BANK FOR INTERNATIONAL SETTLEMENTS

A shadow policy rate to calibrate US monetary policy at the zero lower bound

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Motivation

- After the ZLB was hit, several QE measures were implemented
- This raised several questions:
  - How to measure monetary policy at the ZLB?
  - How to quantify the impact of QE?
  - How to calibrate asset purchases?
- Available analytical tools are not able to provide answers

Measuring monetary policy before the ZLB

- Overnight rates as main indicators and instruments of monetary policy
  - They're even called *policy rates*!
- Policy rates are pervasive in measuring monetary policy:
  - Taylor rules refer to policy rates
  - Monetary VARs: stance measured as shocks to policy rates
  - Monetary policy blocks of DSGEs based on policy rates

- This is rooted in a seminal paper: Bernanke and Blinder (1992)

How to cope with the ZLB?

- Most common approach: event studies (eg Meaning and Zhu 2012)
  - Is the market reaction a valid proxy?
- Enlarge VARs to identify unconventional shocks?
  - Which variables to include?
  - What are the identifying assumptions?
  - What are historical benchmarks?

- Would be optimal to have a single indicator for pre- and post-ZLB times

Measuring monetary policy before the great moderation

- In the 70s there was wide discussion on the best indicator of monetary policy
  - Friedman and Schwartz (1963) and Cagan (1972) stressed the usefulness of M1 and M2
  - Avery (1979) proposed a factor approach to construct a single indicator based on several measures

Our idea in a nutshell

- Interpret monetary policy as an unobservable concept with several facets and gauges
  - *Use a dynamic factor model*

- Construct the policy rate implied by a large set of monetary policy indicators and gauges
  - *Use factors to estimate post-ZLB policy rates*

But that's just a shadow rate!

- *Shadow rate*: how would the policy rate look like, had the ZLB not been binding?
  - Based on a model of the term structure (Black 1995)
- Recent shadow rates are also based on the term structure:
  - Christensen and Rudebusch (2013), Krippner (2013), Wu and Xia (2014)
- Shadow rate is driven by movements in the yield curve
  - Model-based constraint
- Our approach is instead entirely data-driven
  - Based on a dynamic factor model

How do we do it?

- Construct a large data matrix of variables related to (conventional and unconventional) monetary policy
  - Term structure
  - Monetary aggregates
  - Balance sheet items
- Model this as a function of few dynamic factors
- Treat the policy rate as missing after it hit the ZLB and use the factors to reconstruct it
  - This is done using the EM algorithm

The data – Blocs I and II

- **Interest rates**
  - *Effective Federal Funds rate (FFR)*
  - *Rates of US Treasury bills with maturities of 1 month, 3 months, 6 months and 1 year*
  - *Yields of US Treasury bonds with maturities of 1, 2, 3, 5, 7, 10, 20 and 30 years*
  - *OIS spread (3 month)*
- **Monetary aggregates**
  - *Monetary base (M0)*
  - *M1, M2, MZM (Board and St. Louis)*

The data – Bloc III

- **Federal Reserve balance sheet (assets)**
  - *Total assets*
  - *Total Federal Reserve securities held outright*
    - *US Treasury securities*
    - *Federal agency debt securities*
    - *Mortgage-backed securities*
  - *Average maturity of Federal Reserve securities held outright*
  - *Percentage of US Treasury securities (<90d, <1y, <5y, <10y, >10y)*

The data – Bloc IV

- **Federal Reserve balance sheet (liabilities)**
  - *Currency in circulation*
  - *Reserves: Total, Non-borrowed, Required and excess reserve balances*
  - *Deposits of depository institutions (other than reserve balances)*
  - *Reverse repurchase agreements*

The dynamic factor model

- Let $\{X_t,\ t = 1, \ldots, \mathrm{T}\}$ be an *N*-dimensional data matrix
- Factor representation:

$$X_t = \Lambda F_t + e_t$$

- Factor dynamics:

$$F_t = \sum_{i=1}^{p} A_i F_{t-i} + u_t$$

- Factors are unobservable
  - State-space representation
  - ML estimation via the Kalman filter

EM algorithm

- X may have missing entries in the i-th column:
  - Replace them with their expectations based on the observed series!

1. Start with a guess $\underline{X}_{i,t}$
2. Compute the factors F_t
3. Replace the guess with $\mathrm{E}(X_{i,t}|F_t)$
4. Iterate until convergence

- We treat the FFR (and short-term rates) as missing as soon as they hit the ZLB

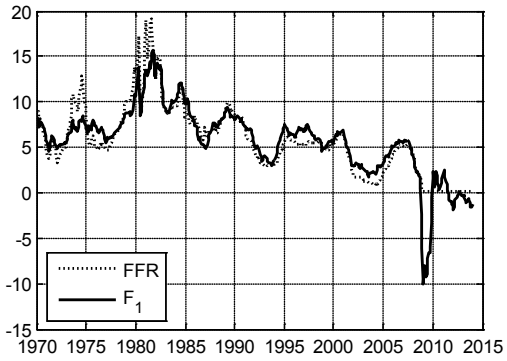
How do factors look like?

Factors and observed variables

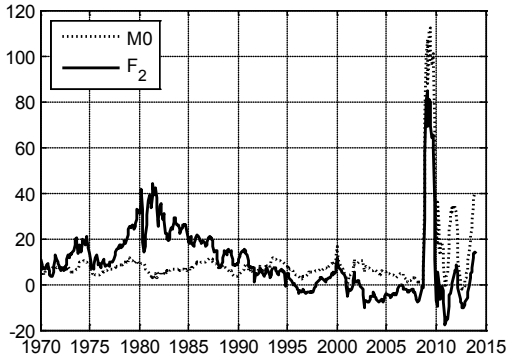
In per cent

Graph 1

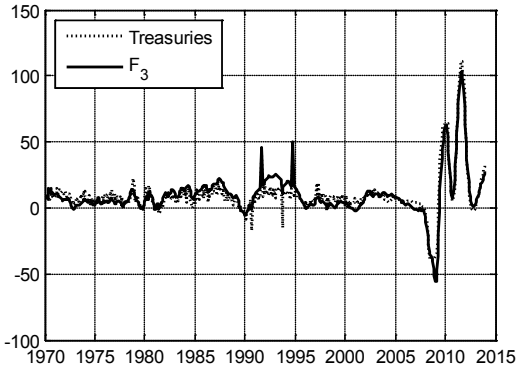
Factor 1[1] and the federal funds rate



Factor 2[1] and monetary base[2]



Factor 3[1] and securities' held[3]



[1] The factors are rescaled (and in the case of factors 2 and 3, multiplied by –1) to match observed series. [2] Year-on-year rate of growth. [3] Year-on-year rate of growth of the outstanding amount of treasuries held by the Fed.

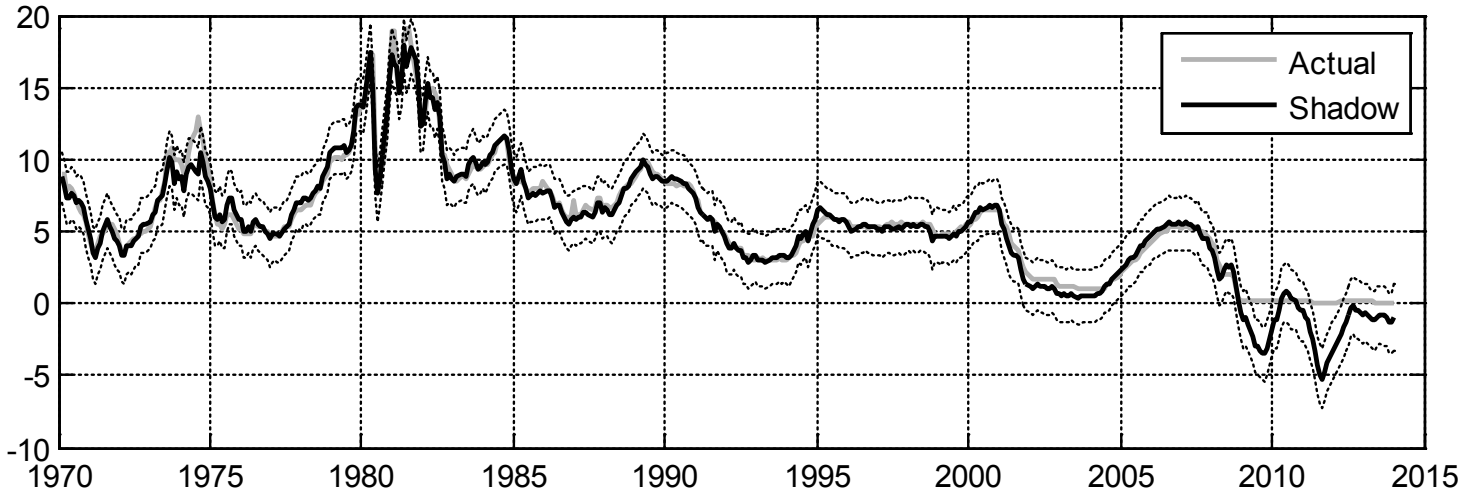
Sources: Federal Reserve, authors' calculations.

What do we get?

Shadow[1] and actual federal funds rate[2]

In per cent

Graph 2



[1] Solid black line; the dotted lines represent the 95% confidence interval. [2] Grey line.

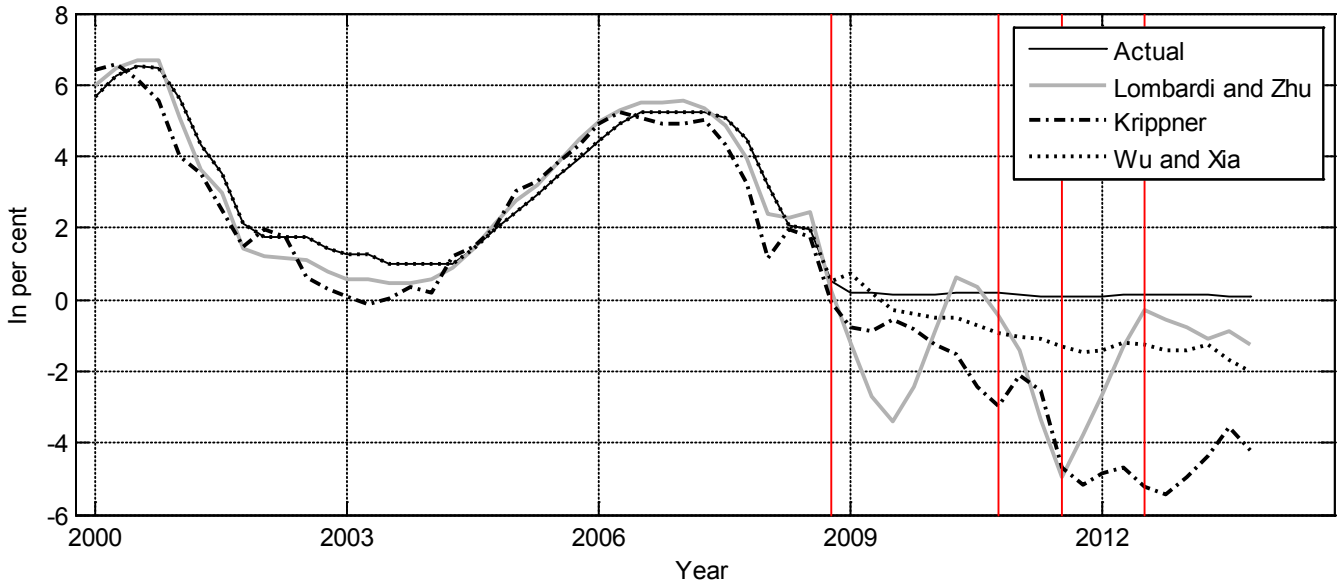
Sources: Federal Reserve, authors' calculations.

How does this compare with other shadow rates?

Alternative estimates of the shadow federal funds rate[1]

In per cent

Graph 7



[1] The red vertical lines correspond to the dates of introduction of the major asset purchase programmes implemented by the Federal Reserve: LSAP1 (November 2008), LSAP2 (November 2010), MEP (September 2011) and LSAP3 (September 2012).

Sources: Federal Reserve, Krippner (2013a), Wu and Xia (2014), authors' calculations.

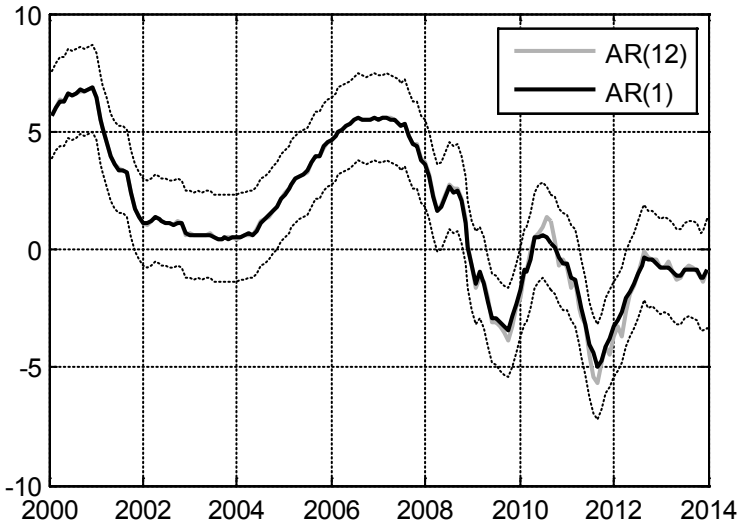
Is it robust to the model specification?

Robustness of the shadow FFR to model specification[1]

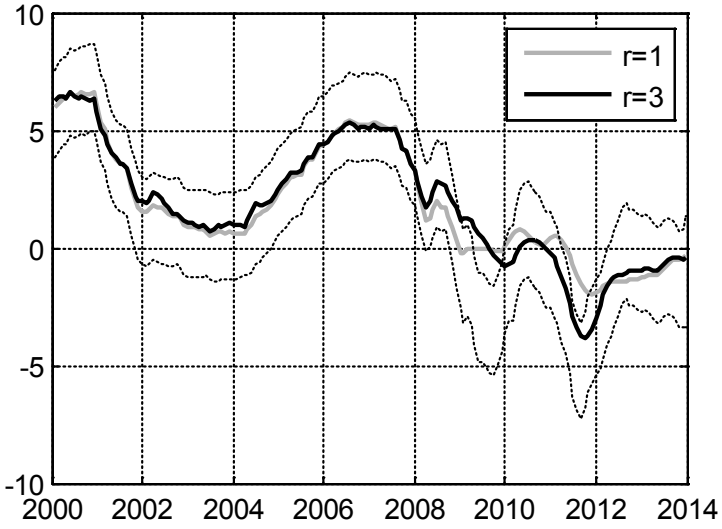
In per cent

Graph 4

Lag order[2]



Number of factors[3]



[1] The dotted lines represent the 95% confidence interval of the baseline specification (2 lags, 8 factors). [2] The solid black line refers to one lag, the grey line to three lags. [3] Black line refers to three factors, as per Bai and Ng (2007) criterion, grey line to one factor.

Source: Authors' calculations.

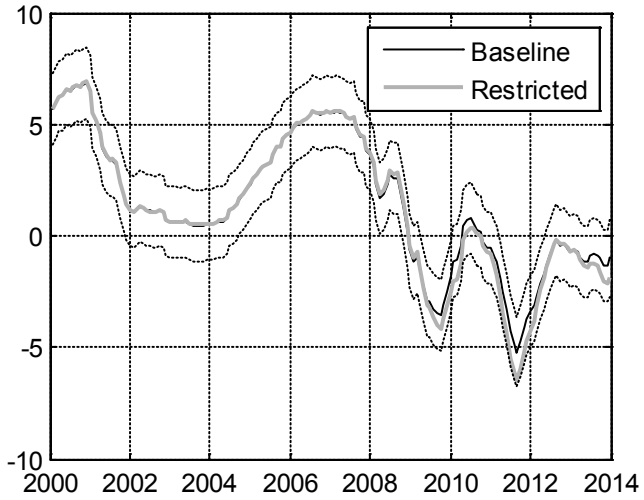
Is it robust to the selection of the series?

Robustness of the shadow FFR to data selection[1]

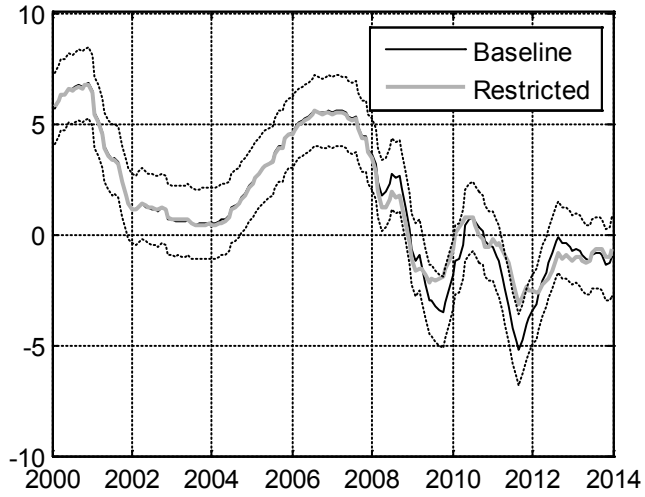
In per cent

Graph 5

Excluding maturity structure of government bonds[2]



Excluding balance sheet items[3]



[1] The black lines refer to the baseline specification on the full dataset, together with 95% confidence bands. [2] The grey line refers to a restricted dataset, from which we exclude the series on the maturity composition of the Fed's holdings of government bonds. [3] The grey line refers to a restricted dataset from which we exclude the series on the maturity composition of the Fed's holdings of government bonds, as well as all balance sheet items.

Source: Authors' calculations.

So, was monetary policy too loose?

- Compare the shadow FFR against the prescription of Taylor rules:
  - Taylor (1993): $i = \pi + 0.5y + 0.5(\pi - 2) + 2$
  - Taylor (1999): $i = \pi + y + 0.5(\pi - 2) + 2$
    - Output and unemployment gap (CBO estimates)

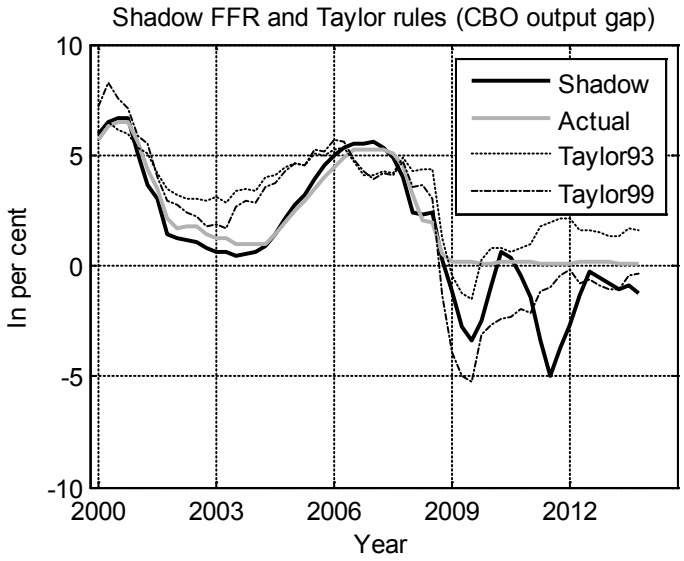
Depends…

Shadow FFR and Taylor rule prescriptions[1]

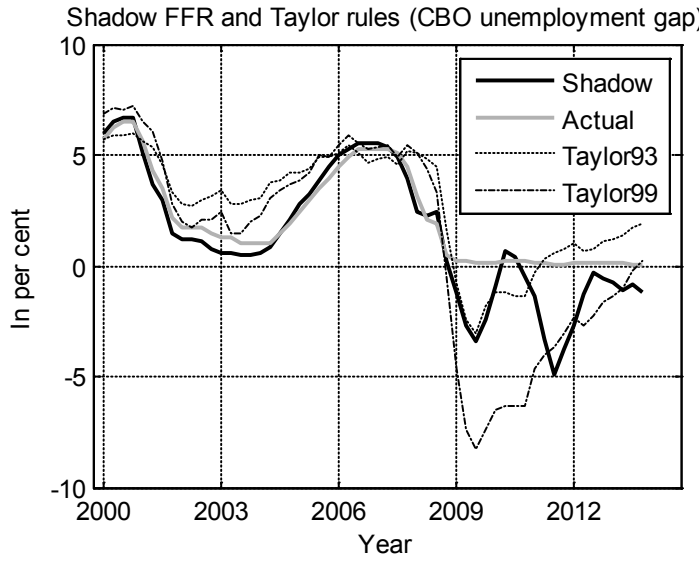
In per cent

Graph 6

Output-gap based Taylor rules[2]



Unemployment-gap based Taylor rules[3]



[1]The black lines refer to the estimated shadow federal funds rate and the grey line refers to the actual effective federal funds rate. Numbers on the horizontal scale are placed to indicate the start of the year. [2] The comparison is made against Taylor (1993) and Taylor (1999) rules based on CBO estimates of potential output. [3] The comparison is made against Taylor (1993) and Taylor (1999) rules based on CBO estimates of long-term NAIRU.

Source: Authors' calculations.

When has the Fed provided more stimulus?

- We estimate two standard monetary VARs
  - Bernanke and Blinder (1992):
    - GDP, GDP deflator, FFR
  - Christiano, Eichenbaum and Evans (1996):
    - GDP, GDP deflator, commodity prices, non-borrowed reserves, FFR, total reserves
- Sample 1970Q1-2013Q4, 4 lags
- Both are based on Choleski identification

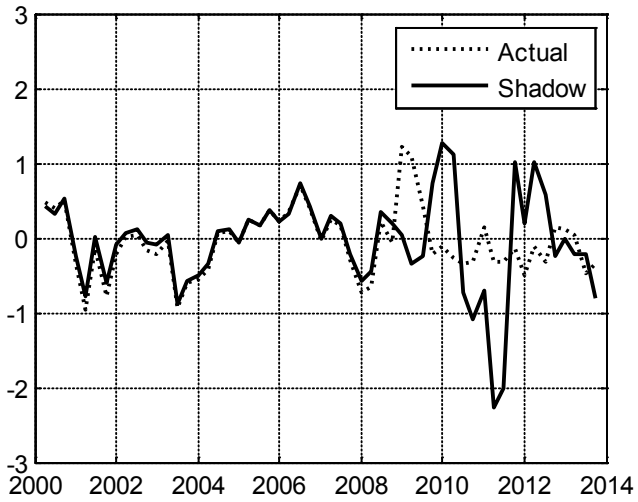
With LSAP2!

Monetary policy shocks[1]

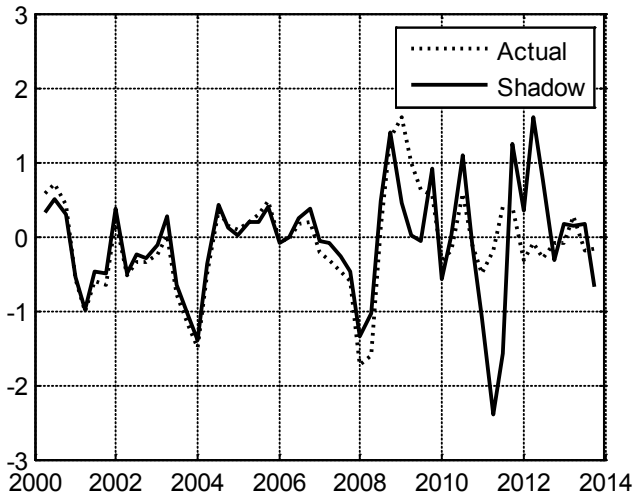
In per cent

Graph 8

Bernanke and Blinder (1992)[2]



Christiano, Eichenbaum and Evans (1996)[3]



[1] Structural shocks are extracted using recursive Choleski schemes; estimation is based on data from January 1970 until December 2012. The dashed line corresponds to a model estimated with actual FFR, while the solid line refers to the shadow FFR series. [2] The model features (in order) the log of real GDP, the log of the GDP deflator and the FFR. [3] The model features (in order) the log of real GDP, the log of the GDP deflator, the log of commodity prices, the log of non-borrowed reserves, the FFR and the log of total reserves.

Source: Authors' calculations.

To wrap up

- We provide a shadow rate which is entirely data-driven
  - As such, it reflects changes in the balance sheet of the central bank more directly

- The shadow rate should be used as a tool for applied analysis
  - For example, it can be plugged in VARs
  - We provided an illustration of this

To-do-list

- Use the shadow rate to assess international spillovers of US monetary policy
- Extend to other countries: JP, UK, CH
- For the euro area, create country-specific measures of monetary policy