

UNCERTAIN KINGDOM: A FRAMEWORK FOR NOWCASTING GDP AND ITS REVISIONS

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WITH

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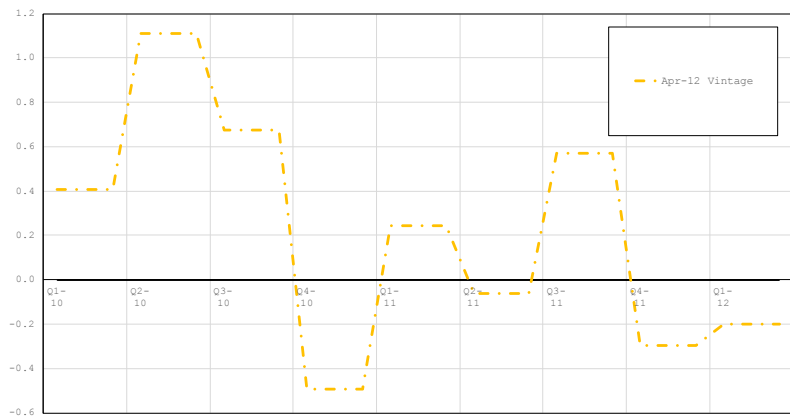
³WARWICK BUSINESS SCHOOL

NOWCASTING AND BIG DATA WORKSHOP
BCRA, BUENOS AIRES – NOVEMBER 24, 2017

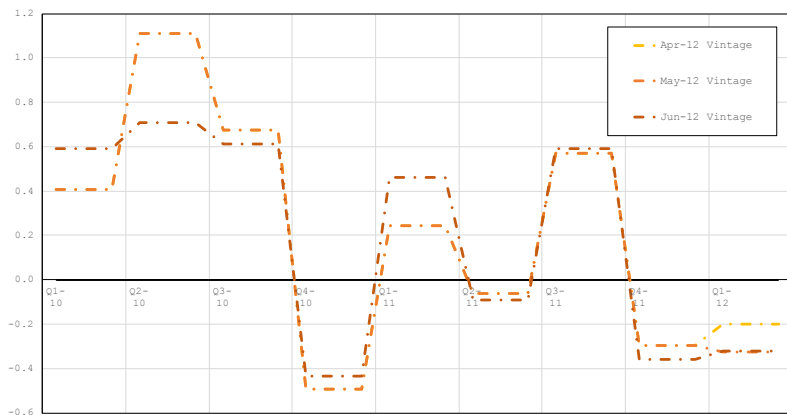
[▷]

The views expressed are those of the authors and do not necessarily reflect those of the Bank of England, the Monetary Policy Committee, the Financial Policy Committee or the Prudential Regulation Authority.

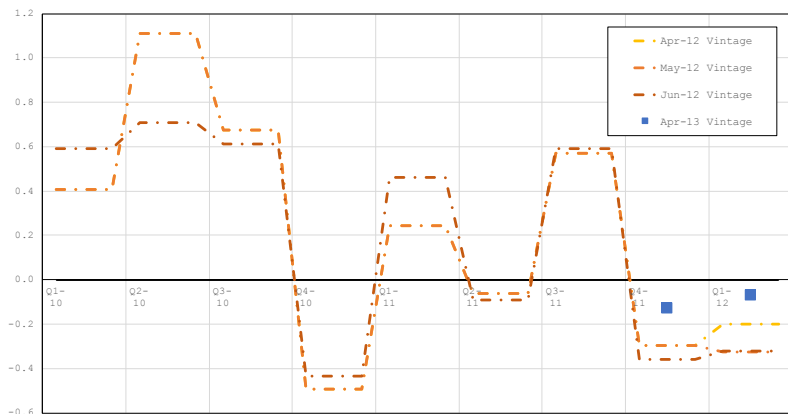
THE MISSED RECESSION



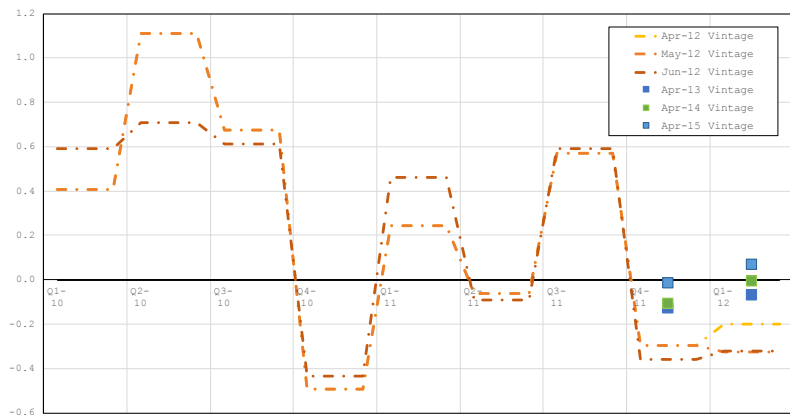
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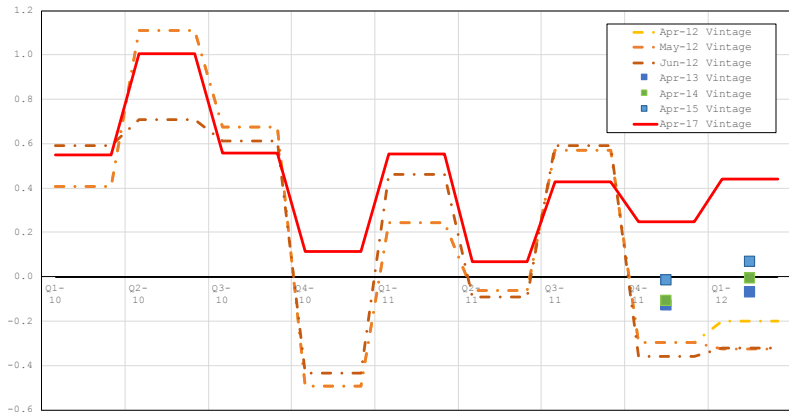
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THE MISSED RECESSION



GDP RELEASE PROCESS

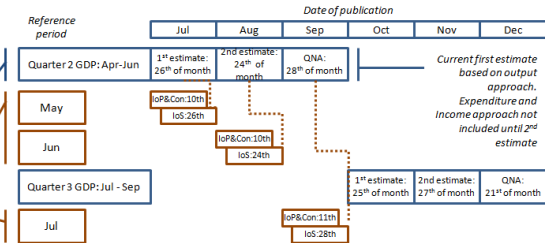
Current model

Separate monthly short term indicators*/ output measures and estimates of GDP

Quarterly GDP publishing not coordinated with short-term indicators. First estimate based on output measure with low data content.

Monthly short-term indicators not all published together

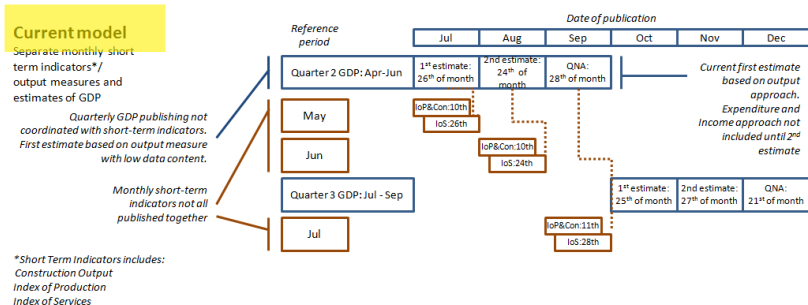
**Short Term Indicators includes:
Construction Output
Index of Production
Index of Services*



Source: Office of National Statistics



GDP RELEASE PROCESS

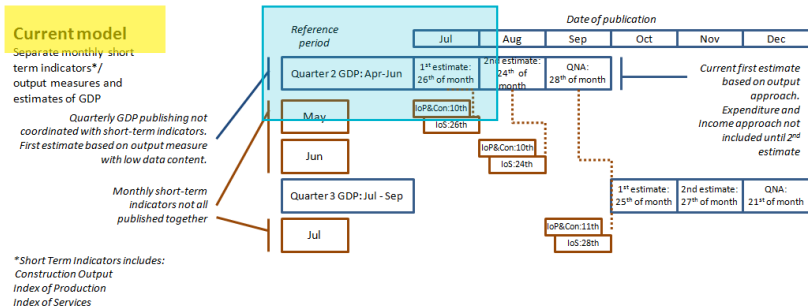


Source: Office of National Statistics

- ▷ Preliminary estimate released 4 weeks after end of reference quarter



GDP RELEASE PROCESS

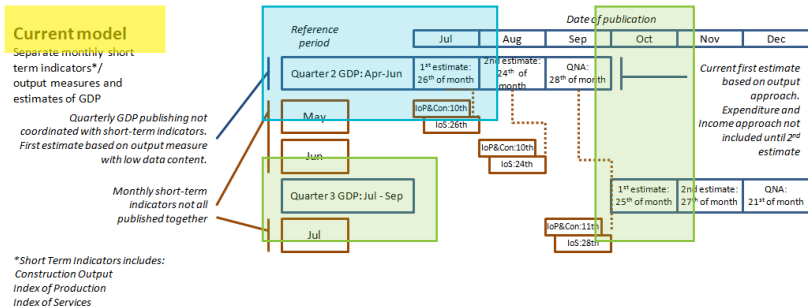


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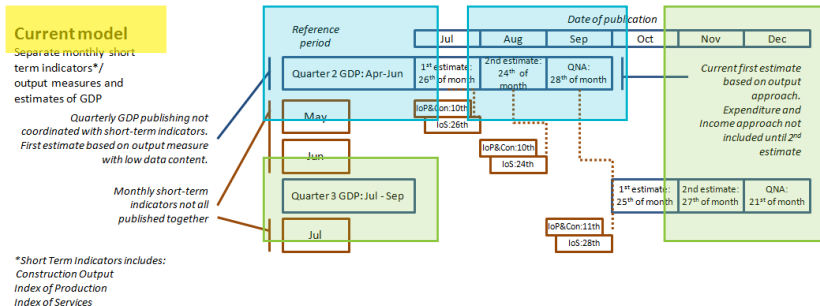


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GDP RELEASE PROCESS

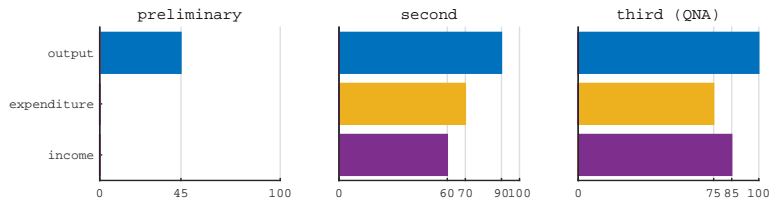


Source: Office of National Statistics

- ▷ Second and Third (QNA) after 8 and 13 weeks



GDP COMPOSITION



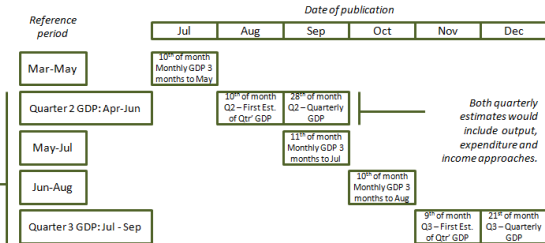
Source: Office of National Statistics

NEW GDP RELEASE PROCESS

New model

Integrated publication of short-term indicators and GDP

Combined publication bringing together short-term indicators to produce a monthly estimate of GDP. Headline measure would be 3 month growth to reference month



All publication dates are for illustrative purposes

Source: Office of National Statistics

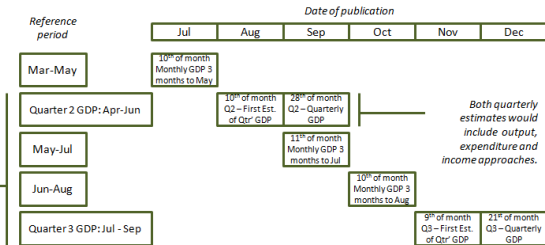


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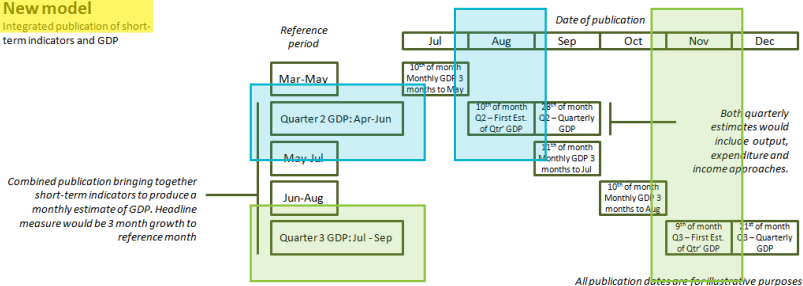
▷ **Preliminary estimate after 6 weeks**



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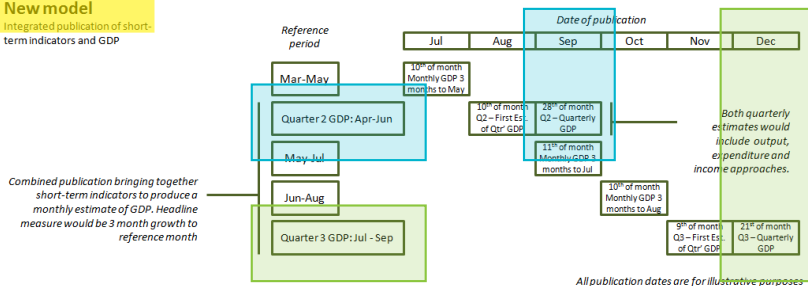
Source: Office of National Statistics

▷ **Preliminary estimate after 6 weeks**

NEW GDP RELEASE PROCESS

New model

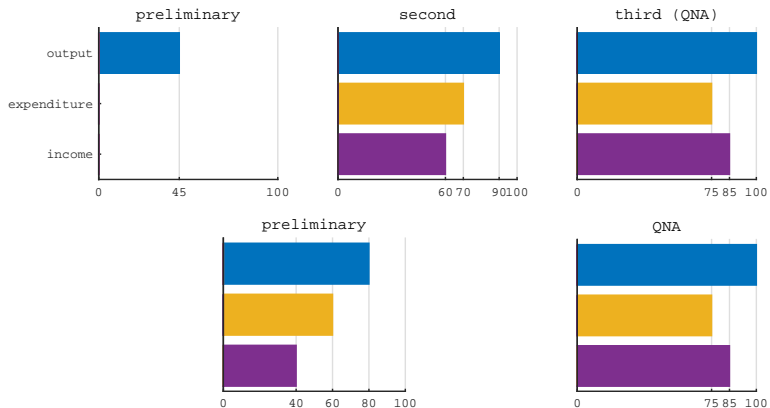
Integrated publication of short-term indicators and GDP



Source: Office of National Statistics

- ▷ Quarterly National Account after 13 weeks

GDP COMPOSITION: NEW



Source: Office of National Statistics

Policy responds to our best judgement of current economic conditions

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1. Is real-time information alone sufficient to estimate “true” growth?

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2. Can we trust a model and information in the real-time data flow to forecast revisions to early released data?

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2. **Alternative way to model successive GDP release**
 - ▷ **Parsimonious state-space** → no a priori stand on “truth”
 - ▷ **Model-implied revision process** → data contribution to revisions’ forecasts

THE RT DATASET



UK ECONOMY IN REAL TIME

- ▷ Not available from the ONS

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1. Quarterly

- ▷ GDP
- ▷ Consumption
- ▷ Investment
- ▷ Construction

2. Monthly

- ▷ Industrial Production
- ▷ Index of Services
- ▷ Retail Sales
- ▷ Imports & Exports
- ▷ Labor Market Statistics



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- ▷ Index of Services
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- ▷ Labor Market Statistics

- ▷ RT Vintages from January 2006 to April 2017

COMPOSITION & COVERAGE

| Code | Variable Name | Source | Group | Frequency |
|---------|----------------------------|--------|----------|-----------|
| IOP | Industrial Production | ONS | Activity | M |
| MPROD | Manufacturing Production | ONS | Activity | M |
| IOS | Index of Services | ONS | Activity | M |
| GDP | Gross Domestic Product | ONS | Activity | Q |
| CONS | Private Consumption | ONS | Activity | Q |
| INV | Total Business Investments | ONS | Activity | Q |
| CONSTR | Housing Investments | ONS | Activity | Q |
| CCOUNTR | Claimant Count Rate | ONS | Labour | M |
| LFSE | LFS Number of Employees | ONS | Labour | M |
| LFSU | LFS Unemployment Rate | ONS | Labour | M |
| BOPEXP | BOP Total Exports (Goods) | ONS | Trade | M |
| BOPIMP | BOP Total Imports (Goods) | ONS | Trade | M |
| RSI | Retail Sales Index | ONS | Trade | M |



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| RSI | Retail Sales Index | ONS | Trade | M |
| MTGAPP | Mortgages Approved | BOE | Credit | M |
| CREDIT | Net Consumer Credit | BOE | Credit | M |
| UKBASKET | UK Focused Equity Index | BOE | Financial | M |
| SERI | Sterling Effective Exchange Rate | LSE | Financial | M |
| TERMSP | Term Spread | BOE | Financial | M |
| CORPSP | Corporate Bond Spread | ML | Financial | M |



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| PMIM | PMI Manufacturing | Markit | Surveys | M |
| CIPSEM | CIPS-E-Manufacturing | Markit | Surveys | M |
| PMIC | PMI Construction | Markit | Surveys | M |
| CIPSEC | CIPS-E-Construction | Markit | Surveys | M |
| PMIS | PMI Services | Markit | Surveys | M |
| CIPSES | CIPS-E-Services | Markit | Surveys | M |
| CBIORDER | CBI Industrial Trends | CBI | Surveys | M |
| CBISALE | CBI Distributive Trade | CBI | Surveys | M |
| LLOYBB | Lloyds Business Barometer | Lloyds | Surveys | M |
| ASCORE | Agents' Score | BOE | Surveys | M |



THE REAL-TIME DATA FLOW

| Release Day | Code | Variable Name | Freq | Reference | Delay |
|-------------|--------|----------------------|------|-----------|-------|
| 1 | PMIM | PMI Manufacturing | M | m-1 | 1 |
| 1 | CIPSEM | CIPS-E-Manufacturing | M | m-1 | 1 |
| 3 | PMIC | PMI Construction | M | m-1 | 3 |
| 3 | CIPSEC | CIPS-E-Construction | M | m-1 | 3 |
| 5 | PMIS | PMI Services | M | m-1 | 5 |
| 5 | CIPSES | CIPS-E-Services | M | m-1 | 5 |



THE REAL-TIME DATA FLOW

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| 1 | PMIM | PMI Manufacturing | M | m-1 | 1 |
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| 3 | PMIC | PMI Construction | M | m-1 | 3 |
| 3 | CIPSEC | CIPS-E-Construction | M | m-1 | 3 |
| 5 | PMIS | PMI Services | M | m-1 | 5 |
| 5 | CIPSES | CIPS-E-Services | M | m-1 | 5 |
| 9 | IOP | Industrial Production | M | m-2 | 39 |
| 9 | MPROD | Manufacturing Production | M | m-2 | 39 |
| 10 | BOPEXP | BOP Total Exports (Goods) | M | m-2 | 40 |
| 10 | BOPIMP | BOP Total Imports (Goods) | M | m-2 | 40 |



THE REAL-TIME DATA FLOW

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| 1 | PMIM | PMI Manufacturing | M | m-1 | 1 |
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| 9 | MPROD | Manufacturing Production | M | m-2 | 39 |
| 10 | BOPEXP | BOP Total Exports (Goods) | M | m-2 | 40 |
| 10 | BOPIMP | BOP Total Imports (Goods) | M | m-2 | 40 |
| 17 | CCOUNTR | Claimant Count Rate | M | m-1 | 17 |
| 17 | LFSE | LFS Number of Employees | M | m-2 | 47 |
| 17 | LFSU | LFS Unemployment Rate | M | m-2 | 47 |
| 20 | RSI | Retail Sales Index | M | m-1 | 20 |
| 20 | CBIORDER | CBI Industrial Trends | M | m | -10 |
| 22 | IOS | Index of Services | M | m-2 | 52 |
| 22 | GDP | GDP and Components | Q | q-1 | - |
| 23 | CBISALE | CBI Distributive Trade | M | m | -7 |



THE REAL-TIME DATA FLOW

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| 22 | GDP | GDP and Components | Q | q-1 | - |
| 23 | CBISALE | CBI Distributive Trade | M | m | -7 |
| 26 | LLOYBB | Lloyds Business Barometer | M | m | -4 |
| 30 | ASCORE | Agents' Score | M | m | 0 |
| 30 | UKBASKET | UK Focused Equity Index | M | m | 0 |
| 30 | SERI | Sterling Effective Exchange Rate | M | m | 0 |
| 30 | TERMSP | Term Spread | M | m | 0 |
| 30 | CORPSP | Corporate Bond Spread | M | m | 0 |
| 30 | MTGAPP | Mortgages Approved | M | m-1 | 30 |
| 30 | CREDIT | Net Consumer Credit | M | m-1 | 30 |



DFM FOR GDP AND REVISIONS



STANDARD TREATMENT OF REAL-TIME DATA & REVISIONS

1. **Most recent vintage** at each forecast horizon [e.g. Diebold and Rudebusch (1991)]
 - ▷ Conventional practice
 - ▷ Lightly & highly revised data may have different statistical properties
 - ▷ Older data likely to weigh more in the estimation

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2. **Successive release as approximations of the “true” value** [e.g. Jacobs and van Norden (2011); Kishor and Koenig (2012); Galvao (2017)]
 - ▷ Explicit model for the revision process
 - ▷ Requires taking a stand on where the “truth” lies
 - ▷ Assumptions on “truth” being eventually observable
 - ▷ Dimension of state-space can rapidly explode

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 - ▷ Dimension of state-space can rapidly explode
3. Use **“fixed-maturity” data** [e.g. Clements and Galvao (2013)]
 - ▷ All data are subject to q rounds of revisions
 - ▷ Requires taking a stand on where the “truth” lies
 - ▷ Unfit for forecasting → recent vintages are discarded

1. Augment measurement equation with successive GDP releases

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OUR APPROACH

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2. GDP releases treated as correlated observables

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2. GDP releases treated as correlated observables

- ▷ Obey same Factor Structure as other data
- ▷ Parsimonious representation

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2. GDP releases treated as correlated observables
 - ▷ Obey same Factor Structure as other data
 - ▷ Parsimonious representation
3. Implicit assumption on “news” component in revisions
 - ▷ Use real-time data flow to forecast the revisions

AUGMENTED MEASUREMENT EQN

$$\begin{matrix} x_t \\ (n \times 1) \end{matrix} \equiv \begin{pmatrix} \\ \\ \\ \\ \end{pmatrix}$$

AUGMENTED MEASUREMENT EQN

$$\underset{(n \times 1)}{x_t} \equiv \begin{pmatrix} x_t^M \end{pmatrix}$$

▷ x_t^M → vector of monthly variables

AUGMENTED MEASUREMENT EQN

$$\underset{(n \times 1)}{x_t} \equiv \begin{pmatrix} x_t^M \\ x_t^Q \end{pmatrix}$$

▷ x_t^Q → vector of quarterly variables

AUGMENTED MEASUREMENT EQN

$$\underset{(n \times 1)}{x_t} \equiv \begin{pmatrix} x_t^M \\ x_t^Q \\ y_t^{(1)} \\ \vdots \\ y_t^{(4)} \end{pmatrix}$$

▷ $y_t^{(1)}, \dots, y_t^{(4)}$ → first 4 GDP releases

AUGMENTED MEASUREMENT EQN

$$\underset{(n \times 1)}{x_t} \equiv \begin{pmatrix} x_t^M \\ x_t^Q \\ y_t^{(1)} \\ \vdots \\ y_t^{(4)} \end{pmatrix} = \begin{pmatrix} \Lambda_M \\ \Lambda_Q \\ \Lambda^{(1)} \\ \vdots \\ \Lambda^{(4)} \end{pmatrix} f_t$$

▷ $y_t^{(1)}, \dots, y_t^{(4)}$ → first 4 GDP releases

AUGMENTED MEASUREMENT EQN

$$\underset{(n \times 1)}{x_t} \equiv \begin{pmatrix} x_t^M \\ x_t^Q \\ y_t^{(1)} \\ \vdots \\ y_t^{(4)} \end{pmatrix} = \begin{pmatrix} \Lambda_M \\ \Lambda_Q \\ \Lambda^{(1)} \\ \vdots \\ \Lambda^{(4)} \end{pmatrix} f_t + \begin{pmatrix} \xi_t^M \\ \xi_t^Q \\ \xi_t^{(1)} \\ \vdots \\ \xi_t^{(4)} \end{pmatrix}$$

▷ $y_t^{(1)}, \dots, y_t^{(4)}$ → first 4 GDP releases

OTHER MODELLING ASSUMPTIONS

- ▷ **Dynamic factor model for now-casting** [e.g. Evans (2005); Giannone, Reichlin and Small (2008); Banbura, Giannone, Modugno and Reichlin (2013)]

$$\begin{aligned}f_t &= A_1 f_{t-1} + \dots + A_p f_{t-p} + u_t & u_t &\sim \mathcal{N}(0, \Sigma_u) \\ \xi_{i,t} &= \rho_i \xi_{i,t-1} + \epsilon_{i,t} & \epsilon_{i,t} &\sim \mathcal{N}(0, \sigma_{\epsilon_i}^2)\end{aligned}$$

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- ▷ **Quarterly variables as partially-observable monthly ones**
[e.g. Mariano and Murasawa (2013)]

$$x_t^Q = (1 + 2L + 3L^2 + 2L^3 + L^4)\tilde{x}_t^M$$

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- ▷ **Dynamic factor model for now-casting** [e.g. Evans (2005); Giannone, Reichlin and Small (2008); Banbura, Giannone, Modugno and Reichlin (2013)]

$$\begin{aligned}f_t &= A_1 f_{t-1} + \dots + A_p f_{t-p} + u_t & u_t &\sim \mathcal{N}(0, \Sigma_u) \\ \xi_{i,t} &= \rho_i \xi_{i,t-1} + \epsilon_{i,t} & \epsilon_{i,t} &\sim \mathcal{N}(0, \sigma_{\epsilon_i}^2)\end{aligned}$$

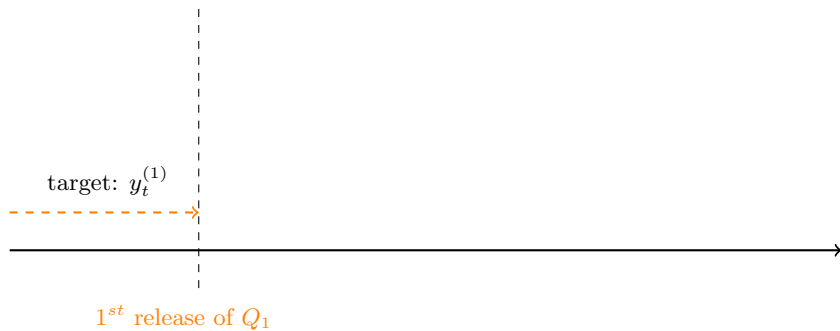
- ▷ **Quarterly variables as partially-observable monthly ones**
[e.g. Mariano and Murasawa (2013)]

$$x_t^Q = (1 + 2L + 3L^2 + 2L^3 + L^4)\tilde{x}_t^M$$

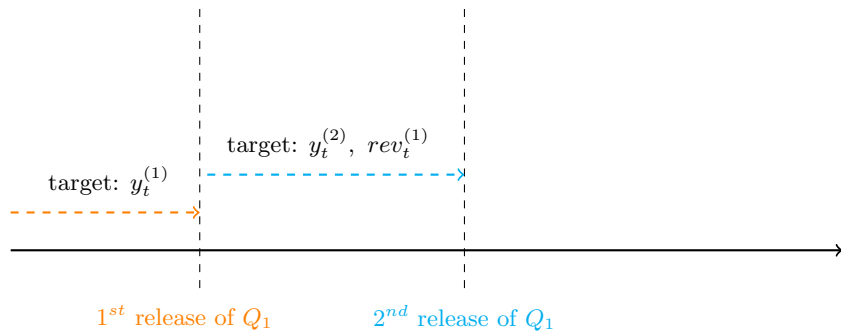
Implied revision process

$$rev_t^k \equiv y_t^{(k+1)} - y_t^{(k)} = \left[\Lambda^{(k+1)} - \Lambda^{(k)} \right] f_t + R(L) \left[\xi_t^{(k+1)} - \xi_t^{(k)} \right]$$

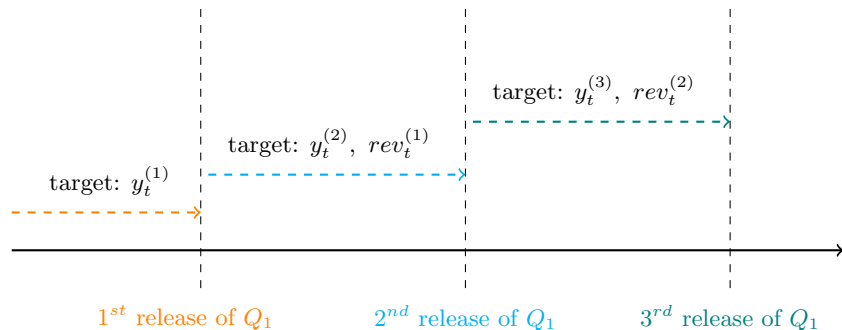
TIME-VARYING FORECAST TARGET



TIME-VARYING FORECAST TARGET



TIME-VARYING FORECAST TARGET



Contribution of releases to GDP forecasts updates [Banbura and Modugno (2010); Banbura et al (2013)]

$$\underbrace{\mathbb{E} \left[y_t^{(k+1)} \mid \Omega_{v+1} \right]}_{\text{new forecast of } k + 1\text{-th GDP release}} = \underbrace{\mathbb{E} \left[y_t^{(k+1)} \mid \Omega_v \right]}_{\text{old forecast}} + \underbrace{\mathbb{E} \left[y_t^{(k+1)} \mid I_{v+1} \right]}_{\text{due to data releases}}$$

Contribution of releases to GDP forecasts updates [Banbura and Modugno (2010); Banbura et al (2013)]

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with known $y_t^{(k)}$ equivalent to forecasting the revision

Contribution of releases to GDP forecasts updates [Banbura and Modugno (2010); Banbura et al (2013)]

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with known $y_t^{(k)}$ equivalent to forecasting the revision

- ▷ **Contribution of releases to reduction in forecast uncertainty**

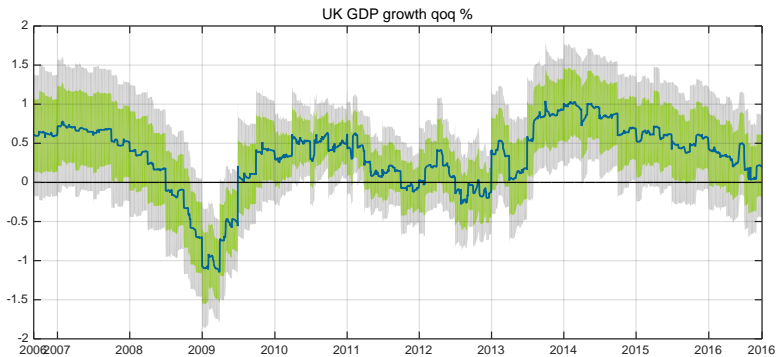
$$\mathbb{E} \left[y_t^{(k+1)} y_t^{(k+1)'} \mid \Omega_v \right] = \mathbb{E} \left[y_t^{(k+1)} y_t^{(k+1)'} \mid \Omega_{v+1} \right] + \mathbb{E} \left[y_t^{(k+1)} y_t^{(k+1)'} \mid I_{v+1} \right]$$

FORECAST EVALUATION

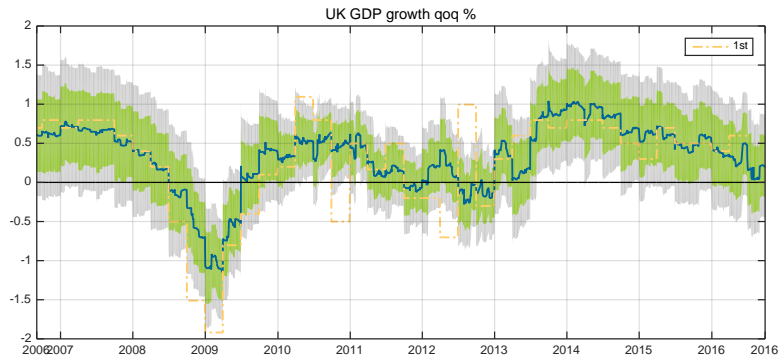


- ▷ Only quarterly variables are GDP releases
- ▷ Data read from Jan-1992
- ▷ OOS: Expanding window 2006Q3 - 2016Q3
alternative: rolling 7-year window
- ▷ SS Parameters updated each year – ML

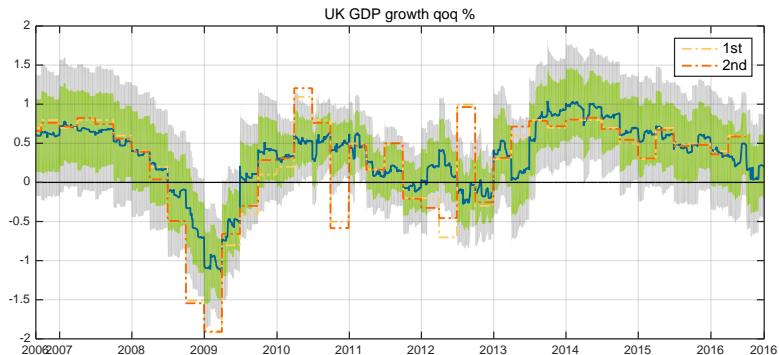
EVOLUTION OF NOWCAST



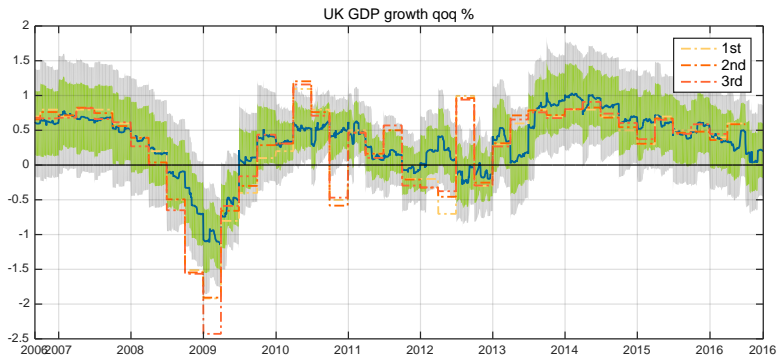
EVOLUTION OF NOWCAST



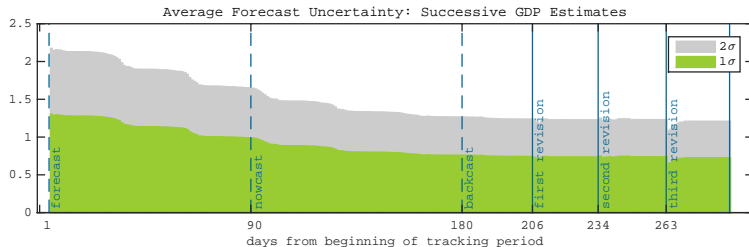
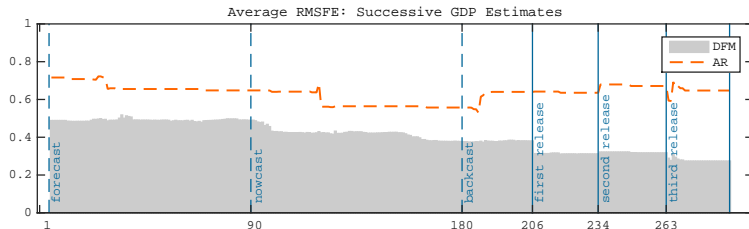
EVOLUTION OF NOWCAST



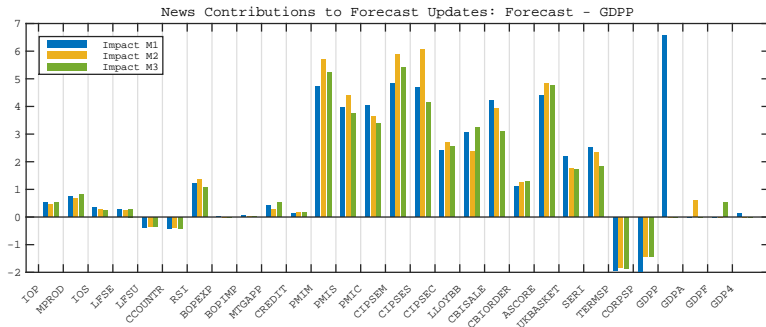
EVOLUTION OF NOWCAST



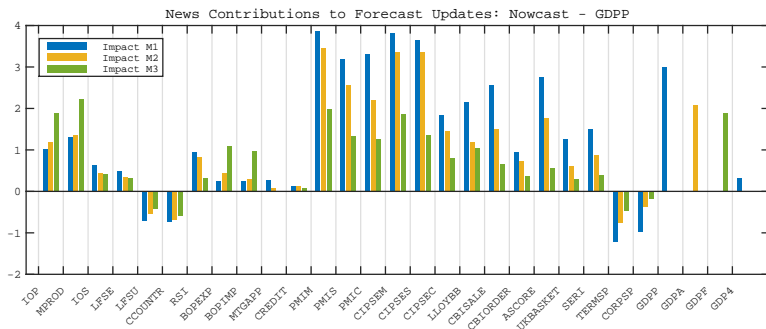
IMPROVED ACCURACY AND REDUCTION IN UNCERTAINTY



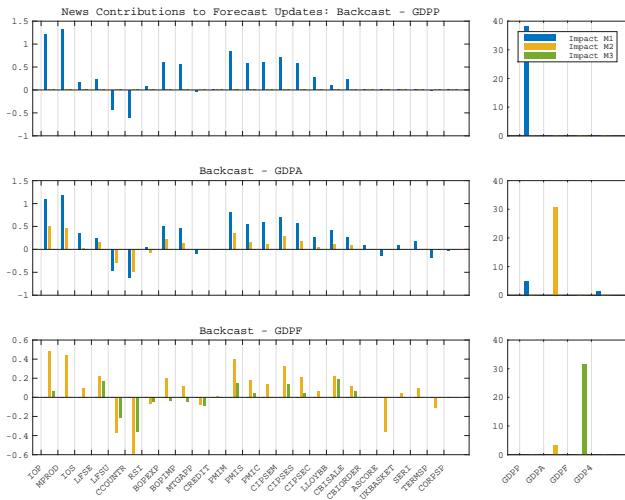
CONTRIBUTION OF DATA RELEASES: FORECAST



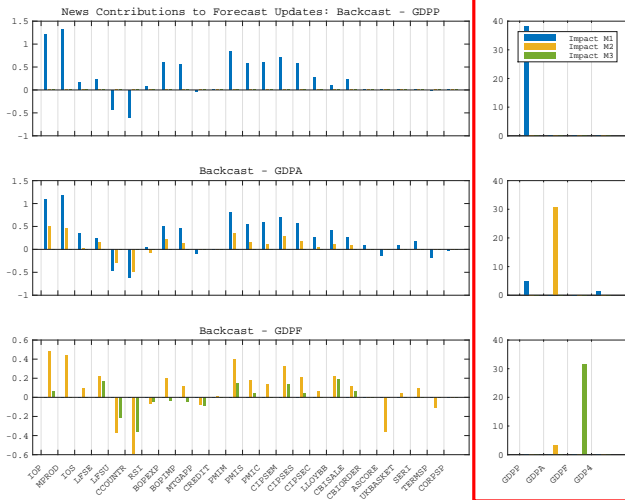
CONTRIBUTION OF DATA RELEASES: NOWCAST



CONTRIBUTION TO BACKCAST.. FORECASTING THE REVISIONS?

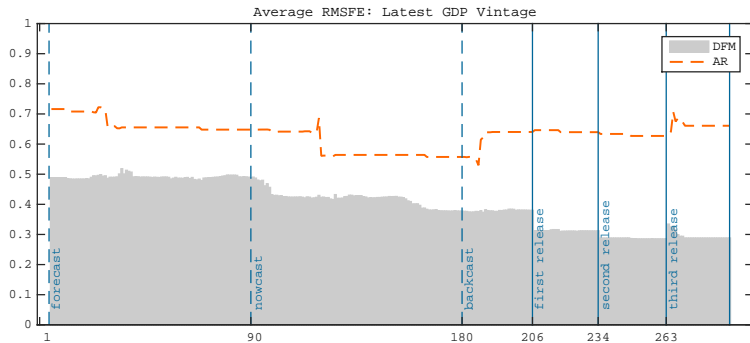


CONTRIBUTION TO BACKCAST.. FORECASTING THE REVISIONS?

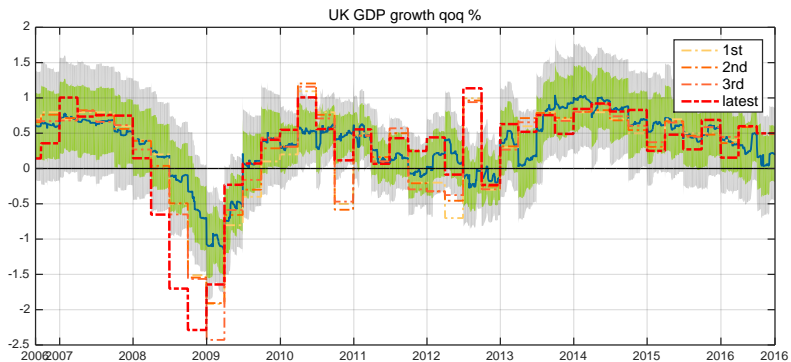


not really.. → contribution of quarterly GDP components

THE TRUTH?



MODEL VS LATEST VINTAGE



THE MISSED RECESSION

