Can GDP measurement be further improved?
Data revision and reconciliation

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Motivation I

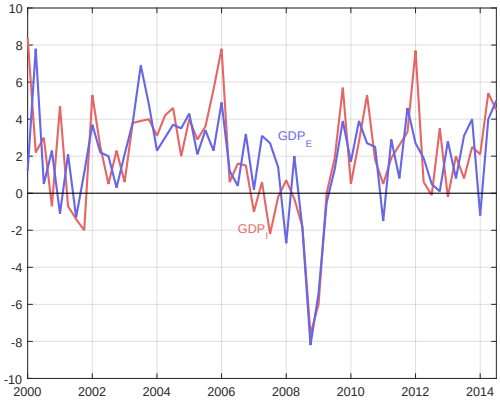


Figure: U.S. Real GDP growth: Expenditure vs Income measures

Motivation II

Which is the better measure of GDP?
Expenditure (GDE) or Income (GDI)?

- Nalewaik (2012)
- Chang and Li (2015)

Reconciliation:

- Stone, Champernowne and Meade (1942)
- Weale (1992)
- Diebold (2010)
- Aruoba et al (2012)
  - FRB Philadephia publishes GDP$^+$

Motivation III

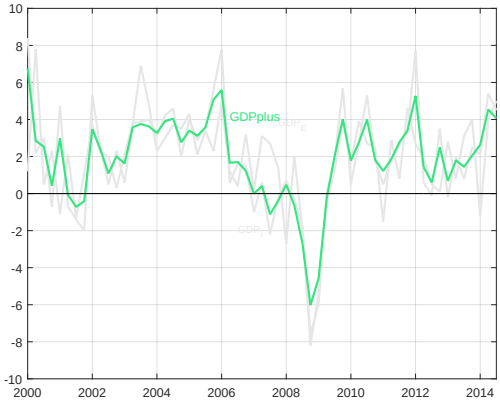


Figure: Following Aruoba et al. (2015), FRB Philadelphia publish reconciliations: GDP$^+$

Motivation IV

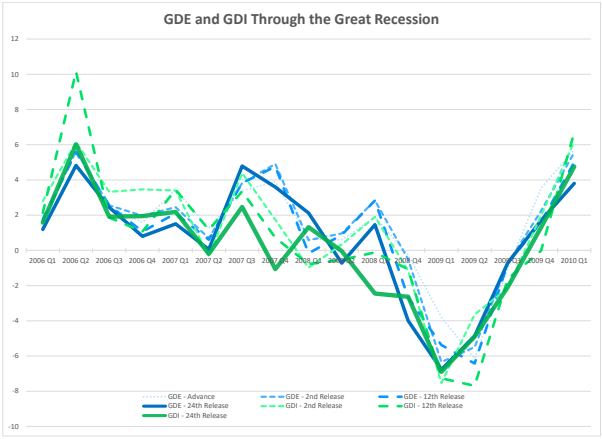


Figure: Both series have important revisions

Problem

Reconciliation relies on assumptions about the errors in the series being reconciled.

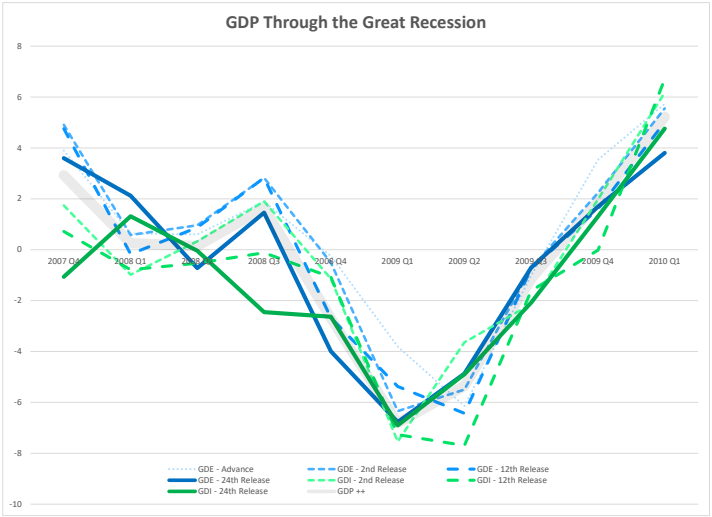
- which is more precise?
- lead/lag relationships?
- News or Noise?

These relationships vary depending on which release(s) we consider.

- Important for producing efficient estimates.
- Important for understanding reliability of estimates.

Our Contribution

1. We model the reconciliation problem in a standard, linear state-space framework. (following Jacobs and van Norden JoE 2011)
2. We show how to allow for
   - multiple data releases
   - varying precision
   - series dynamics
   - combinations of news and noise errors
3. Reconcile real GDE and GDI growth in a real-time data environment
4. Compare our new measure (GDP^{++}) to real GDE and GDI growth
5. Decompose initial estimates of GDE and GDI growth into news and noise shocks



Revision properties

News and Noise

Let y_t^i be the i-th release of y in period t and $\tilde{y}_t \equiv$ 'true' value of y_t

1. **Noise:**

$$y_t^i = \tilde{y}_t + \zeta_t^i, \qquad \text{cov}(\tilde{y}_t, \zeta_t^i) = 0 \quad \forall i$$

   $\Rightarrow$ revisions (partly) forecastable
   $\Rightarrow$ vintages **more** volatile than 'true' values

2. **News:**

$$\tilde{y}_t = y_t^i + \nu_t^i, \qquad \text{cov}(y_t^i, \nu_t^i) = 0 \quad \forall i$$

   Linked to rational forecasts (De Jong 1987)
   rational statistical agency (Sargent 1989)
   $\Rightarrow$ revisions *cannot* be forecast
   $\Rightarrow$ vintages **less** volatile than "true" values

Notation

GDP_t	real GDP growth ("Truth")
GDE_t	real GDP growth (Expenditure measure)
GDI_t	real GDP growth (Income measure)
GDP_t^i	superscript ^{i} indicates release
GDP_t^+	real GDP growth - FRB Philadelphia measure (after Aruoba et al. 2015)
GDP_t^{++}	our real GDP growth measure
ν_t	News measurement error
ζ_t	Noise measurement error

State-Space Model I

Measurement Equation:

$$\begin{bmatrix} GDE_t^L \\ GDI_t^L \end{bmatrix} = [\iota] \cdot GDP_t + \begin{bmatrix} \nu_{Et}^L \\ \nu_{It}^L \end{bmatrix} + \begin{bmatrix} \zeta_{Et}^L \\ \zeta_{It}^L \end{bmatrix} \tag{1}$$

where

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

and ι is a $2l \times 1$ vector of ones.

News: $E[\nu_t^j | GDP_t^k] = 0 \; \forall j > k$
Noise: $E[\zeta_t^L | GDP_t] = 0$

State-Space Model II

Transition Equation:
Let $\boldsymbol{\alpha}_t = [GDP_t, \nu_{Et}^{L\prime}, \nu_{It}^{L\prime}, \zeta_{Et}^{L\prime}, \zeta_{It}^{L\prime}]'$
The transition equation may be compactly written as

$$\boldsymbol{\alpha}_t = \begin{bmatrix} \rho & 0 \\ 0 & 0 \end{bmatrix} \boldsymbol{\alpha}_{t-1} + \boldsymbol{R} \cdot \boldsymbol{\eta}_t, \tag{2}$$

$$\boldsymbol{R} = \begin{bmatrix} 1 & \boldsymbol{\iota}_l' & \boldsymbol{\iota}_l' & 0 & 0 \\ 0 & -\boldsymbol{U} & 0 & 0 & 0 \\ 0 & 0 & -\boldsymbol{U} & 0 & 0 \\ 0 & 0 & 0 & \boldsymbol{I}_l & 0 \\ 1 & 0 & 0 & 0 & \boldsymbol{I}_l \end{bmatrix} \tag{3}$$

$\boldsymbol{U}$ is upper triangular matrix of ones
$\boldsymbol{\eta}_t = [\eta_{Gt}, \boldsymbol{\eta}_{E\nu t}^{i\prime}, \boldsymbol{\eta}_{I\nu t}^{i\prime}, \boldsymbol{\eta}_{E\zeta t}^{i\prime}, \boldsymbol{\eta}_{I\zeta t}^{i\prime}]' \sim \boldsymbol{N}(\boldsymbol{0}, \boldsymbol{D})$ for a diagonal matrix $\boldsymbol{D}$

Identification

How can we hope to distinguish News and Noise measurement errors?

(2) implies that all persistence comes through GDP_t.

- News shocks are part of GDP_t, and so have a persistent effect.
- Noise shocks are not, and so must be transitory.

Jacobs and van Norden (2011) consider more general news and noise dynamics in the univariate case.

- We provide a formal proof of identification in their special case using Komunjur and Ng (2011, Ectra)

Kishor and Koenig (2012) also identify both news and noise shocks in the univariate case.

Data and estimation

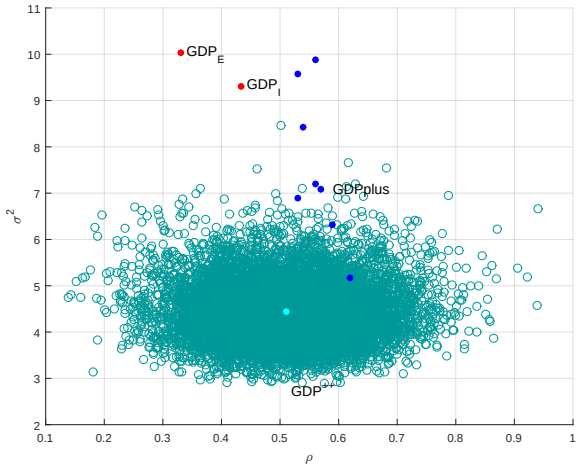
Data

- Monthly vintages of quarterly series 2003Q1–2014Q3 from Bureau of Economic Analysis (BEA)
- For real GDE growth
  we use the advance, third, the 12th and the 24th releases
- For real GDI growth
  we use the second/third, the 12th and the 24th releases

Estimation

- Gibbs Sampling with diffuse priors
- Estimate with News only, Noise only, and News & Noise
  Results as expected
  - Noise only gives less volatile GDP growth
  - News only gives more volatile GDP growth

Real GDP growth dynamics



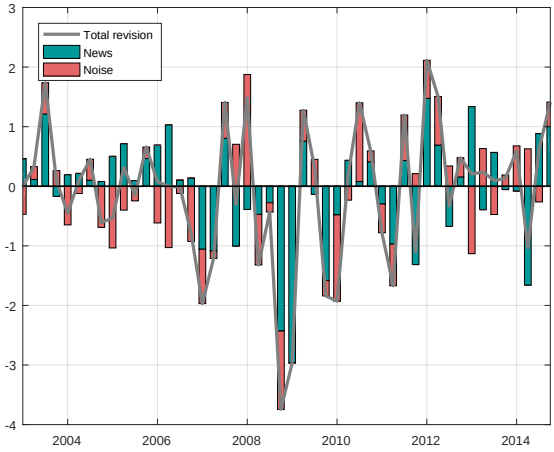
Contribution to GDP_t^{++}

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

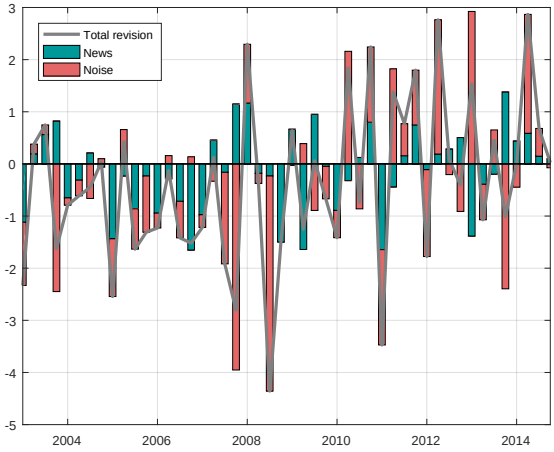
Table: Kalman gains

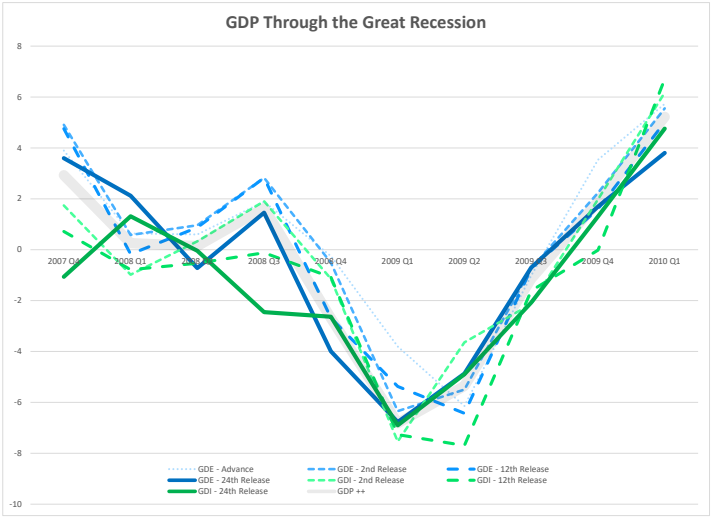
	GDP_E	GDP_I
Advance	0.06	−−
Third	0.02	−−
12th	0.25	0.26
24th Release	0.22	0.09

Historical decomposition of real GDE growth



Historical decomposition of real GDI growth





Conclusion

We show how to reconcile series subject to revision due to news and noise.

- Identification possible due to differing dynamic impact of news and noise errors.

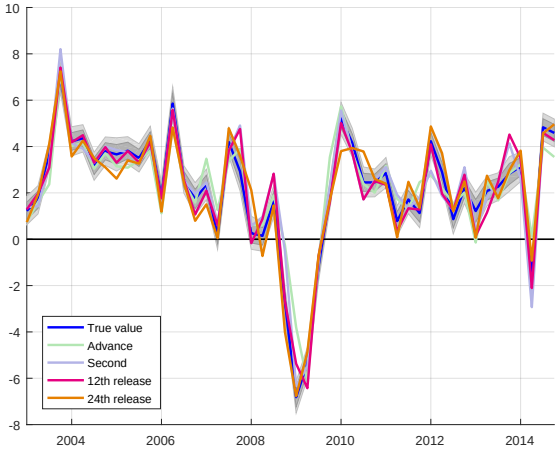
We provided a new real GDP growth measure using real-time data

- 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
- 2008 downturn in GDI seems like noise rather than a leading indicator of recession.

GDP^{++} vs. real GDE growth



GDP^{++} vs. real GDI growth