Improving *GDP* Measurement Further: Data Revisions with News-Noise Measurement Errors

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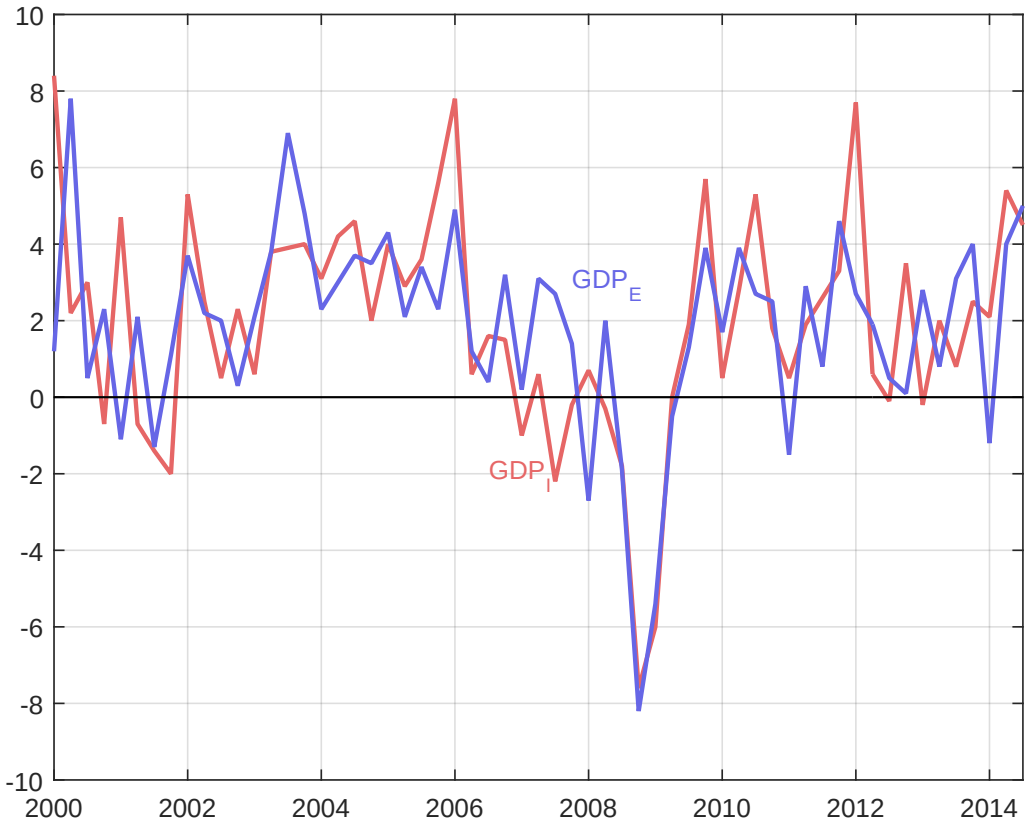
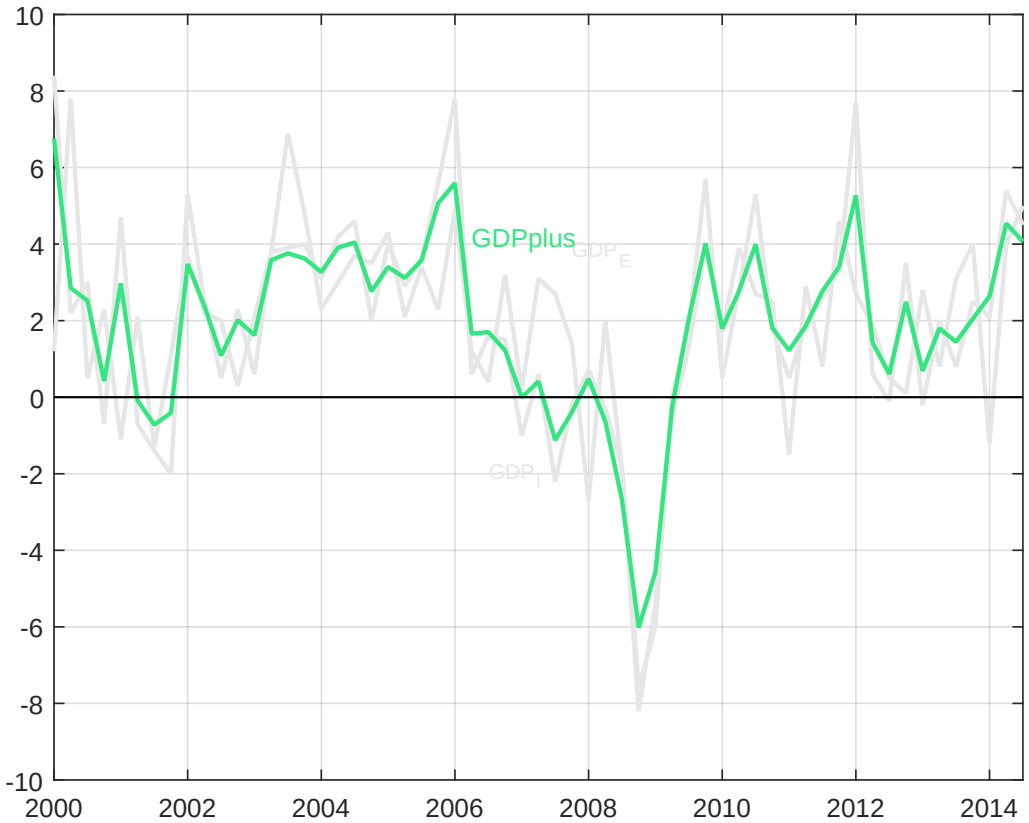
The XIII Conference on Real-Time Data Analysis, Methods and Applications, Banco de España, Madrid, October 2017

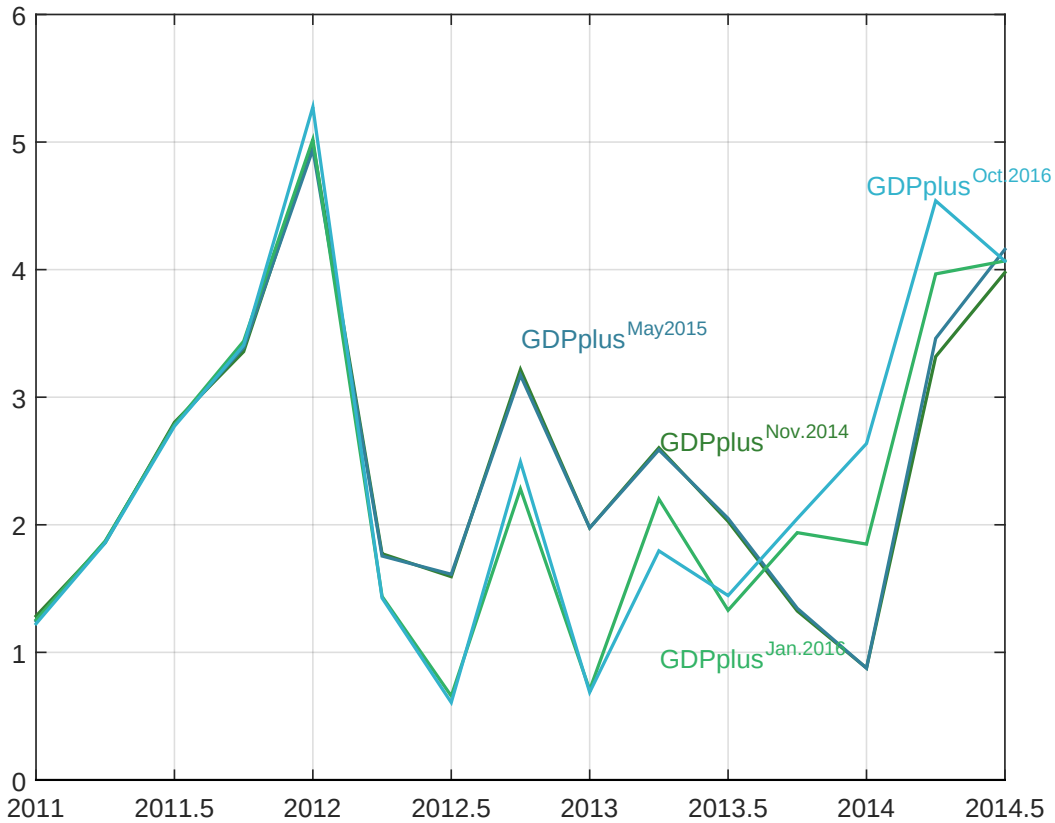
U.S. real GDP Growth: Expenditure Side vs. Income Side



Recent Reconciliation: $GDP+$



But Reconciled real GDP growth also Subject to Revision



This paper

- What we do:
  - Reconcile real GDE growth and real GDP growth in a real-time data environment
  - Decompose measurement errors into news and noise using a multivariate extension of Jacobs and van Norden (2011, JoE; henceforth JvN)
- Our contribution:
  - Compute new real GDP growth series that takes data revisions into account
  - Compare real GDE growth and $realGDI$ growth
    - Historical decomposition of real GDE growth and real GDI shocks into news and noise shocks
  - Identification through real-time data and news-noise assumptions

Notation

GDP_t	real GDP growth
GDE_t	real GDP growth of the expenditure side
GDI_t	real GDP growth of the income side
GDP_t^+	real GDP growth measure of Aruoba et al. (2015)
GDP_t^{++}	real GDP growth measure of Aruoba et al. (2015)
ϵ_t	measurement error (noise) of Aruoba et al. (2015)
ε_t	measrurement error (news and noise) as in JvN
ν_t	news as in JvN
ζ_t	noise as in JvN

Notation and Econometric Framework

Point of departure: Aruoba et al. (2015):

$$\begin{bmatrix} GDE_t \\ GDI_t \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} GDP_t^+ + \begin{bmatrix} \epsilon_{Et} \\ \epsilon_{It} \end{bmatrix} \tag{1}$$

$$GDP_t^+ = \mu(1-\rho) + \rho GDP_{t-1}^+ + \epsilon_{Gt}, \tag{2}$$

where

$$[\epsilon_{Et}, \epsilon_{It}, \epsilon_{Gt},]' \sim N(0, \Sigma)$$

Move to real-time data environment:

$$\begin{bmatrix} GDE_t^L \\ GDI_t^L \end{bmatrix} = \begin{bmatrix} \iota_l \\ \iota_l \end{bmatrix} GDP_t^{++} + \begin{bmatrix} \nu_{Et}^L \\ \nu_{It}^L \end{bmatrix} + \begin{bmatrix} \zeta_{Et}^L \\ \zeta_{It}^L \end{bmatrix}, \tag{3}$$

where

$$\begin{aligned} GDE_t^L &= [GDE_t^1, \ldots, GDE_t^l]', & GDI_t^L &= [GDI_t^1, \ldots, GDI_t^l]', \\ \nu_{Et}^L &= [\nu_{Et}^1, \ldots, \nu_{Et}^l]', & \nu_{It}^L &= [\nu_{It}^1, \ldots ..., \nu_{It}^l]' \\ \zeta_{Et}^L &= [\zeta_{Et}^1, ..., \zeta_{Et}^l]', & \zeta_{It}^L &= [\zeta_{It}^1, ..., \zeta_{It}^l]', \end{aligned}$$

and ι_l is a $l \times 1$ vector of ones

News: $E[GDP_t^{++}, \nu_t^L] \neq 0$ and Noise: $E[GDP_t^{++}, \zeta_t^L] = 0$

Econometric Framework

State space representation

$$\begin{bmatrix} GDE_t^L \\ GDI_t^L \end{bmatrix} = \boldsymbol{Z}\boldsymbol{\alpha}_t \tag{4}$$

$$\boldsymbol{\alpha}_t = \begin{bmatrix} \rho & 0 \\ 0 & 0 \end{bmatrix} \boldsymbol{\alpha}_{t-1} + \boldsymbol{R}\boldsymbol{\eta}_t, \tag{5}$$

$$\boldsymbol{Z} = [\boldsymbol{\iota}_{2l}, \boldsymbol{I}_{2l}, \boldsymbol{I}_{2l}], \qquad \boldsymbol{\alpha}_t = [GDP_t^{++}, \nu_{Et}^{L\prime}, \nu_{It}^{L\prime}, \zeta_{Et}^{L\prime}, \zeta_{It}^{L\prime}]',$$

$$\boldsymbol{R} = \begin{bmatrix} 1 & \boldsymbol{\iota}_l' & \boldsymbol{\iota}_l' & 0 & 0 \\ 0 & -\boldsymbol{U} & 0 & 0 & 0 \\ 0 & 0 & -\boldsymbol{U} & 0 & 0 \\ 0 & 0 & 0 & \boldsymbol{I}_l & 0 \\ 1 & 0 & 0 & 0 & \boldsymbol{I}_l \end{bmatrix} \qquad \boldsymbol{\eta}_t = [\eta_{Gt}, \eta_{E\nu t}^{L\prime}, \eta_{I\nu t}^{L\prime}, \eta_{E\zeta t}^{L\prime}, \eta_{I\zeta t}^{L\prime}]'$$

Example: l releases of GDE_t

$$
\begin{aligned}
GDE_t^1 &= \rho GDP_{t-1}^{++} + \eta_{Gt} + \eta_{E\zeta t}^1 \\
GDI_t^2 &= \rho GDP_{t-1}^{++} + \eta_{Gt} + \eta_{E\nu t}^1 + \eta_{E\zeta t}^2 \\
\vdots \quad &= \qquad\qquad \vdots \\
GDE_t^l &= \rho GDP_{t-1}^{++} + \eta_{Gt} + \eta_{E\nu t}^1 + \ldots + \eta_{E\nu t}^{l-1} + \eta_{E\zeta t}^l
\end{aligned}
$$

Total revision

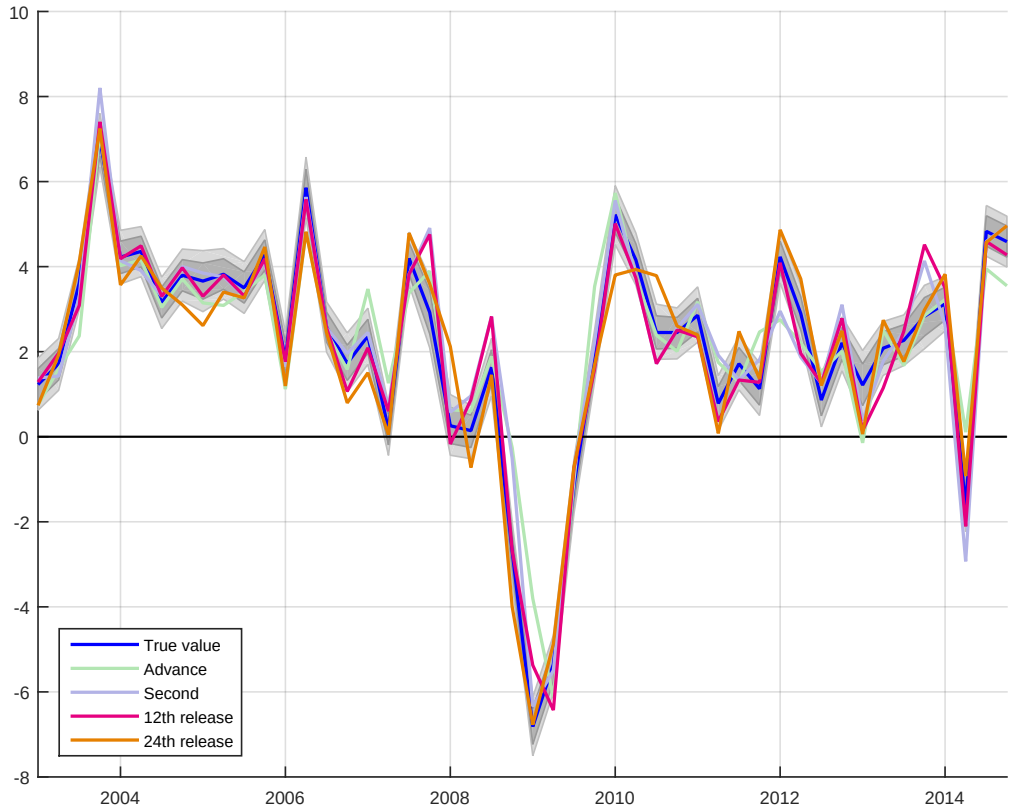
$$
GDE_t^l - GDE_t^1 = \underbrace{\eta_{E\nu t}^1 + \ldots + \eta_{E\nu t}^{l-1}}_{\text{News}} + \underbrace{\eta_{E\zeta t}^l - \eta_{E\zeta t}^1}_{\text{Noise}}
$$

Data and Estimation

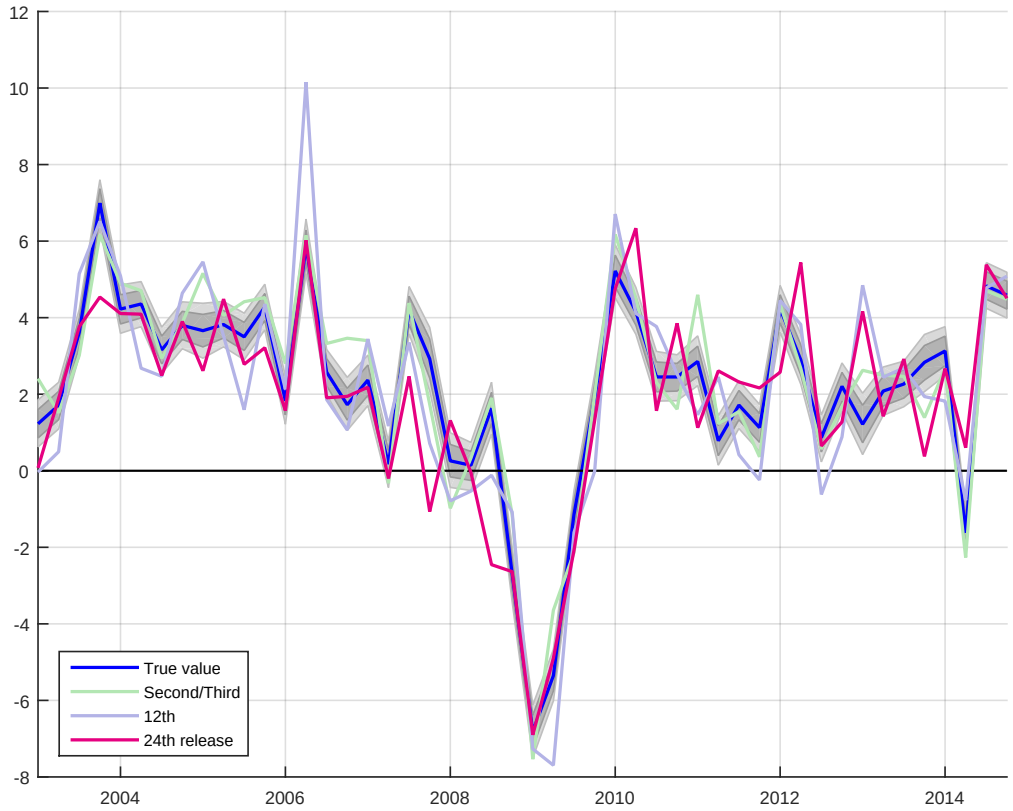
- Data
  - Data provided by the Bureau of Economic Analysis (BEA)
  - Monthly vintages of quarterly series
    - For GDE we use Advance, Third, 12th and the 24th releases
    - For GDI we use Second/Third, 12th and the 24th releases
  - Sample we cover thus is 2003Q1–2014Q3

- Estimation
  - Bayesian methods
  - We apply the Gibbs sampling procedure
  - Overall diffuse priors

GDP^{++} vs. real GDE growth



GDP^{++} vs. real GDI growth



GDP^{++} vs. all other real GDP measures

- Compare (ρ - σ_{G++}) pairs:
- Fit AR(1) to different vintages of GDP^{+}, GDP_E and GDP_I
- Compute average ρs and σ^2s

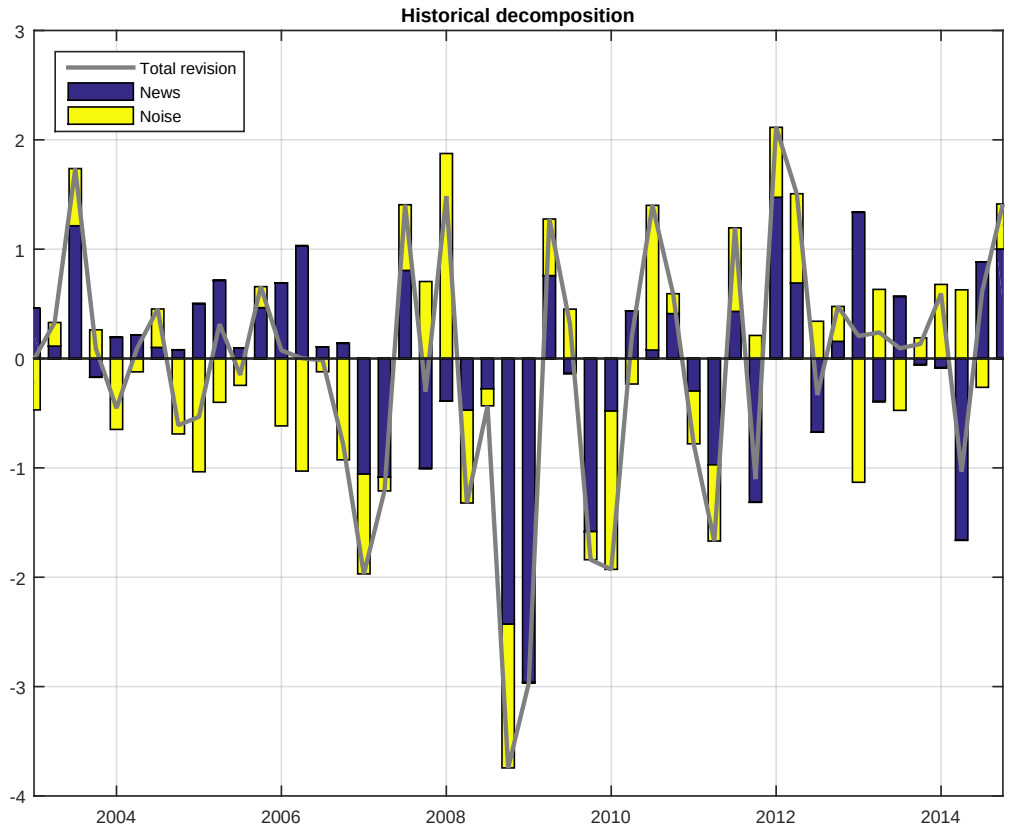
Contribution to GDP_t^{++}

- Use Kalman gain to assess importance of GDP_I and GDP_E at different releases

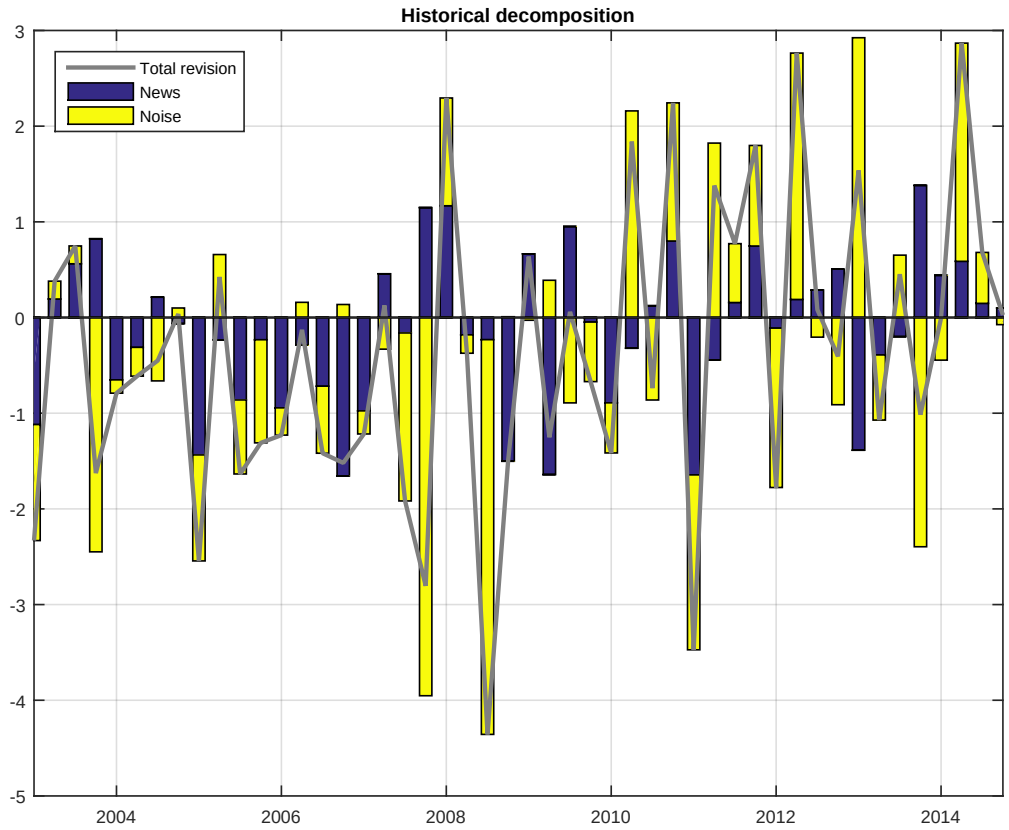
Table: Kalman Gains

	GDP_E	GDP_I
Advance	0.0600	–
Third	0.02	–
12th	0.2465	0.2578
24th Release	0.2178	0.0861

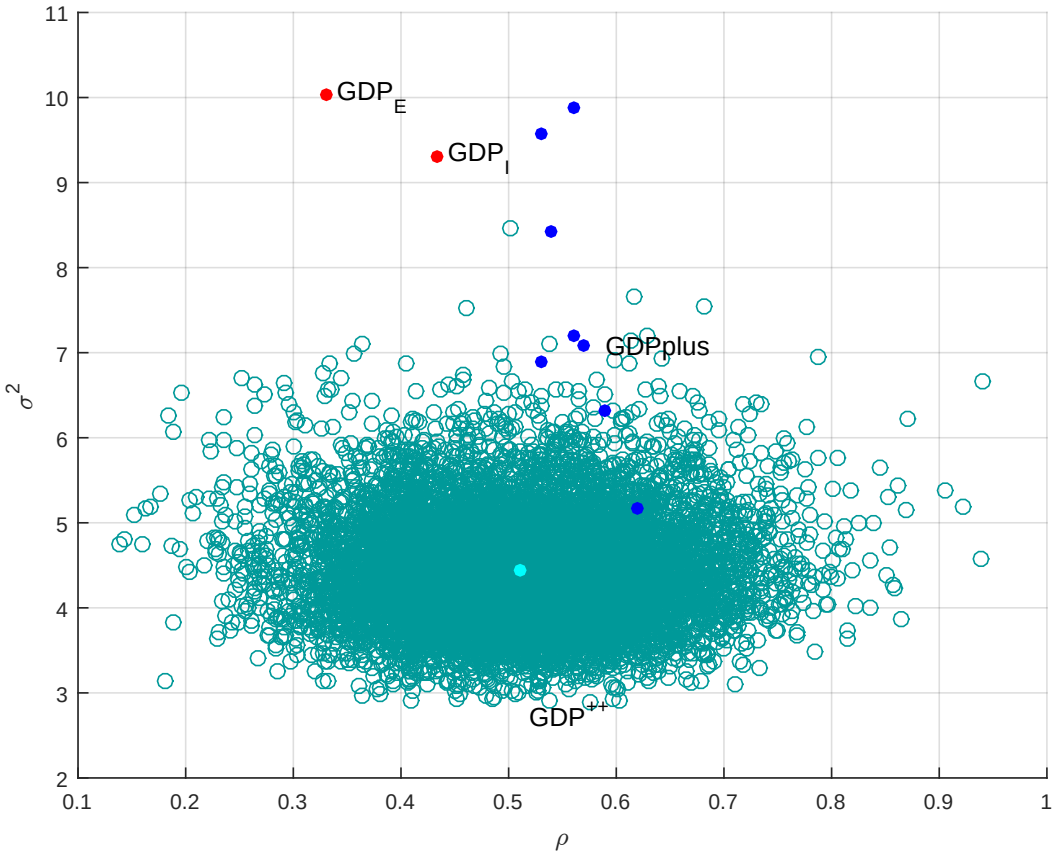
Historical Decomposition of real GDE growth



Historical Decomposition of real GDI growth



Real GDP Growth Dynamics



Historical Decomposition of GDP_E

- Show total revision of the real GDP growth measures together with share of news and noise shares

Historical decomposition of GDP_I

- Show total revision of the GDP measures together with share of news and noise shares

Conclusion

- Provided new real GDP growth measure using real-time data
  - More persistent and smaller residual variance than real GDE growth and real GDI growth
  - Similar AR-coefficient but smaller residual variance than GDP^{+}
- Computed historical decomposition of real GDE growth and real GDP growth measurement errors
  - Higher news share in real GDE growth than in real GDI growth
- System is identified using real-time data and news-noise assumptions

Identification

JvN: from dynamics in the state equation

Aruoba et all. (2015): from Komunjur and Ng (2011, Ectra)

Here: we also use Komunjur and Ng (2011, Ectra).
System is identified using real-time data and news-noise assumptions

Modelling *GDP* growth in Real-Time

One variable: JvN (Jacobs and van Norden JE 2011)

Measurement equation

$$\boldsymbol{y}_t = \text{truth}_t + \text{news}_t + \text{noise}_t$$

State equation

$$\begin{bmatrix} \text{truth}_{t+1} \\ \text{news}_{t+1} \\ \text{noise}_{t+1} \end{bmatrix} = \begin{bmatrix} \boldsymbol{T}_{\text{truth}} & \boldsymbol{0} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{T}_{\text{news}} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{T}_{\text{noise}} \end{bmatrix} \begin{bmatrix} \text{truth}_t \\ \text{news}_t \\ \text{noise}_t \end{bmatrix} + \begin{bmatrix} \boldsymbol{R}_{\text{truth}} & \boldsymbol{R}_{\text{news}} & \boldsymbol{0} \\ \boldsymbol{0} & -\boldsymbol{R}_{\text{news}} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{R}_{\text{noise}} \end{bmatrix} \begin{bmatrix} \boldsymbol{\eta}_{\text{truth},t} \\ \boldsymbol{\eta}_{\text{news},t} \\ \boldsymbol{\eta}_{\text{noise},t} \end{bmatrix}$$

Modelling *GDP* growth in Real-Time

Two variables: *GDE* and *GDI*

1. JvN on individual series
   take 'average' of *GDE* truth and *GDI* truth
   factor analysis / principal components / common trend
2. JvN two series, one factor (truth)
   uncorrelated news, noise shocks
   this paper
3. JvN two series, one factor
   correlated news, noise shocks

Fly in the ointment[1]

real $GDP \sim I(1)$
real GDP growth $\sim I(0)$
Misspecified model!

Measurement equation

$$GDP = GDP^{++} + \varepsilon_t$$

where ε_t is measurement error.

We need ECM-equation with lagged real GDP to avoid spurious regression problem.

[1] Private correspondence with Adrian Pagan