalotti, Federal Reserve Bank of New York Staff Reports, no. 830, November 2017)

See Giannone et al. (2008), Banbura et al. (2012), Lahiri and Monokroussos (2013), and Liebermann (2014) for nowcasting the United States; Angelini et al. (2011) and Banbura et al. (2011) for the aggregate euro area economy alongside Runstler et al. (2009) for individual member countries; and Bragoli (2017) for Japan. See Chernis and Sekkel (2017) for Canada; Aastveit and Trovik (2012) and Luciani and Ricci (2014) for Norway; Matheson (2010) for New Zealand; and Anesti et al. (2017) for the UK. See Dahlhaus et al. (2015) for BRIC countries and Mexico; Bragoli et al. (2015) for Brazil; Bragoli and Fosten (2016) for India; Yiu and Chow (2010) for China; Caruso (2015) for Mexico; Luciani et al. (2017) for Indonesia; and Kabundi et al. (2016) for South Africa.

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# Alternative models and extensions

It is also possible to use VAR, or better BVAR (Sims, 1980; Doan et al., 1984), connected with factor models and suitable for the analysis of big data (De Mol et al., 2008; Banbura et al., 2010).

For a recent survey of BVAR, see Karlsson (2013) and Koop (2017).

BVARs are also suitable for nowcasting: they can be cast in a state-space form allowing for conveniently handling data in real time using filtering techniques, in the same way described for the factor model.

Extensions:

- Heterogeneity in the lead-lag relationships (D'Agostino et al., 2016)
- Time-varying parameters (Kim and Nelson, 2001)
- Time varying volatility (Marcellino et al., 2016)
- Time variation in the intercept (Antolin-Diaz et al., 2017)

# Outline

# Nowcasting: DFM and dimensionality reduction

$$x_t = \mu + \Lambda f_t + \epsilon_t \tag{1}$$

$$f_t = A_t f_{t-1} + ... + A_p f_{t-p} + u_t;\ u_t\ i.i.d. \sim \mathcal{N}(0, Q) \tag{2}$$

- $x_t$: vector of standardized stationary monthly variables
- $f_t$: unobserved common factors following a $VAR(p)$
- $\Lambda$: factor loadings
- $\epsilon_t$: vector of idiosyncratic components following an $AR(1)$

# Nowcasting

Mixed frequency:

Quarterly variables are modelled as monthly variables with periodically missing values; see the approximation of Mariano and Murosawa (2003). We can assume that the unobserved MoM GDP growth rate has the same FM representation as the monthly variables.

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Estimation:

Maximum Likelihood: allows for autocorr. of idio. and restrictions, consistent and feasible even in case of an approximate factor model (Doz et al., 2012) and can cope with missing data and ragged edge (Banbura and Modugno, 2014).

# Nowcasting: Estimation

EM algorithm

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- Maximization step: parameters are estimated maximizing the expected log-likelihood
- Repeat up to convergence

# Outline

# Reference

Caruso, A. (2018). Nowcasting with the help of foreign indicators: The case of Mexico. Economic Modelling, 69, 160-168.

# Outline

# Data

How do I choose the variables?

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- Bloomberg calendar
- Reports from statistical office and central bank
- Media

# Nowcasting Mexican GDP

Objectives

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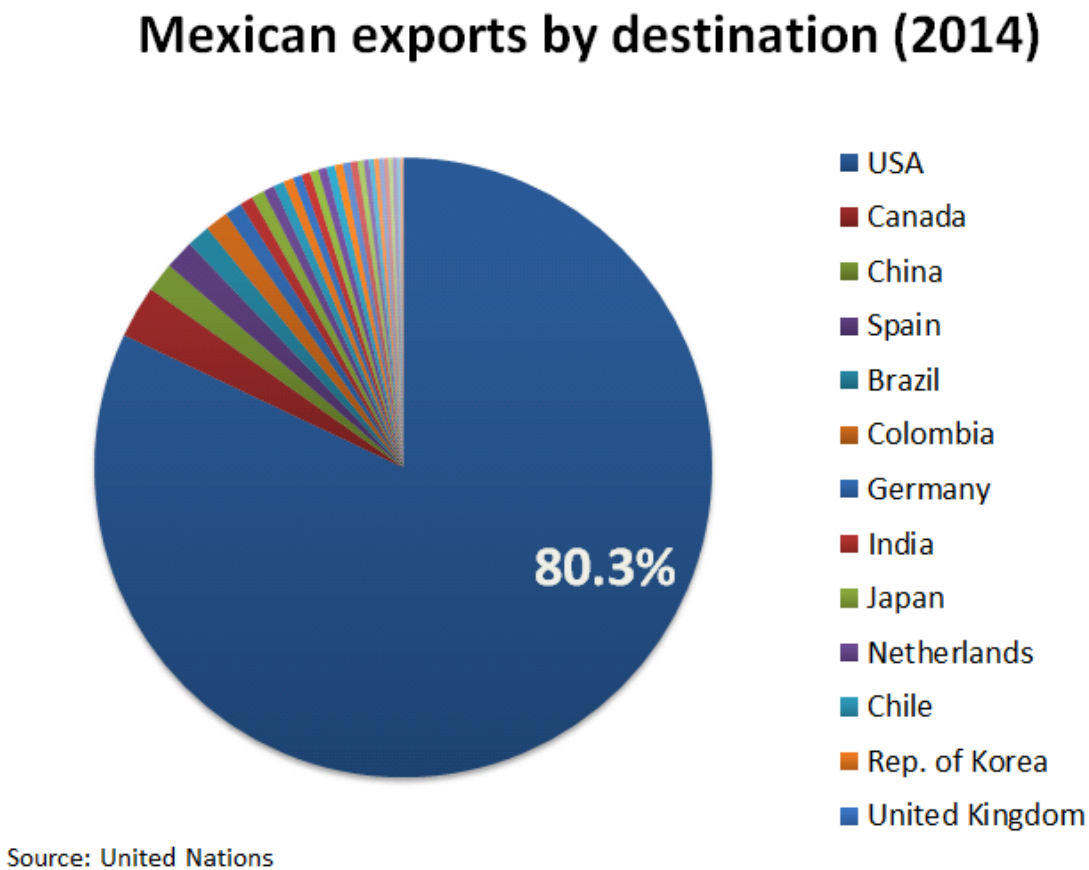
- To jointly analyse those data in a nowcasting model that is continuously updated as new data get released.
- To evaluate the relative importance of Mexican and US releases.

# Introduction



# Literature

On Mexico/US relationships:

- Evidence of synchronization of US and Mexican business cycles: Torres and Vela (2003), Hernandez (2004) and Mejía-Reyes and Campos-Chávez (2011)
- Impact of NAFTA: Cuevas et al. (2002), Kose et al. (2004), Chiquiar and Ramos-Francia (2005), Bayoumi and Swiston (2008) Miles and Vijverberg (2011)
- Spillovers from the US: Sosa (2008), documenting the major role of US IP and of indicators about the automotive sector.

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On forecasting/nowcasting Mexican GDP:

- Coutino (2005): PC and macro model, no OOS evaluation
- Liu et al. (2012): DFM, find no improvements using external data
- Guerrero et al. (2013): VAR model for back-casting (15gg lag)

# Data: The Variables

| | Series | Source | Start date | Unit | Transf. | Lag |
|---|---|---|---|---|---|---|
| Mexico | IMEF Bus.Clim. Index: Mfg | IIEEM | Jan-04 | INDEX | Level | 3 |
| Mexico | IMEF Bus.Clim. Index: Nonmfg | IIEEM | Jan-04 | INDEX | Level | 3 |
| Mexico | Consumer Confidence | INEGI | Apr-01 | INDEX | Level | 4 |
| Mexico | Producer Confidence Index | INEGI | Jan-04 | Units | YoY | 4 |
| Mexico | Opinion Survey: Mfg. Orders | INEGI | Jan-04 | INDEX | Level | 4 |
| Mexico | Total Vehicle Production | AMIA | Jan-91 | Units | YoY | 10 |
| Mexico | Industrial Production | INEGI | Jan-91 | INDEX | MoM | 13 |
| Mexico | Total Vehicle Exports | AMIA | Jan-91 | Units | YoY | 13 |
| Mexico | Unemployment Rate | INEGI | Apr-00 | % | M diff | 22 |
| Mexico | Petroleum Exports: Crude | INEGI | Jan-91 | US$ | MoM | 24 |
| Mexico | Imports | INEGI | Jan-91 | US$ | MoM | 24 |
| Mexico | Exports | INEGI | Jan-91 | US$ | MoM | 24 |
| Mexico | Production of Crude Petroleum | INEGI | Jan-91 | Units | MoM | 26 |
| Mexico | Automobile Sales | AMIA | Jan-91 | Units | MoM | 37 |
| Mexico | Truck Sales: Total | AMIA | Jan-95 | Units | YoY | 37 |
| Mexico | Retail Sales | INEGI | Jan-94 | INDEX | MoM | 52 |
| Mexico | Gross Domestic Product | INEGI | Jan-91 | Mil.Pesos | QoQ | 55 |
| Mexico | Trade Balance: United States | INEGI | Jan-93 | US$ | YoY | 57 |
| US | UoM: Cons. Sentiment | Un. of Mich. | Jan-91 | INDEX | Level | -3 |
| US | Conference Board: Cons. Conf. | CB | Jan-91 | INDEX | Level | -3 |
| US | ISM Mfg: PMI Composite Index | ISM | Jan-91 | INDEX | Level | 1 |
| US | Employees on Nonfarm Payrolls | BLS | Jan-91 | Units | M diff | 5 |
| US | Retail Sales | CENSUS | Jan-91 | US$ | MoM | 13 |
| US | Industrial Production | FRB | Jan-91 | INDEX | MoM | 16 |
| US | Capacity Utilization | FRB | Jan-91 | % | M diff | 16 |
| US | Housing Starts | CENSUS | Jan-91 | Units | MoM | 18 |
| US | Wholesalers: Sales: Automotive | CENSUS | Jan-92 | US$ | MoM | 40 |
| US | Car Imports | CENSUS | Jan-91 | US$ | YoY | 41 |
| US | Truck Imports | CENSUS | Jan-91 | US$ | YoY | 41 |

# Data: Example of the calendar (May 2013)

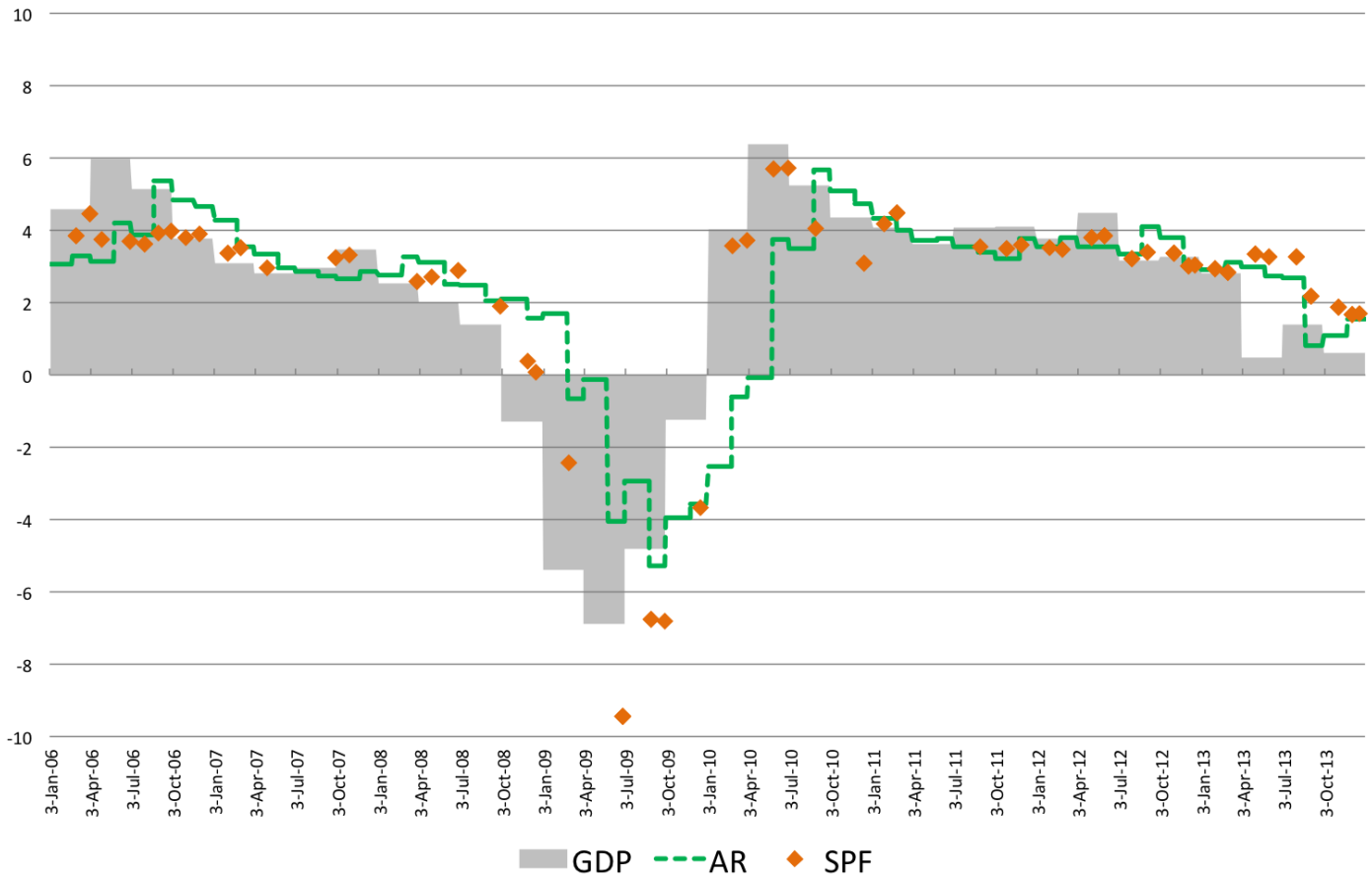
| Date | Country | Series | Average delay | Ref. Period | Bloomberg relevance |
|---|---|---|---|---|---|
| 01-May | US | ISM Mfg: PMI Composite Index | 1 | April | 94.7 |
| 02-May | Mexico | IMEF Index: Mfg | 3 | April | 17.5 |
| 02-May | Mexico | IMEF Index: Nonmfg | 3 | April | 12.5 |
| 02-May | US | Car Imports | 41 | March | |
| 02-May | US | Truck Imports | 41 | March | |
| 03-May | Mexico | Producer Confidence Index | 4 | April | |
| 03-May | Mexico | Manufacturing Orders | 4 | April | |
| 03-May | US | Employees on Nonfarm Payrolls | 5 | April | 99.1 |
| 06-May | Mexico | Consumer Confidence | 4 | April | 82.5 |
| 07-May | Mexico | Total Vehicle Production | 10 | April | 37.5 |
| 07-May | Mexico | Total Vehicle Exports | 13 | April | 30 |
| 08-May | Mexico | Automobile Sales | 37 | March | |
| 08-May | Mexico | Truck Sales | 37 | March | |
| 09-May | US | Automobile Sales | 40 | March | |
| 10-May | Mexico | Industrial Production | 43 | March | 92.5 |
| 13-May | US | Retail Sales | 13 | April | 89.4 |
| 15-May | US | Industrial Production | 16 | April | 86.7 |
| 15-May | US | Capacity Utilization | 16 | April | 60.71 |
| 16-May | US | Housing Starts | 18 | April | 88.5 |
| 24-May | Mexico | Unemployment rate | 22 | March | 77.5 |
| 22-May | Mexico | Retail Sales | 52 | March | 80 |
| 23-May | Mexico | Gross Domestic Product | 55 | 2013 Q1 | 87.5 |
| 26-May | Mexico | Imports | 24 | April | 75* |
| 26-May | Mexico | Exports | 24 | April | 75* |
| 26-May | Mexico | Trade Balance: United States | 57 | March | |
| 26-May | Mexico | Oil Exports | 24 | April | |
| 26-May | Mexico | Oil Production | 26 | April | |
| 28-May | US | Consumer Confidence | -3 | May | 95.6 |
| 31-May | US | Univ. of Michigan: Cons. Sentiment | -3 | May | 92.9 |

# Outline

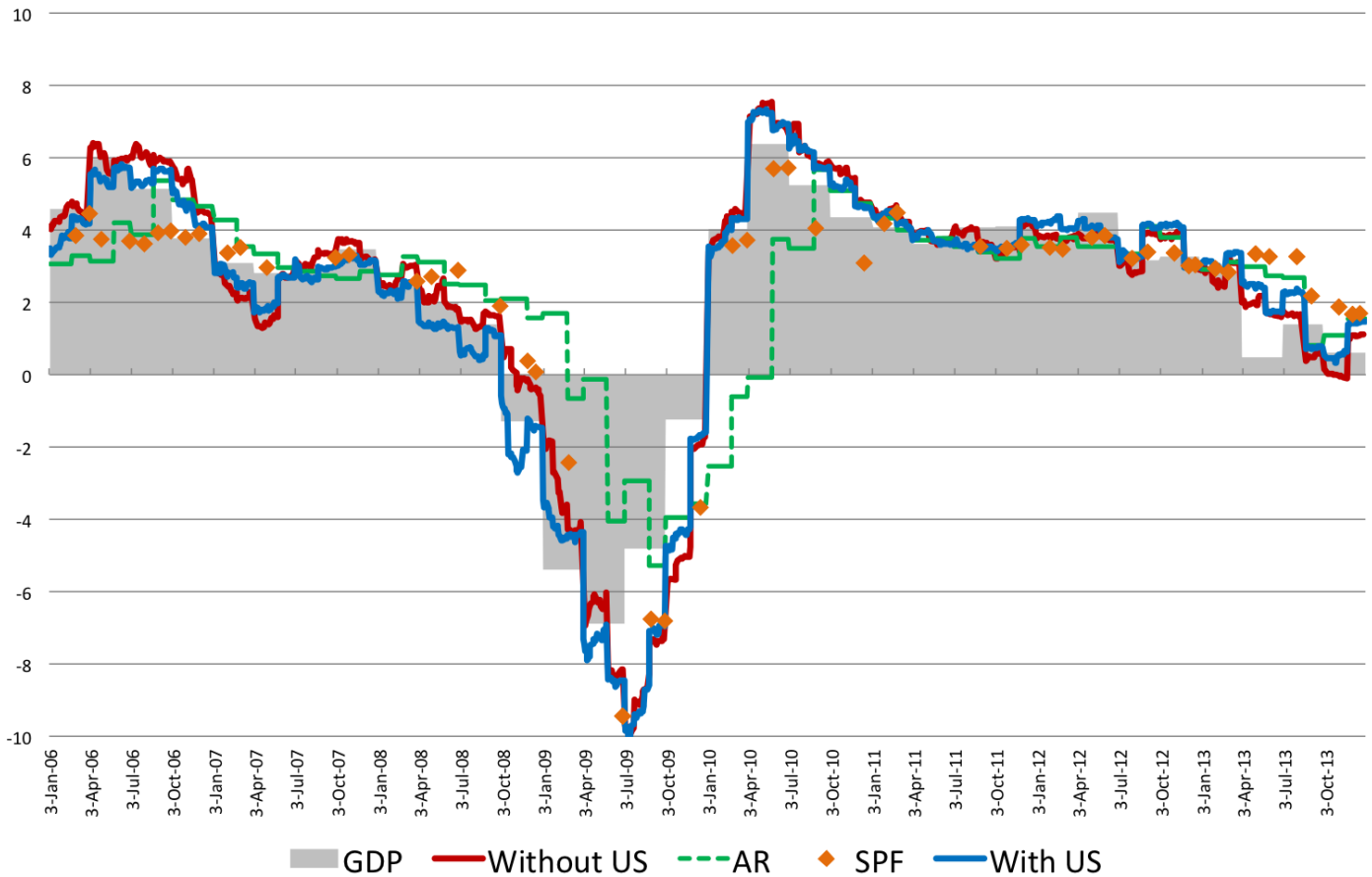
# OOS Evaluation

- Pseudo out-of-sample exercise (reconstructing the calendar)
- Estimation starts in 1991
- Evaluation period: 2006Q1 - 2013Q4
- 1 factor, 2 lags (results are robust to changes in the specification)

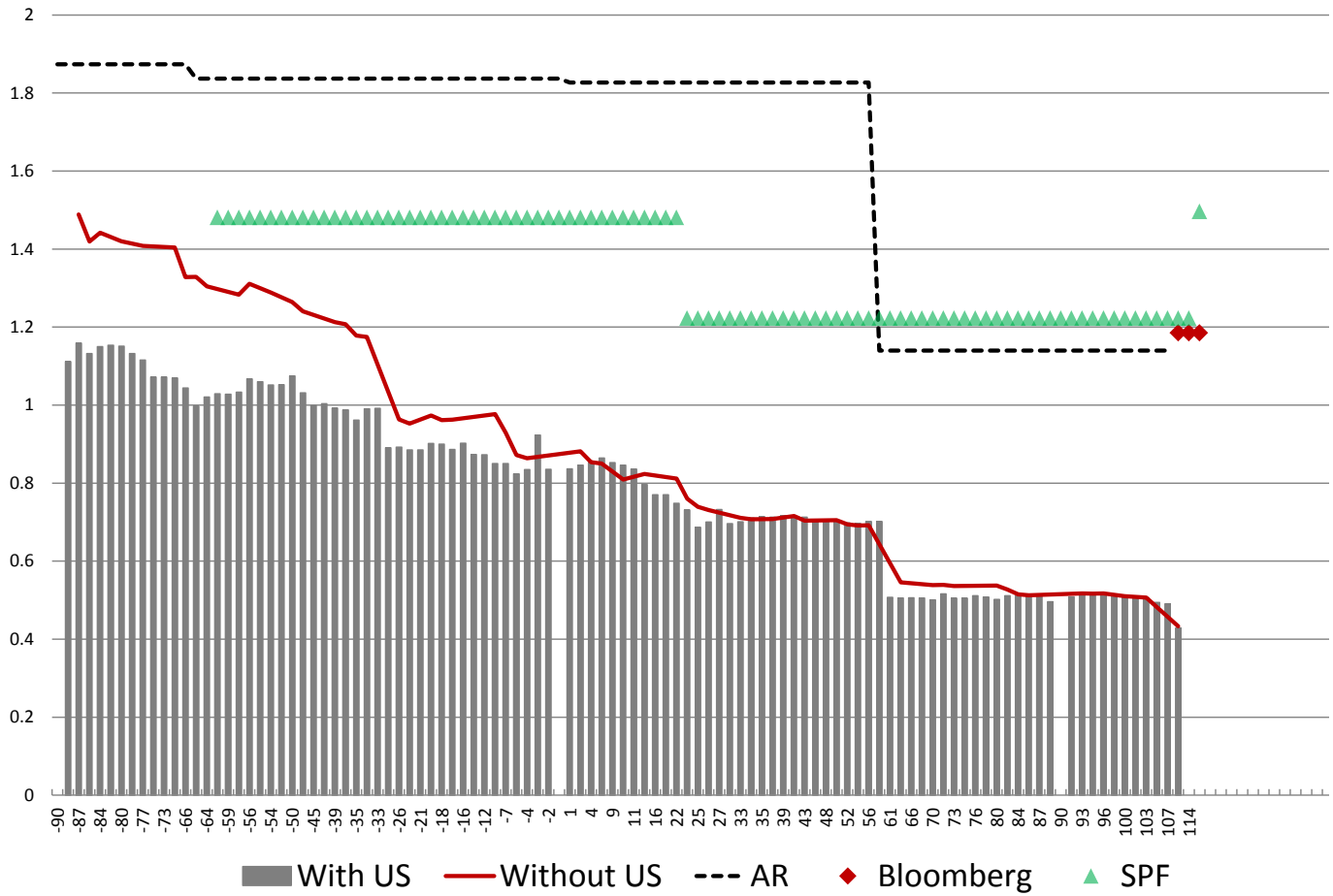
# OOS Evaluation: YoY



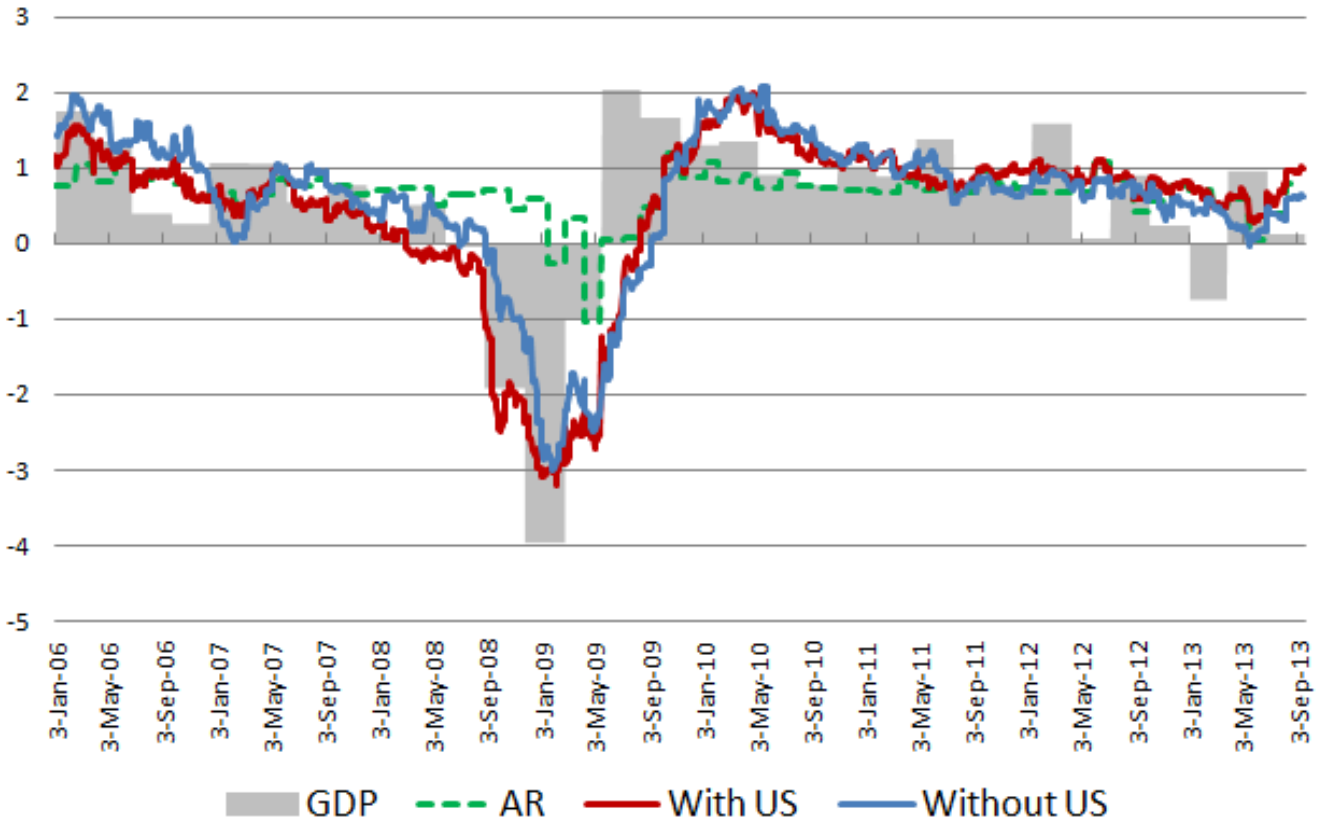
# OOS Evaluation: YoY



# OOS Evaluation: RMSFE YoY



# OOS Evaluation: QoQ



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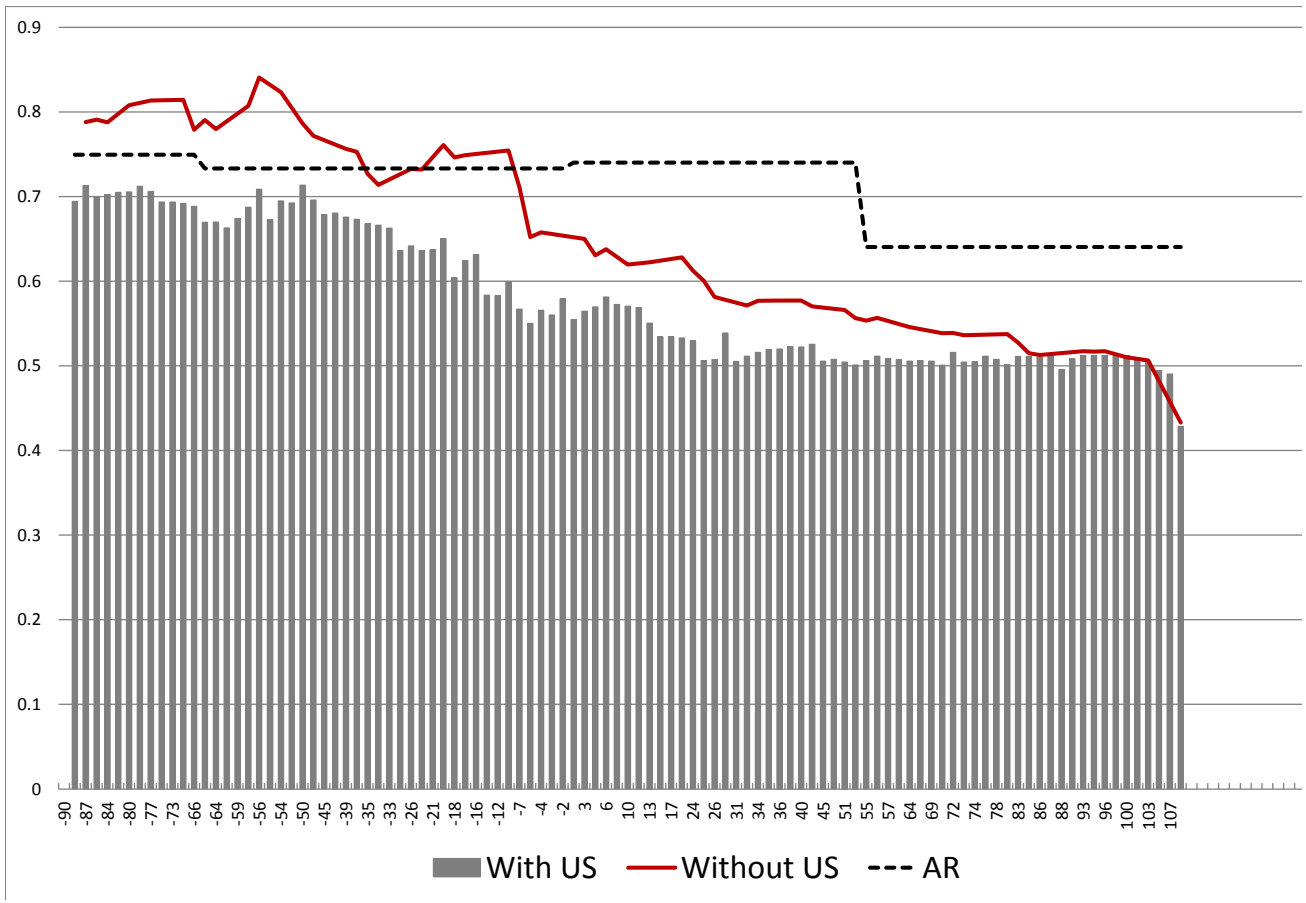
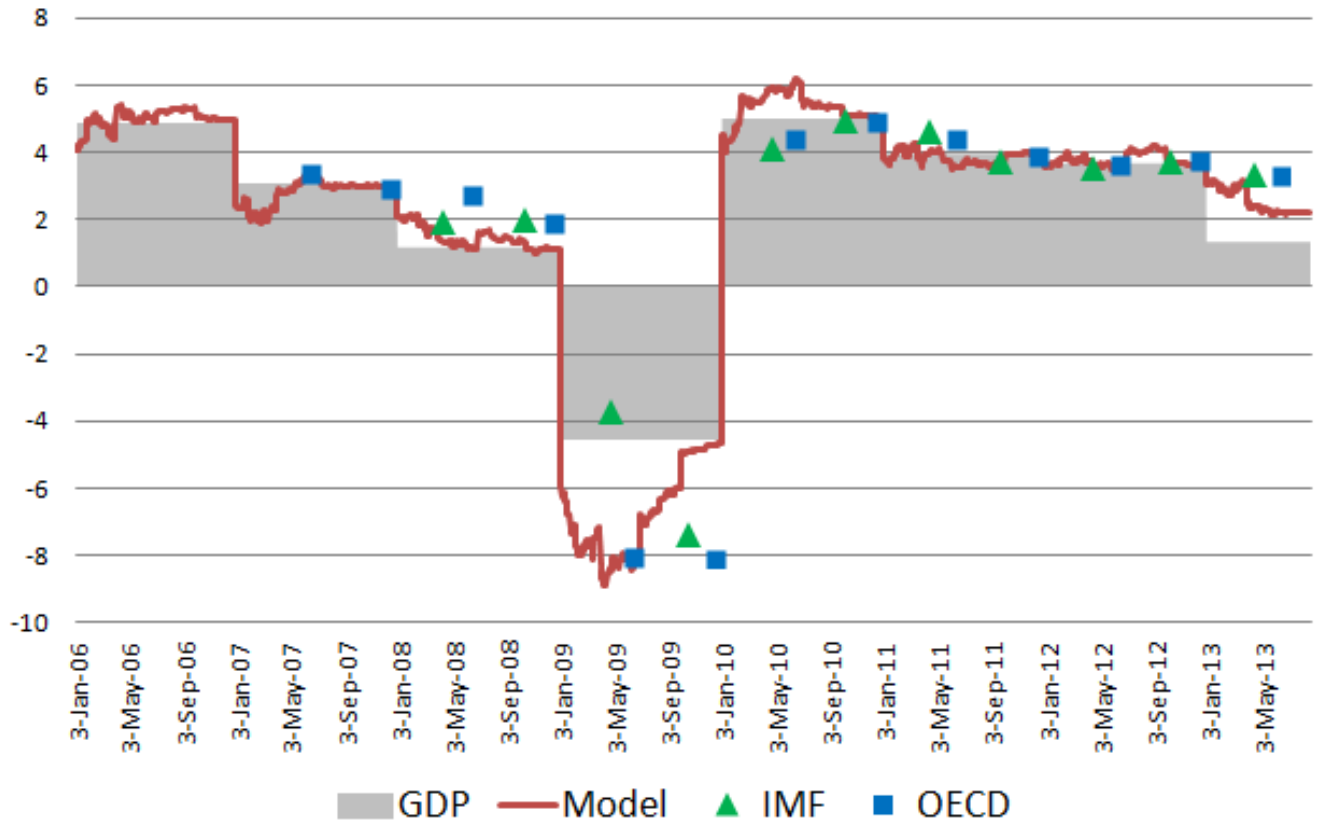


# OOS Evaluation: Calendar year



| | DM stat | Backcast | Nowcast | Forecast |
|---|---|---|---|---|
| QoQ | Mex vs (Mex+US) | 0.479 | 2.048 | 1.693 |
| | AR vs (Mex+US) | 1.262 | 1.783 | 0.912 |
| | AR vs Mex | 1.299 | 1.541 | 0.256 |
| YoY | Mex vs (Mex+US) | 0.479 | 1.496 | 1.971 |
| | AR vs (Mex+US) | 2.271 | 3.403 | 3.379 |
| | AR vs Mex | 2.267 | 3.354 | 3.231 |
| | SPF vs Mex | | 3.497 | 2.490 |
| | SPF vs (Mex+US) | | 4.212 | 2.630 |

In the table the results of a Diebold-Mariano (1995) test of equal predictive accuracy. The model written as the second is the one whose forecast are tested to be more accurate in the alternative hypothesis (e.g.: A vs B, $H_1$ is that forecasts from B are more accurate than forecasts from A). "Mex" refers to the model with just Mexican variables; "Mex+US" to the model with all the variables; "AR" to the AR(1); "SPF" to the survey of professional forecasters (Bank of Mexico).

# News analysis

Let $y_t^Q$ be the GDP at time $t$, and $\Omega_\nu$ the information set at time $\nu$, where $\nu$ is a vintage of data. The nowcast is the projection of $y_t^Q$ using the available data, $\mathbb{E}[y_t^Q|\Omega_\nu]$. At any release, the information set expands : $\Omega_\nu \subset \Omega_{\nu+1}$, and it is possible to decompose the new forecast in:

$$\underbrace{\mathbb{E}[y_t^Q|\Omega_{\nu+1}]}_{\text{new forecast}} = \underbrace{\mathbb{E}[y_t^Q|\Omega_\nu]}_{\text{old forecast}} + \underbrace{\mathbb{E}[y_t^Q|I_{\nu+1}]}_{\textit{revision}}$$

Where $I_{\nu+1}$ is the information in $\Omega_{\nu+1}$ orthogonal to $\Omega_\nu$. Express the revision as:

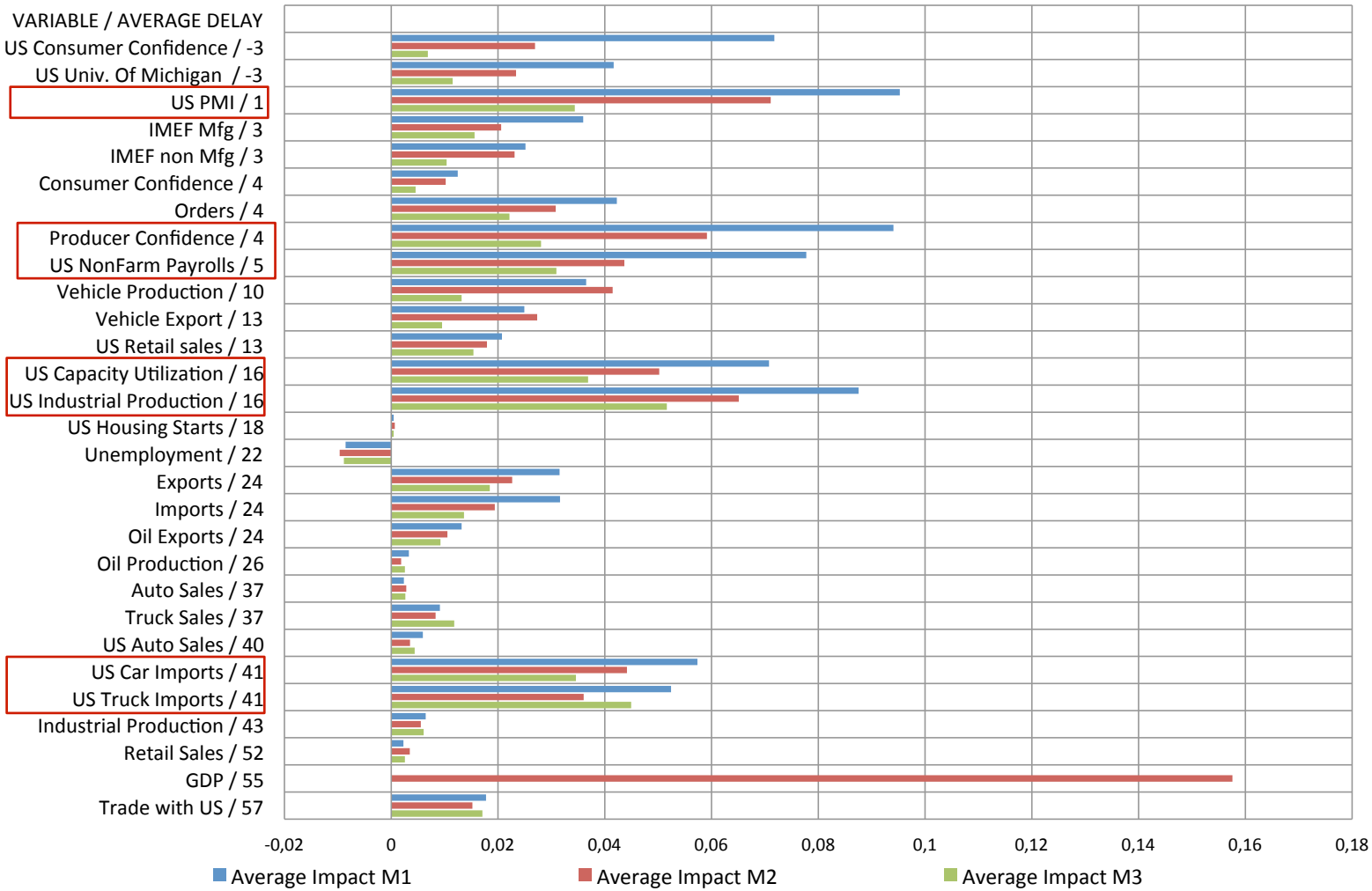
$$\underbrace{\mathbb{E}[y_t^Q|\Omega_{\nu+1}] - \mathbb{E}[y_t^Q|\Omega_\nu]}_{\textit{revision}} = \sum_{j \in J_{\nu+1}} b_{j,t,\nu_+1} \underbrace{(x_{i_j,t_j} - \mathbb{E}[(x_{i_j,t_j}|\Omega_\nu)]}_{\textit{news}}$$

# News analysis

We can use this analysis to evaluate the average contribution of any release of interest.

In the present work, the analysis can be used to evaluate the average impact of US variables.

# News analysis



# Conclusions

## Contributions

- I reconstruct the data flow monitored by the markets and use it in a model useful to nowcast Mexican GDP
- The model produces forecasts whose accuracy is similar to that of institutional and judgemental forecasts
- I document the importance of US variables to assess Mexican economic conditions