



FEDERAL RESERVE BANK *of* NEW YORK

The Federal Reserve in the 21st Century

Models for Forecasting and Policy Analysis

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The views expressed in this presentation are those of the presenter and not necessarily those of the Federal Reserve Bank of New York or The Federal Reserve System

Outline

- Introduction: Monetary Policy and the Economy
 - Fed's organization and mandate
 - Summary of Economic Projections (SEP)
 - How does monetary policy affect the economy?
- Economic forecasts
 - Essential role of forecasts
 - Judgmental forecasts
 - Model-based forecasts
- Monetary policy strategy
 - Policy using models
- Conclusion



Introduction: Monetary Policy and the Economy

The Federal Reserve: Organization

- Board of Governors (BOG), Washington, DC
 - 7 governors: 14-year terms, appointed by president
 - Including Chair (Janet Yellen, 2014-...): 4-year term renewable
- 12 Regional Federal Reserve Banks
 - Part private, part government institutions
- **Federal Open Market Committee (FOMC)**
 - Governors + FRB Presidents
 - Meets 8 times per year:
 - Assesses economic and financial conditions, risks to long-run goals
 - Votes on actions that affect money supply and interest rates
 - Issues: statement, minutes (3 weeks lag), transcripts (5 years lag), summary of economic projections (SEP) and press conference quarterly



The Fed's Mandate

General goals: foster economic prosperity and promote social welfare

More specific objectives are established by the government

- Goals of monetary policy (Federal Reserve Act, Section 2A):
 - “The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and credit aggregates commensurate with the economy's long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates”
 - “maximum employment” and “stable prices” = Fed's dual mandate



FOMC Statement of Longer-Run Goals

Interpretation of dual mandate: Statement on 'Longer-Run Goals and Monetary Policy Strategy' (*adopted in 2012, most recently amended in Jan 2017*)

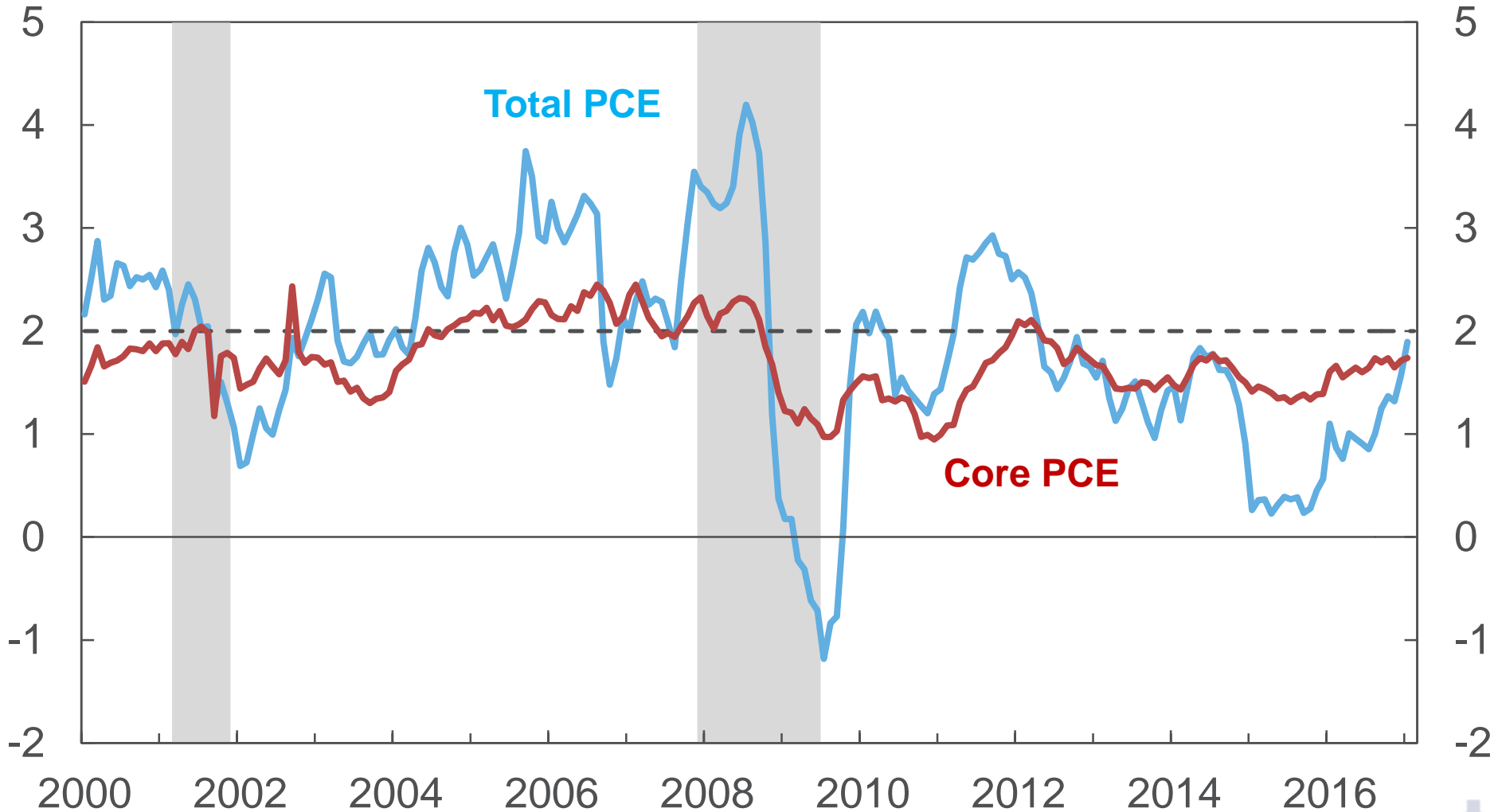
- **Price stability** → longer-run goal for inflation
 - Inflation at the rate of 2 percent is most consistent over the longer run with the Fed's statutory mandate
 - Measured by the annual change in the price index for personal consumption expenditures (PCE), a comprehensive measure of prices faced by US households
- **Maximum employment** → no fixed goal
 - Policy decisions must be informed by assessments of the maximum level of employment, based on a wide range of indicators
 - Assessments uncertain and subject to revision
 - Estimates of the longer-run normal rates of output growth and unemployment published in *Summary of Economic Projections* (SEP)
 - March 2017 SEP: longer-run normal rate of unemployment is between 4.7 and 5.0 percent (central tendency)



Total and Core PCE Inflation in Recent Years

% Change – Year to Year

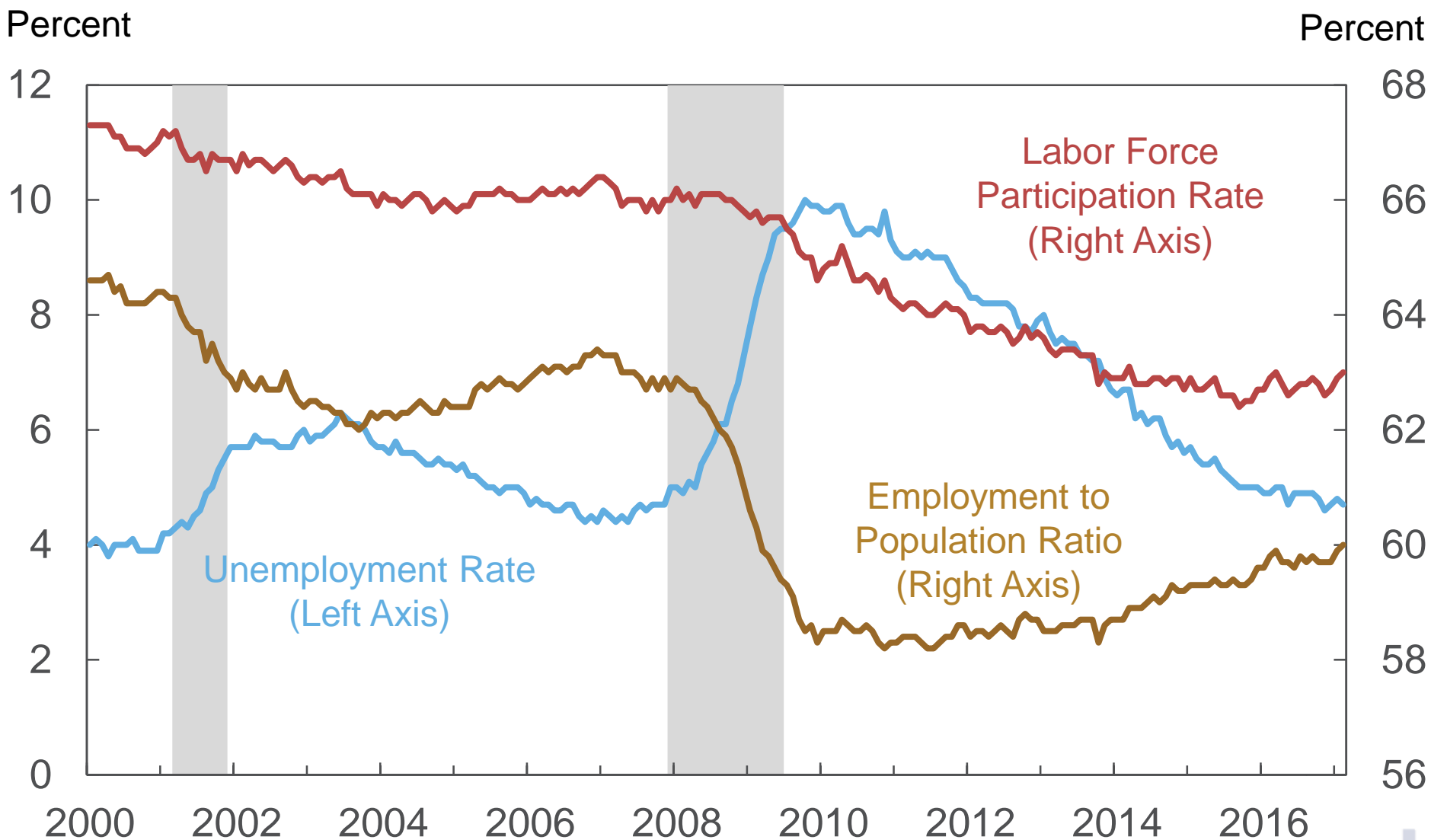
% Change – Year to Year



Source: Bureau of Economic Analysis

Note: Grey shading shows NBER recessions

Recent History of the US Labor Market



Source: Bureau of Labor Statistics

Note: Grey shading shows NBER recessions

Summary of Economic Projections (SEP)

- Every other FOMC meeting (March / June / September / December)
- Each FOMC participant submits economic projections:
 - Based on each FOMC participant's assessment of *appropriate monetary policy*
 - For each FOMC participant, projections combine both forecast of evolution in economic conditions and preferred policy path (which may differ from policy path chosen by the committee as a whole)
- Longer-run projections represent each participant's assessment of the rate to which each variable would be expected to converge under appropriate monetary policy and in the absence of further shocks to the economy



Projections vs Goals: From the Latest SEP



Source: Summary of Economic Projections, March 15th, 2017

The Importance of Projections



From the March 2017 FOMC statement :

- In view of realized and **expected** labor market conditions and inflation, the Committee decided to raise the target range for the federal funds rate to 3/4 to 1 percent. The stance of monetary policy remains accommodative, thereby supporting some further strengthening in labor market conditions and a sustained return to 2 percent inflation.

Note: FOMC *expectations* are based on the presumption that there will be *appropriate policy accommodation*.

How Does Monetary Policy Affect the Economy?

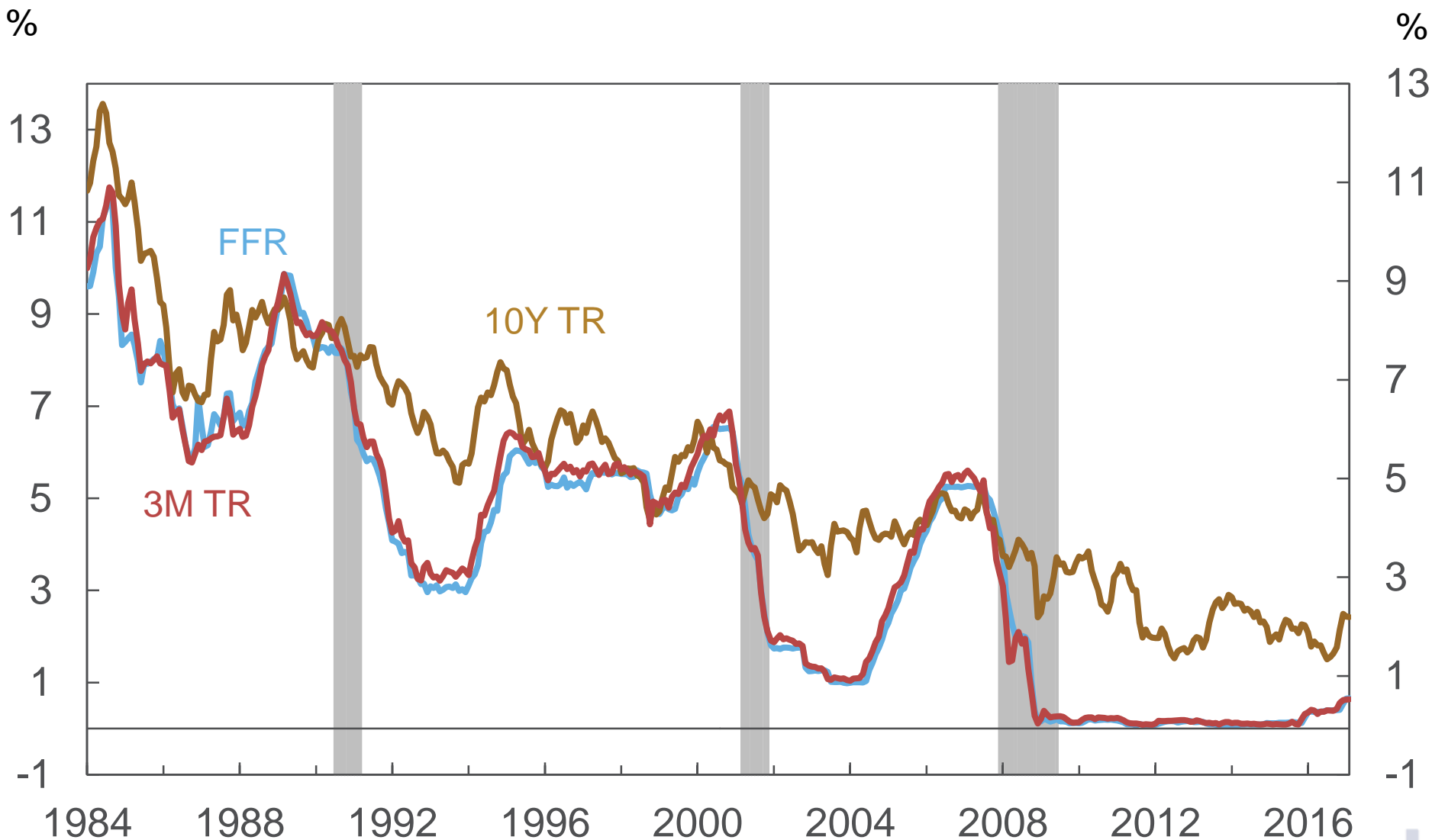
- **Conventional Policy:** Fed sets the Federal funds rate (FFR)
- Current and expectations of future FFR affect **financial conditions**:
 - Other interest rates and borrowing costs: short-term interest rates (e.g., Treasury bills), longer-term interest rates (e.g., Treasury bonds, mortgages, corporate bonds)
 - Foreign exchange value of the dollar
 - Asset prices (e.g., stocks, ...)
 - financial sector's **balance sheets** → amount of lending
- Financial conditions influence households' and businesses' spending decisions, as well as financial sector's lending, and hence **aggregate demand**, production, employment, and ultimately inflation
- But policy affects the economy with **“long and variable lags”** (M. Friedman)

Policy Instruments – Unconventional Policy

- When FFR is close to **zero**, cannot be lowered more (zero lower bound)
- **Forward guidance**
 - FOMC makes announcements about its intentions regarding future path of Federal funds rate
 - Goal: affect long-term rates, as long-term rates depend on market expectations of future short-term rates
- **Large scale asset purchases (LSAP)**
 - Fed buys long-term Treasury securities and Mortgage-Backed Securities (MBS)
 - Goal: affect long-term rates and mortgage rates, asset prices
- **Policy with a large Federal Reserve balance sheet**
 - IOER and ONRRP: see next presentation



Fed Funds Rate, 3-month and 10-year Treasuries



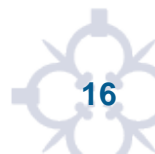
Source: Federal Reserve Board

Note: Grey shading shows NBER recessions

Economic Forecasts

Essential Role of Forecasts

- Because policy has persistent and lagged effects, the FOMC needs to assess:
 - The current state of the economy
 - How it is likely to evolve, conditional on a particular policy path
- ➔ Economic **forecasts** are essential for conduct of policy
- A forecast = set of numbers + narrative
 - What assumptions are behind the forecast?
 - What are the risks to the central forecast?
 - alternative “scenarios”



Types of Forecasts

- Judgmental forecasts
 - Bottom-up
- Model-based forecasts
 - Empirical models (VAR, Factor models)
 - Structural models (DSGE)
 - Large-scale semi-structural: e.g., FRB/US
- Analysis of 'risks' around modal scenario



Judgmental Forecasts

- Used for:
 - FRBNY central forecast
 - Board's staff forecast (“Tealbook”, i.e., former “Greenbook”)
 - Many private sector forecasts
- “Bottom-up” approach
- Use a **collection of models** and comparisons to past episodes to help generate projections for various blocks (or sectors):
 - Consumption, government spending, etc.
- Frequently include “add factors” in equations
- GDP forecast computed by aggregating sectoral inputs
- Forecasts of other variables (e.g. inflation, employment) derived using GDP forecast as input

Why Judgmental Forecasts?

- Judgmental forecasts can be much more timely than models' projections
 - As they can readily incorporate any type of information
- Need to provide a “narrative” and details behind forecast
 - “Narrative”: explanation of current developments and implications for outlook
 - “Bottom-up” aggregation helpful in this regard
- Other models not yet able to deliver details tractably



Adding Up “Current Quarter” GDP

- Much forecasting effort focuses on “**nowcasting**”
 - Estimating the next release (e.g., 2017:Q1)
- Want to understand how current developments may spill over to aggregate activity
 - Examples: weather, oil price change, government shutdown, ...
- Use wide range of **data** series:
 - Directly related to FOMC goals (employment, CPI,...)
 - Primary high-level inputs to GDP estimates
 - Retail sales, construction put-in-place, etc.
 - Sources of information about current or future GDP movements
 - Industrial production, hours worked, manufacturing surveys, ...



Model-Based Forecasts

- Empirical models
 - Vector Auto-Regressions (VAR)
 - Factor models
- Structural models
 - DSGE
- Large-scale semi-structural:
 - e.g., FRB/US



Empirical Models

- Vector Auto-Regressions (VAR):

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + e_t$$

- Y_t vector of small number of key macroeconomic variables
- $A_1, A_2 \dots$ matrices of estimated coefficients (using regressions)

- Factor models (FRBNY Nowcast):

$$X_t = B Y_t + u_t$$

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + e_t$$

- X_t may contain a very large number of data series
- Y_t contains some potentially latent “factors”
- Estimate matrices $A_1, A_2 \dots, B$, and vectors of factors $Y_t, Y_{t-1} \dots$

Why VARs, Factor Models?

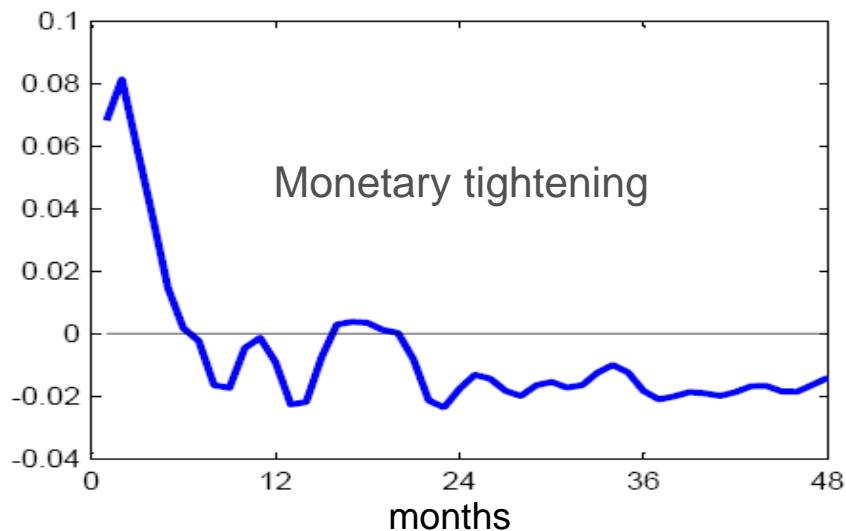
- Exploit historical relationships between various data series
- Impose few restrictions
- Good to explain dynamic effects of shocks (e.g., FFR increase, oil-price shock, ...) on key variables
- Factor models can trace impact of shocks on broad set of variables
- Provide relatively good forecasts
- Downsides:
 - Black box: Don't provide a “narrative”
 - Assume that historical relationship will continue to hold
 - May be inappropriate for alternative policy simulations



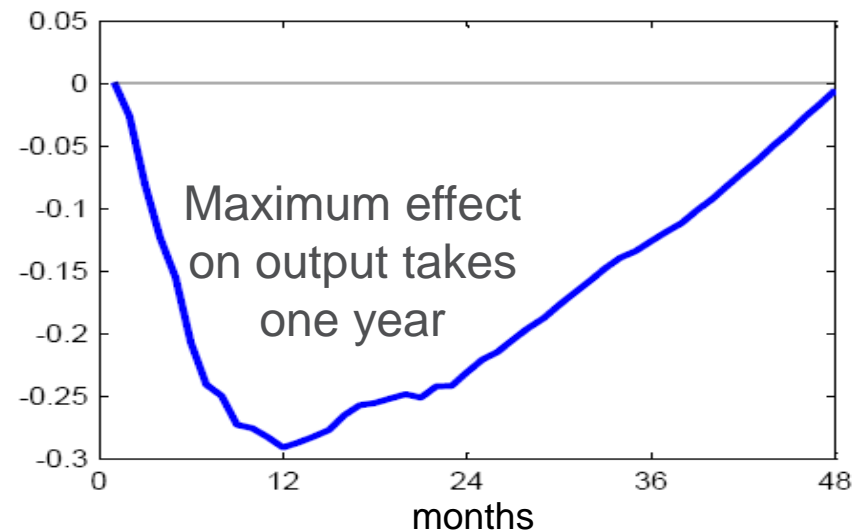
Typical Exercise: Effects of Monetary Policy

Estimated responses to monetary tightening

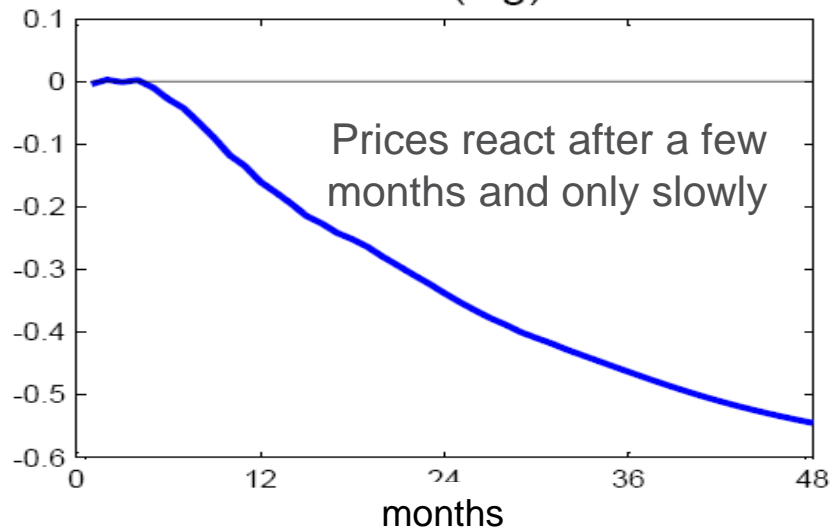
Federal Funds Rate



Industrial Production



Price level (log): PCE



Monetary policy affects the economy with a lag

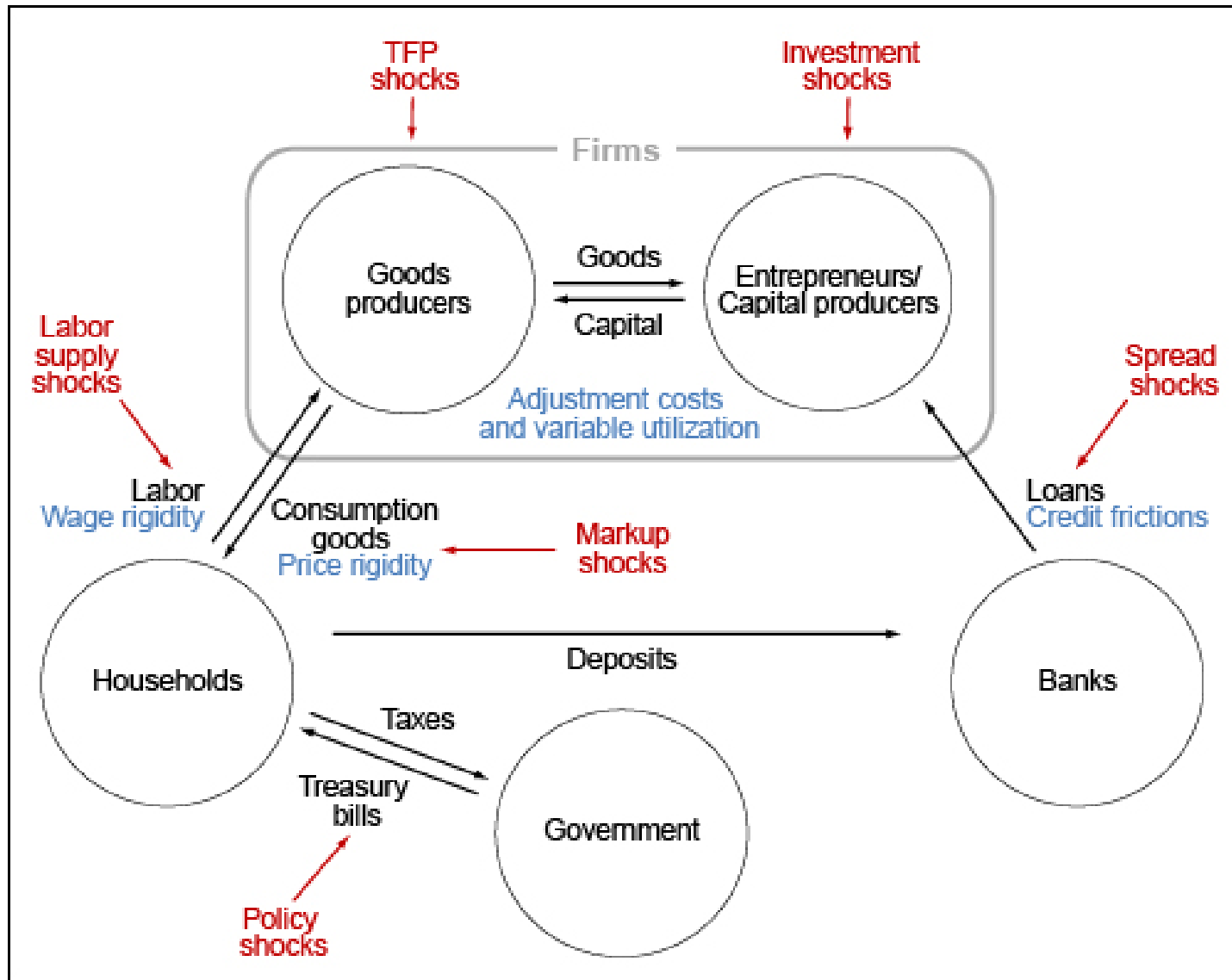
Dynamic Stochastic General Equilibrium (DSGE) Models

- Stylized representation of reality based on economic theory
- Focus on key interactions among critical economic actors:
 - Households: which work and consume
 - Firms: employ capital and labor to produce
 - Banks: intermediate credit between savers and borrowers
 - Government: sets fiscal and monetary policy
- **D = dynamic**: Agents' choices take into account both current and future expected conditions
- **S = stochastic**: Agents face uncertain circumstances when making decisions and environment subject to random disturbances, called “shocks”
- **GE = general equilibrium**: All prices, wages, financial prices are determined simultaneously by aggregate behavior of all agents



Structure of FRBNY DSGE Model

— Frictions — Shocks



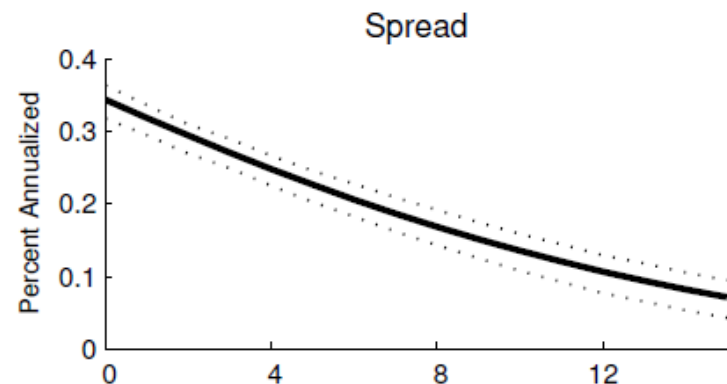
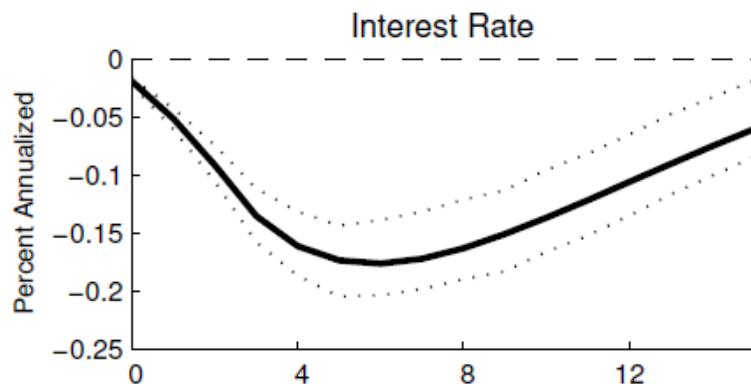
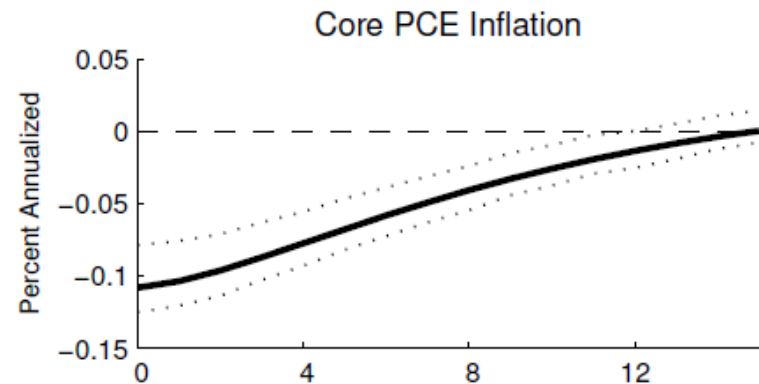
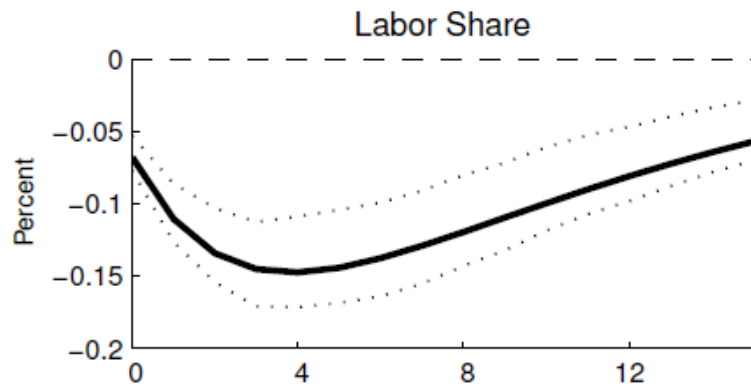
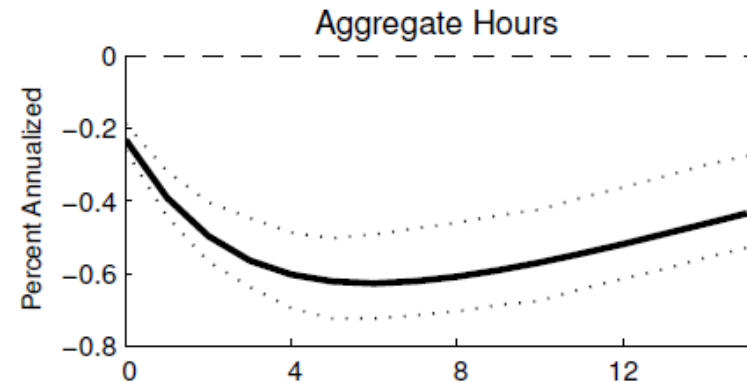
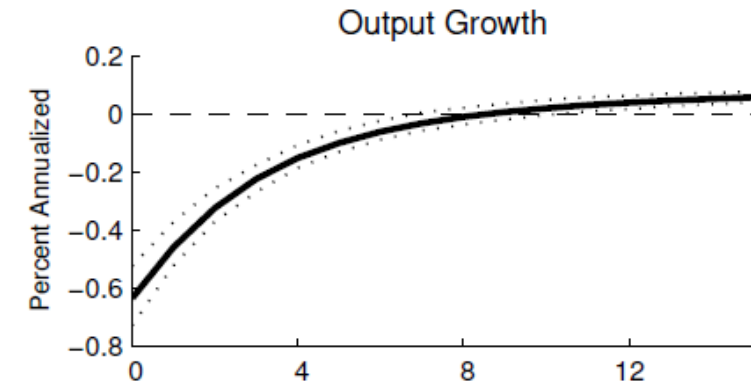
DSGE Model Estimation

- Model **parameters** and underlying **shocks** estimated via Bayesian methods
 - Combine prior information on the parameters with information about key data series
- Data series used in current FRBNY-DSGE model:
 - Real GDP, real GDI, Consumption, Investment
 - GDP deflator, PCE core deflator
 - Wages, hours worked, total factor productivity
 - Federal funds rate (FFR), 10-year yield, spread (Baa-10y yield)
 - FFR expectations, inflation expectations
- Model and computer codes made public; FRBNY DSGE forecasts made public twice a year. See *Liberty Street Economics* blog:
 - <http://libertystreeteconomics.newyorkfed.org/2014/09/forecasting-with-the-frbny-dsge-model.html>
 - <http://libertystreeteconomics.newyorkfed.org/2017/02/the-frbny-dsge-model-forecast-february-2017.html>

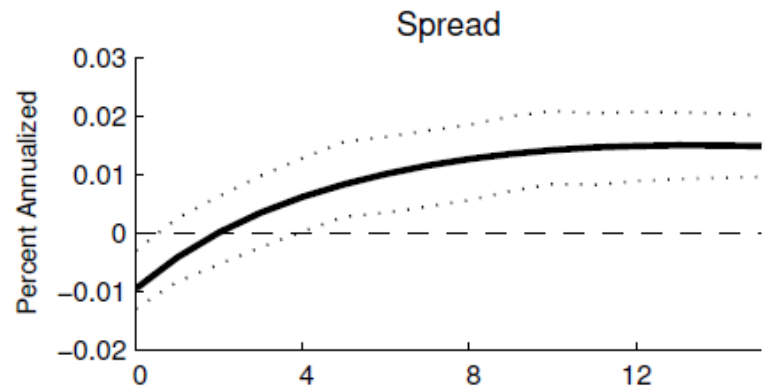
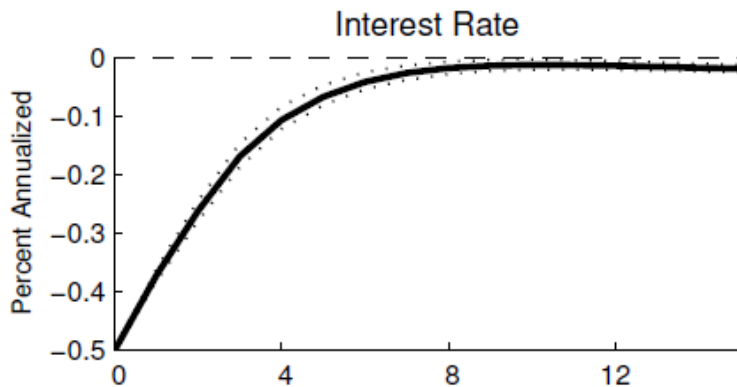
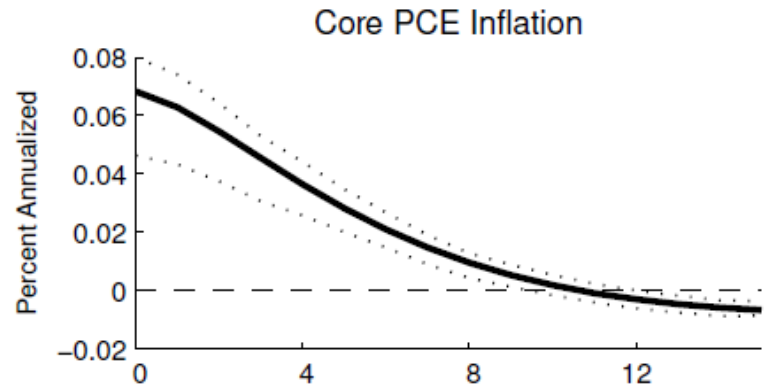
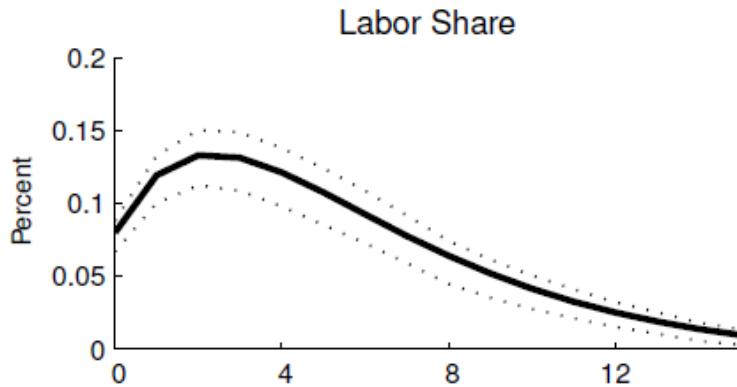
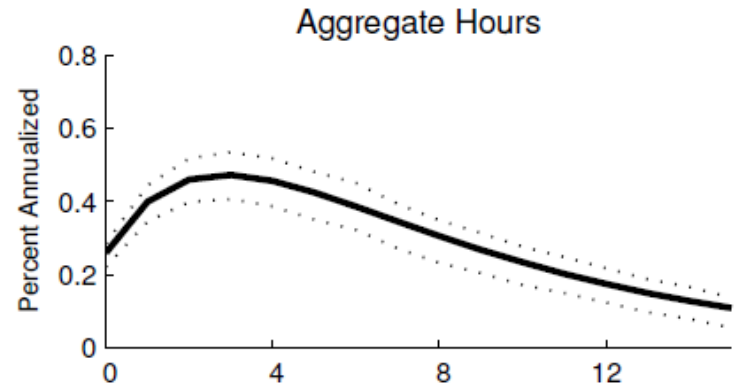
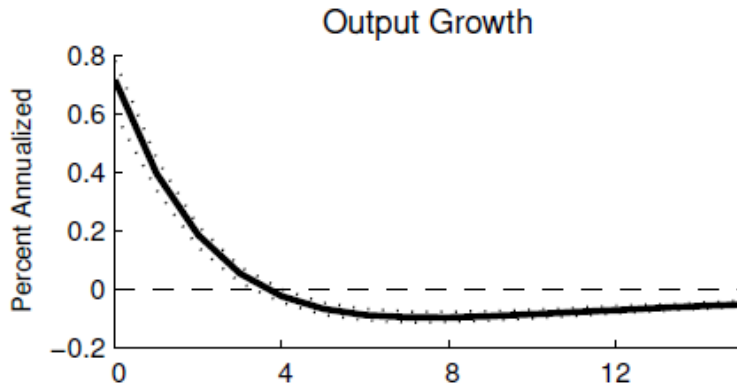
Why a DSGE Model?

- Coherent story for interpreting macroeconomic outcomes
- Optimally combines theoretical knowledge with data
 - Allows to compute unobserved concepts of interest
- Laboratory for **policy experiments**
 - Economic relationships expected to remain invariant to experiments
 - In contrast, (non-structural) empirical relationships are likely to change with alternative policies
 - With monetary policy operating in uncharted waters (e.g. forward guidance, ...) theory has become more essential than ever to guide policy analysis
 - No historical precedent to measure effects of new policies
- Recent DSGE models tend to perform relatively well for forecasting
 - Especially at the horizon of several quarters out

Transmission Mechanism: I. Spread Shocks

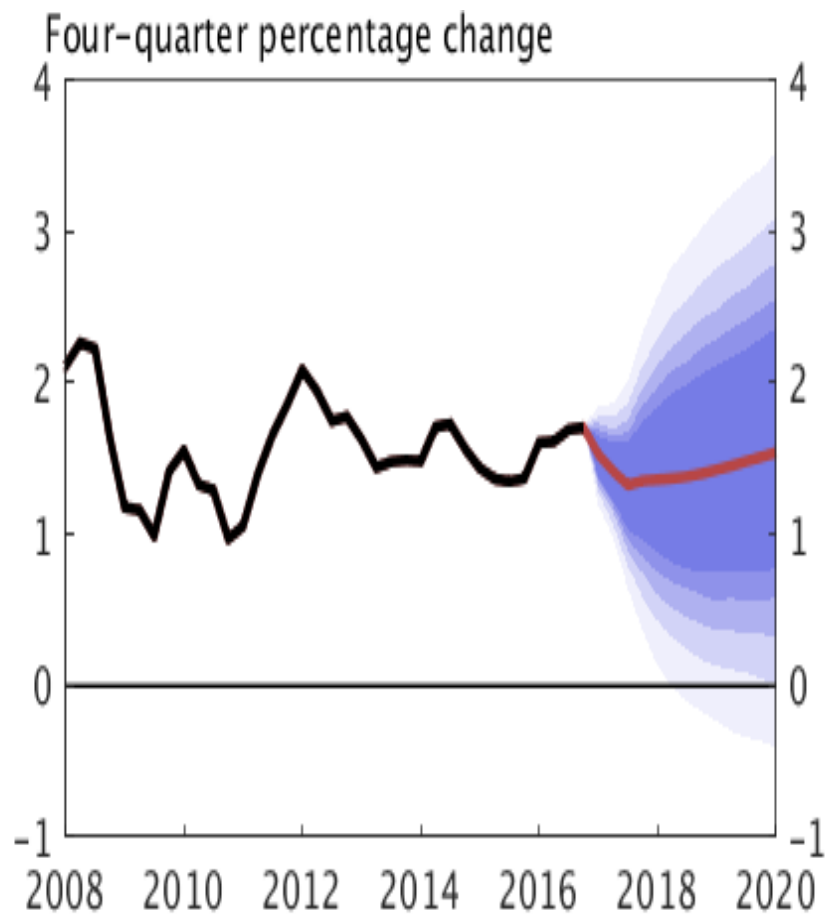


Transmission Mechanism: II. Policy Easing

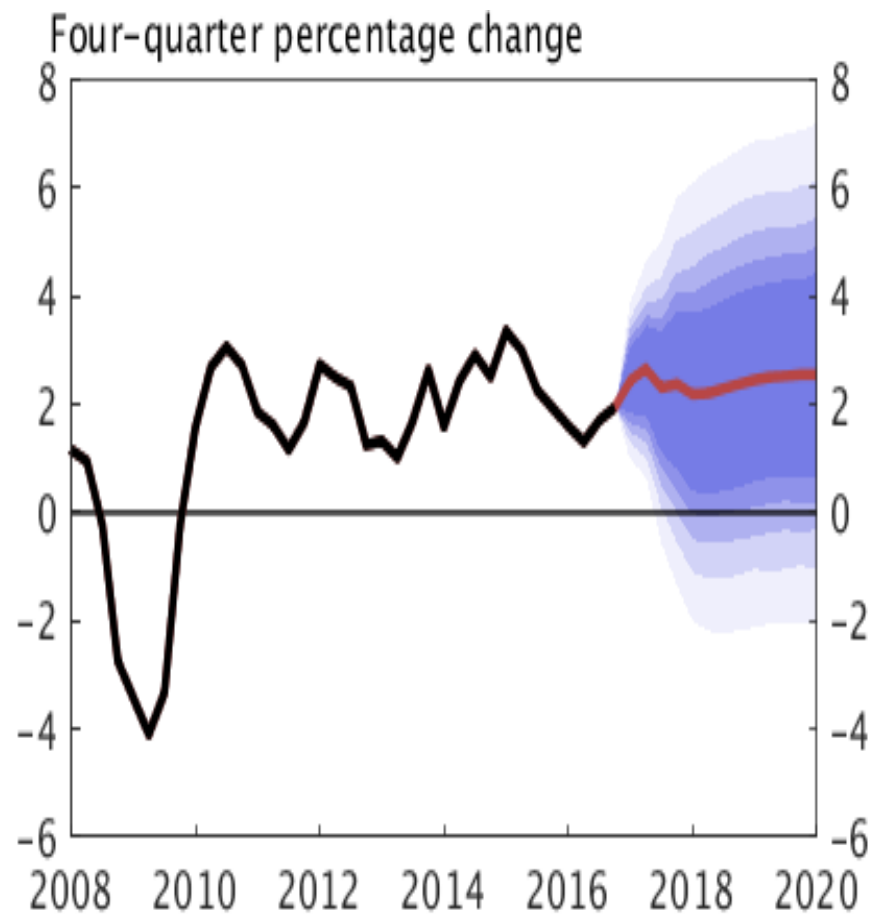


February 2017 FRBNY DSGE Projections

Inflation



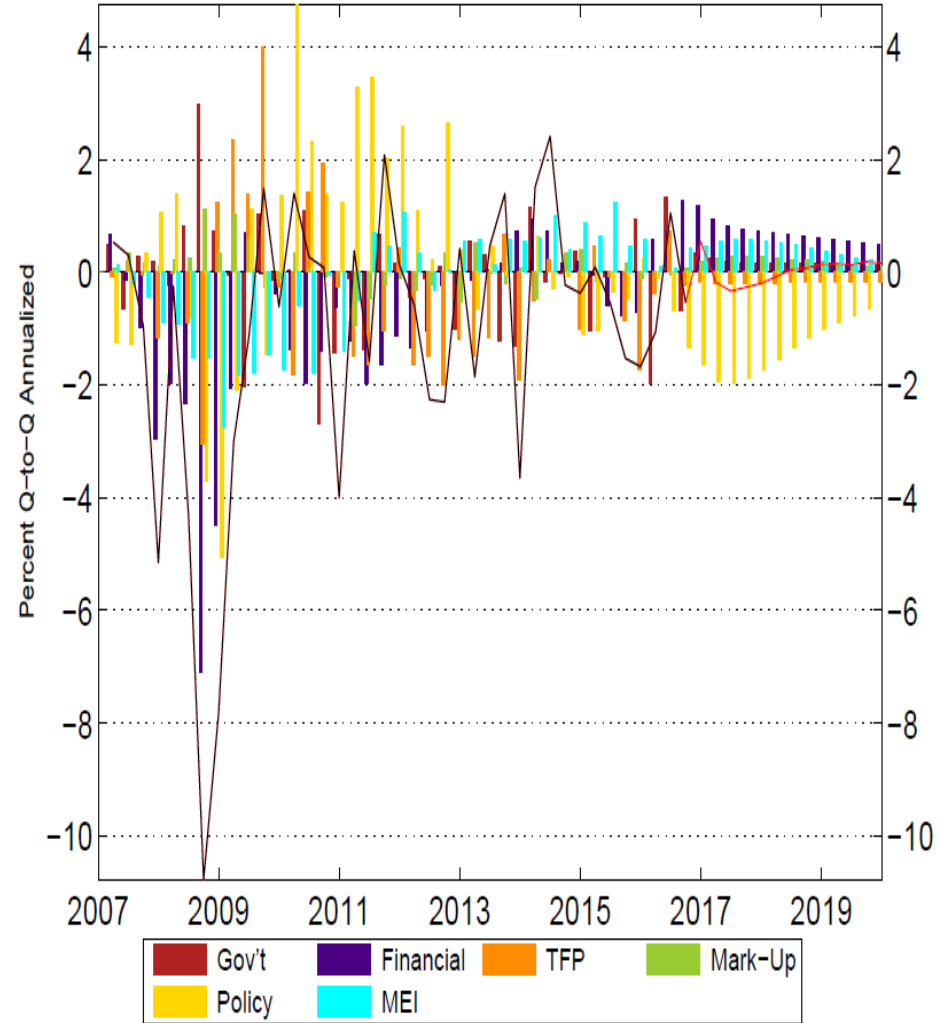
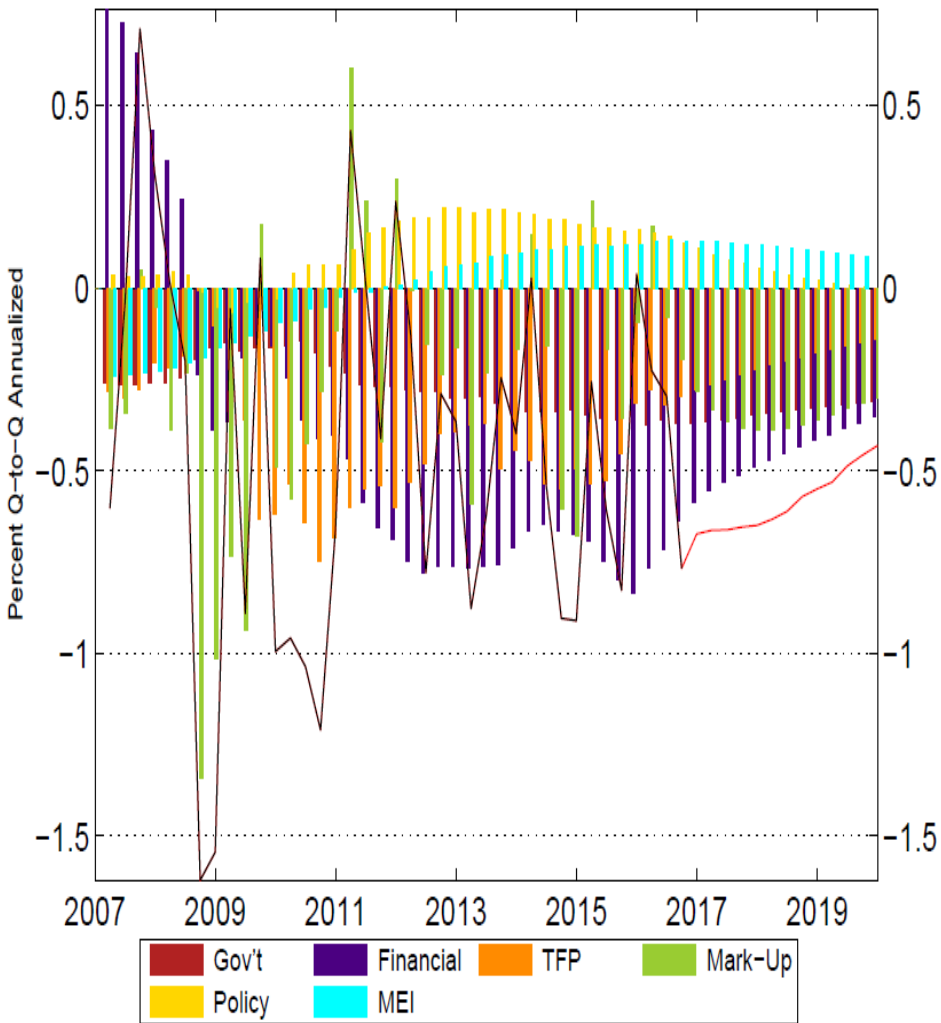
Output Growth



The “Story” Behind the Forecasts

Inflation

Output Growth

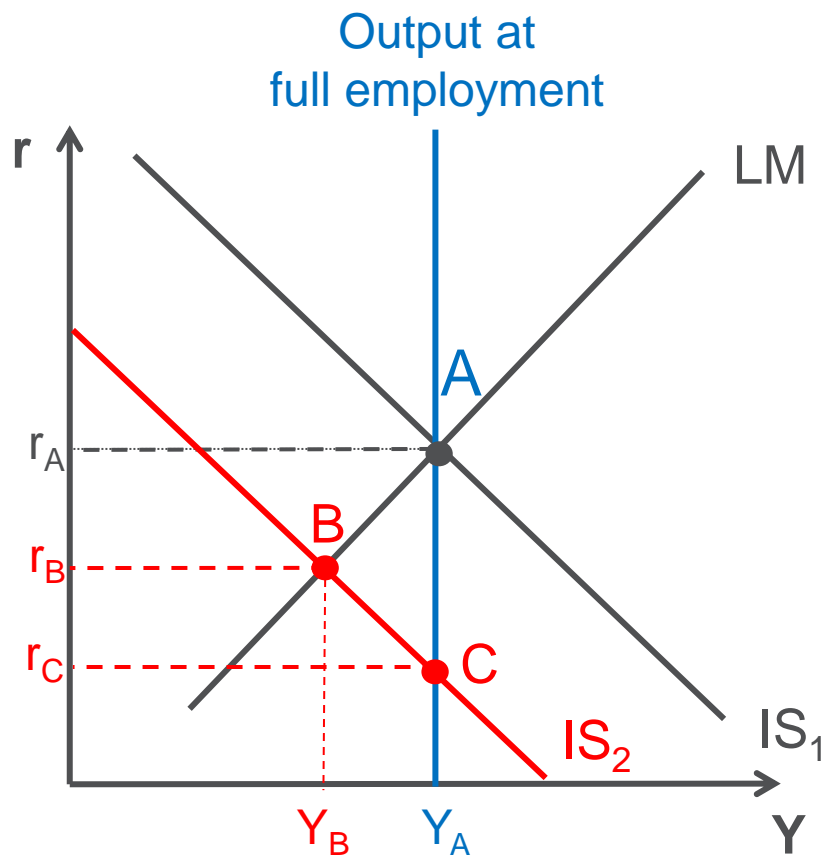


Models Useful to Estimate Unobserved Concepts

- Fed Chair Yellen, Dec 2, 2015:
 - “[...] economic conditions may, for some time, warrant keeping the target federal funds rate below levels the Committee views as normal in the longer run.
This expectation is consistent with an implicit assessment that the *neutral nominal federal funds rate* -- defined as the value of the federal funds rate that would be neither expansionary nor contractionary if the economy were operating near its potential -- is currently low by historical standards and is likely to rise only gradually over time.”
- The Real “Natural” Rate of Interest r^* :
 - Real interest rate that equates desired saving and investment if output were at its full-employment level
 - r implied by IS curve, when output is at full employment

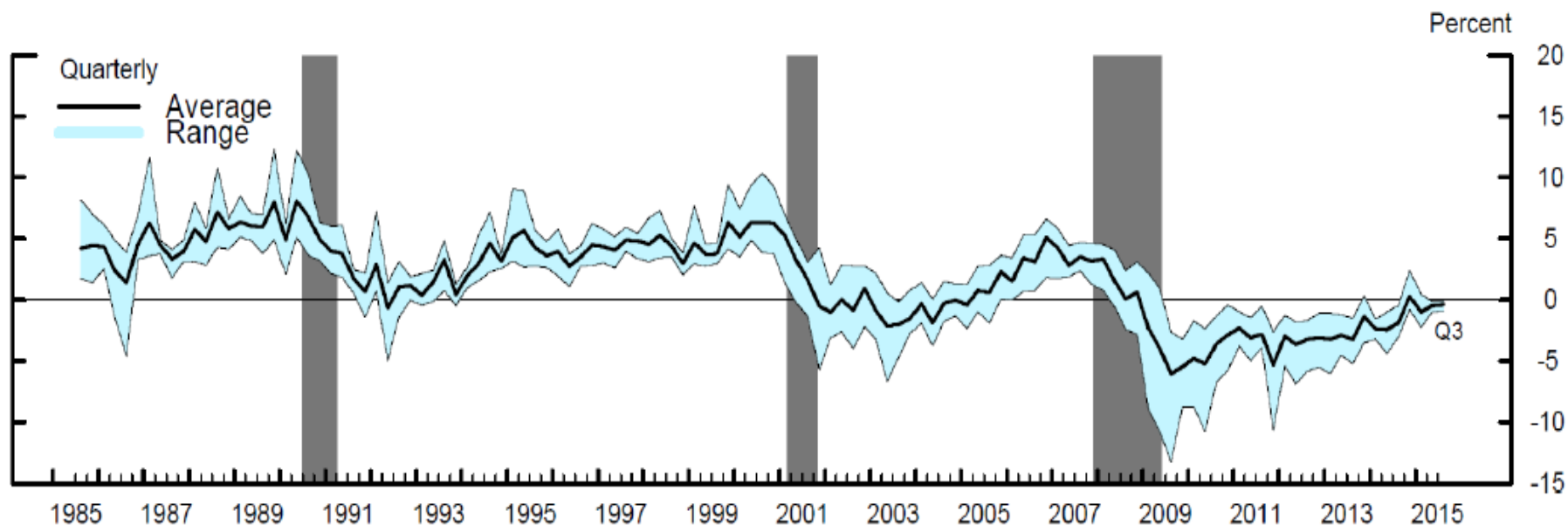
Real Natural Rate (r^*) and IS-LM

- Start at full employment (A): $\{Y_A, r_A\}$
- Suppose downward shift in IS (e.g., drop in wealth, ...)
- If r is lowered to r_B (e.g., if money supply is constant): recession
- Natural rate of interest is now r_C : level consistent with full employment



Natural Rate in Practice

Estimates of the Real Natural Rate of Interest from Different Macroeconomic Models



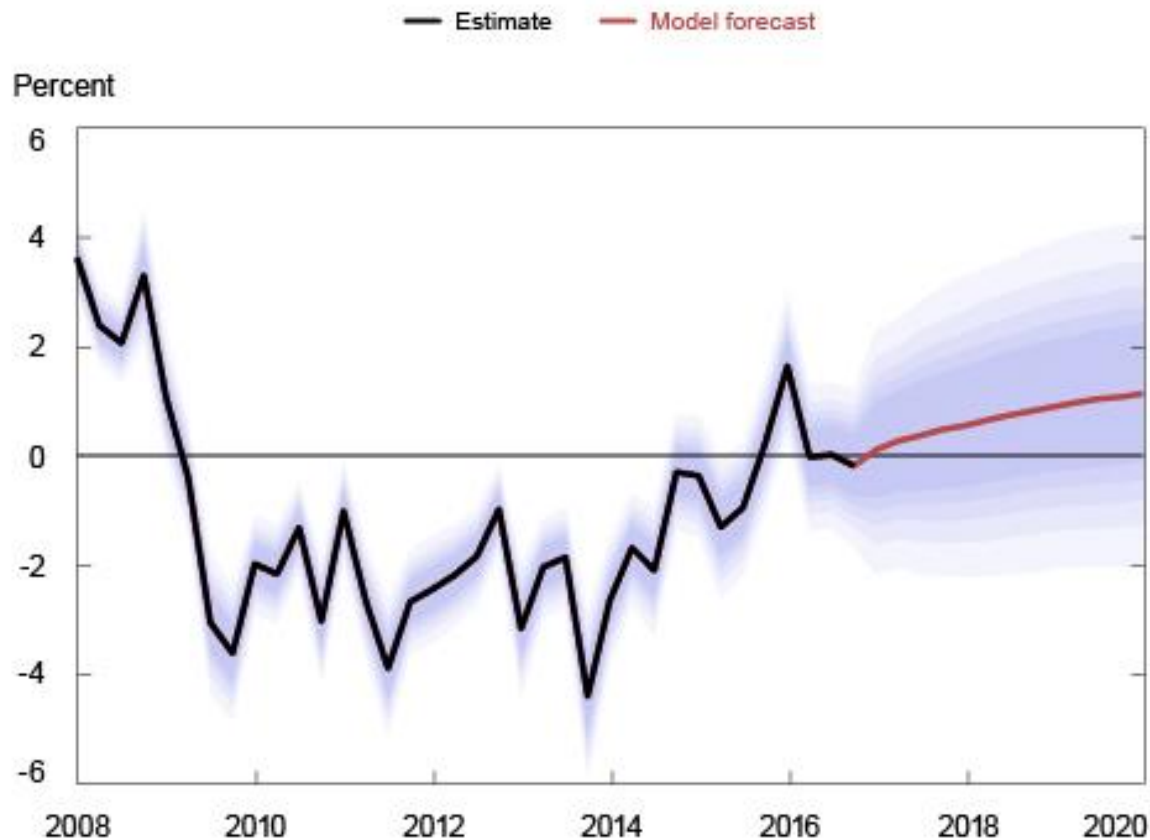
Note: The shaded bars indicate periods of business recession as defined by the National Bureau of Economic Research.

Source: The estimates are drawn from four models: (1) a dynamic stochastic general equilibrium (DSGE) model developed by the staff of the Federal Reserve Board and described in Kiley (2013); (2) a DSGE model developed by the staff of the Federal Reserve Bank of New York and described in Del Negro and others (2013); (3) a DSGE model developed by the staff of the Federal Reserve Board based on Christiano, Motto, and Rostagno (2014); and (4) a DSGE model developed by the staff of the Federal Reserve Board based on Guerrieri and Iacoviello (2013 [rev. 2014]).

Source: Janet Yellen, "The Economic Outlook and Monetary Policy," Economic Club of Washington, 12/2/2015 (<http://www.federalreserve.gov/newsevents/speech/yellen20151202a.htm>)

Natural Rate in Practice

Estimates of the Real Natural Rate of Interest from the FRBNY DSGE Model



Source: Authors' calculations.

Notes: The black line shows the model's mean estimate of the real natural rate of interest; the red line shows the model forecast of the real natural rate. The shaded areas mark the uncertainty associated with the forecasts at 50, 60, 70, 80 and 90 percent probability intervals.

Monetary Policy Strategy

Monetary Policy Strategy

Again, see Statement on 'Longer-Run Goals and Monetary Policy Strategy':

- In setting monetary policy, the Committee seeks to **mitigate deviations (or gaps) of inflation from its longer-run goal and deviations of employment from the Committee's assessments of its maximum level.**
- These objectives are **generally complementary**
 - Means that generally a policy that helps closing the inflation gap also helps closing the employment gap
 - But sometimes there may be **policy trade-offs**: a policy that helps closing the inflation gap may worsen the employment gap, and vice versa
- Under circumstances in which the Committee judges that the objectives are not complementary, it follows a **balanced approach** in promoting them, taking into account the magnitude of the deviations and the potentially different time horizons over which employment and inflation are projected to return to levels judged consistent with its mandate

Role of Communication and Transparency

- Statement on ‘Longer-Run Goals and Monetary Policy Strategy’ provides important information about Fed’s “reaction function”:
 - I.e., specifies how policy will likely respond to shocks and unexpected contingencies
- Crucial for FOMC to be **transparent** about its “reaction function”:
 - Helps anchor market participants expectations (about inflation, etc.)
 - Facilitates decision making for firms, households, financial markets
- Beneficial for FOMC to act in a **systematic** fashion
 - “**Data-dependent**” policy: E.g. loosen monetary policy when economy slows down and inflation falls below target, and tighten when economy overheats, inflation is above target
- Extensive communication is key to effective monetary policymaking

Would a Formal Rule Facilitate Policymaking?

- A simple proposal: **Taylor rule**

$$FFR = 2\% + \pi + 0.5(\pi - 2\%) + 0.5(Y - Y^{FE}) / Y^{FE}$$

Equilibrium real interest rate

Target inflation rate

Output gap

- Formal interest rate rules have some attractive properties
 - Clear link between adjustment of policy rate and deviations from objectives
 - Policy setting is data-dependent
 - Transparent communication
 - Reasonably good guidepost for US monetary policy, from mid-1980s to 2007
- But simplicity is both a virtue and a shortcoming
 - Policy rules do not capture complex link between financial conditions and “optimal” policy
 - Very misleading during and after zero-lower bound episodes
 - If transmission is uncertain and variable, monetary policy cannot be put on autopilot

“Optimal Policy” Using Models

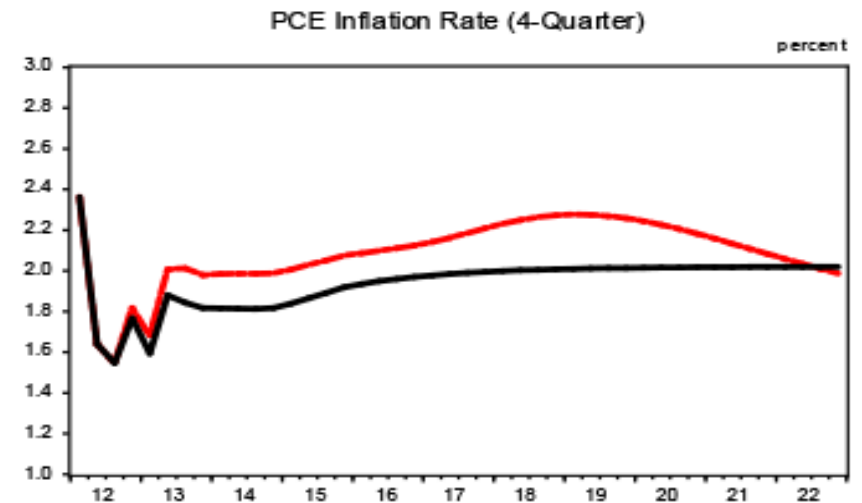
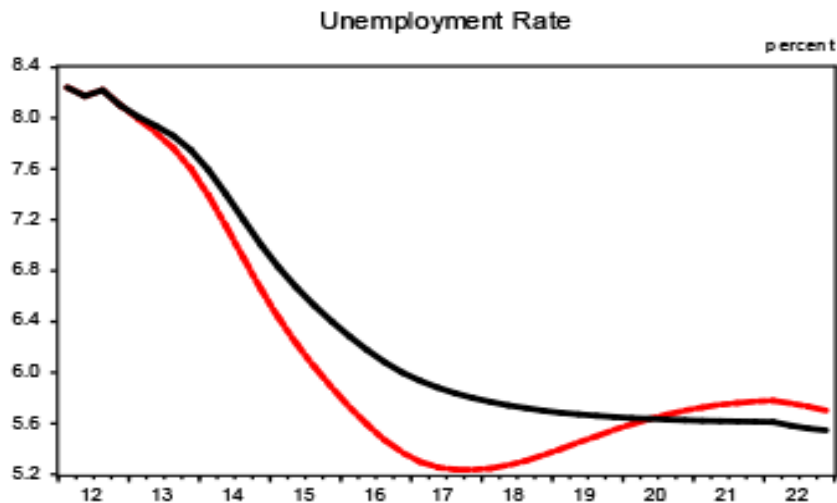
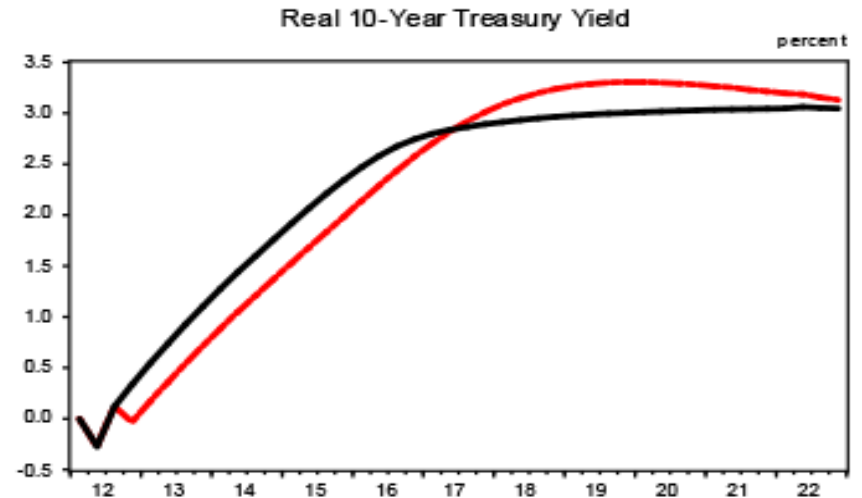
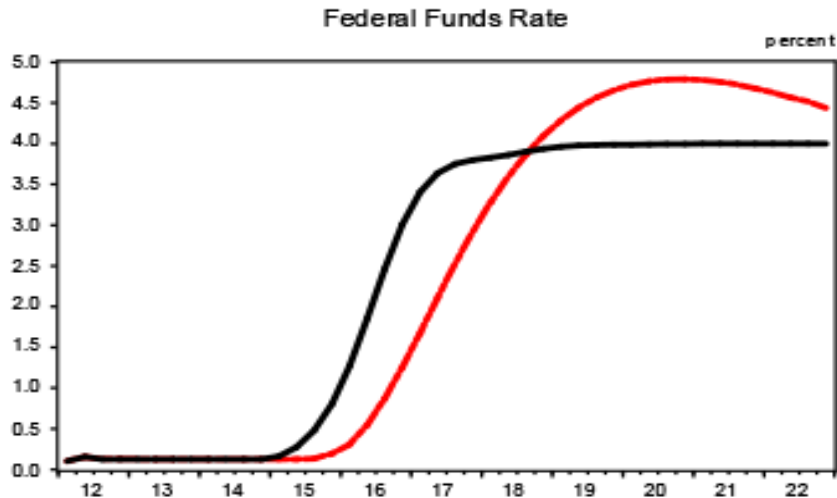
- Fed’s dual mandate can be summarized by a formal objective function:

$$L_0 = \sum_{t=0}^T 0.99^t (\omega_{\pi} (\pi_t - 2)^2 + \omega_u (u_t - u^*)^2 + \omega_i (\Delta i_t)^2)$$

- Captures (squared) deviations of inflation from objective, unemployment u from normal level u^* , and changes in FFR (Δi)
- Model characterizes behavior of economic agents
 - Can be viewed as set of constraints that the Fed is facing when setting policy
- **Optimal policy** = path of FFR that minimizes the objective subject to the constraints imposed by behavior of economic agents

Optimal Policy Using Board's FRB/US Model (2012)

— OC policy using late-2012 model and information — September 2012 SEP-consistent baseline



- **Black lines:** based on September 2012 SEP
- **Red lines:** projections made at end of 2012 conditional on “optimal policy”

Optimal Policy Using Board's FRB/US Model (2012)

- Optimal FFR path implies more accommodation than SEP
 - Delayed FFR lift-off
 - Lower real 10-year Treasury yield for several years
 - Faster decline in unemployment rate
 - Faster return of inflation to 2%
- Implies temporary overshooting of inflation objective and undershooting of normal value of the unemployment rate
 - Such a path generates the financial conditions needed to make more-rapid progress towards goals

- FRBUS model available online:

<http://www.federalreserve.gov/econresdata/frbus/us-models-about.htm>

<http://www.federalreserve.gov/econresdata/notes/feds-notes/2014/optimal-control-monetary-policy-in-frbus-20141121.html>



Conclusion

- A wide range of models is used for **forecasting** and **policy analysis**
 - These models help policymakers understand current state of the economy, its likely evolution, potential risks, and effects of policy actions
 - Judgment remains central
- Federal Reserve has become a lot more **transparent** in recent years
 - Statement about “Longer-Run Goals and Monetary Policy Strategy” codifies FOMC’s “reaction function”
 - SEP and extensive communication provide insights about Fed’s view on the economy and policy actions
 - Should help promote the attainment of its objectives of maximum employment and price stability