The Federal Reserve in the 21st Century

Models for Forecasting and Policy Analysis

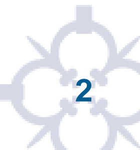
Marc Giannoni, Assistant Vice President
Research and Statistics Group

March 24, 2015

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

- Fed’s organization and mandate
- Survey 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
  - Optimal policy using models
- Conclusion



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)
  - 12 voters:
    - 7 governors of BOG
    - President of Federal Reserve Bank of New York (FOMC Vice Chair)
    - 4 of the remaining 11 FRB presidents on a rotating basis
  - 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
    - Nonvoting FRB presidents participate to discussions
  - Issues: statement, minutes (3 weeks lag), transcripts (5 years lag), summary of economic projections (SEP) and press conference quarterly

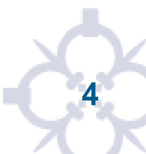
The Fed's Mandate

General goals: foster economic prosperity and promote social welfare

More specific objectives are established by the government

Federal Reserve Act: provides statutory basis for monetary policy

- Goals of monetary policy: Original language from 1913
  - ". . . to furnish an elastic currency, to afford means of rediscounting commercial paper, to establish more effective supervision of banking in the United States, and for other purposes."
- Goals of monetary policy: Amendment in 1977
  - "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

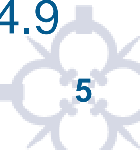


FOMC Statement of Longer-Run Goals

Interpretation of dual mandate: Statement on 'Longer-Run Goals and Monetary Policy Strategy' *(adopted in 2012, most recently amended in Jan 2015)*

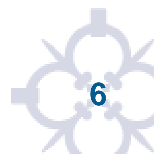
- **Price stability** → longer-run goal for inflation
  - Inflation at the rate of 2 percent is most consistent over the longer run with the Fed's statutory mandate
  - Measured by the annual change in the price index for personal consumption expenditures (PCE), a comprehensive measure of prices faced 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 2015 SEP: longer-run normal rate of unemployment is between 4.9 and 5.8 percent (central tendency: 5.0 to 5.2)



Why Price Stability and What Can the Fed Do?

- Prices act as the key mechanism for allocating resources efficiently throughout the economy
  - If inflation is high, *lenders* are harmed because they can buy fewer goods and services with their payments than they expected. If inflation is low, *borrowers* are harmed
  - If inflation is high, demand for goods and services is pushing hard on available resources. If inflation is low there is not enough demand to fully use the available resources in society
- When inflation is *stable* and *neither too high nor too low* over time, it does not materially enter into the decisions of households and firms
- The central bank has primary influence over the long-run behavior of the general price level
  - Importance of "well-anchored" inflation expectations around levels consistent with objectives of price stability



Total and Core PCE Inflation in Recent Years

% Change – Year to Year

% Change – Year to Year

7
6
5
4
3
2
1
0
-1
-2

Total PCE

Core PCE

2000 2002 2004 2006 2008 2010 2012 2014

Source: Bureau of Economic Analysis

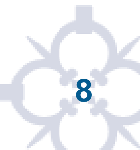
Note: Grey shading shows NBER recessions

Why Maximum Employment and What Can the Fed Do?

- Social welfare improves as human resources are utilized more fully and efficiently

- *Long-run* employment and output are determined by:
  - Population growth, technological progress, preferences for saving, risk and work effort
  - Not by monetary policy

- In the *short-run*, the economy goes through business cycles
  - Output and employment fluctuate above or below long-run levels (changes in demand relative to supply)
  - Monetary policy can help 'smooth' these fluctuations, and thus stabilize employment and incomes



Recent History of the US Labor Market

Percent

Percent

12 10 8 6 4 2 0

68 66 64 62 60 58 56

2000 2002 2004 2006 2008 2010 2012 2014

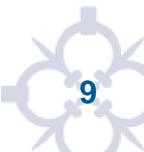
Labor Force Participation Rate (Right Axis)

Unemployment Rate (Left Axis)

Employment to Population Ratio (Right Axis)

Source: Bureau of Labor Statistics

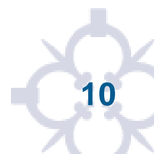
Note: Grey shading shows NBER recessions



Is the FOMC Achieving its Objectives?

- The FOMC has fallen short on both objectives since the Great Recession
  - Inflation has been running *below* the 2% longer-run objective of the Committee
  - Unemployment remains *above* estimates of its longer-run normal level, although the gap is currently narrow

- FOMC participants' **forecasts** for unemployment and inflation indicate that both objectives are expected to be met over the medium term



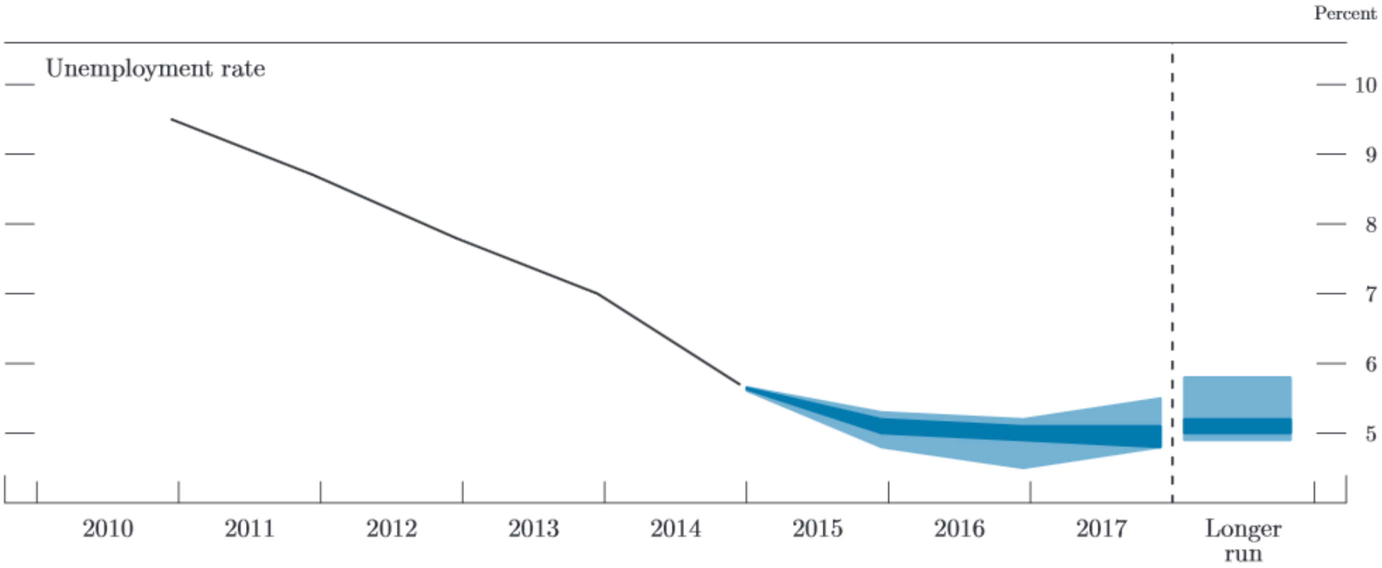
Survey of Economic Projections (SEP)

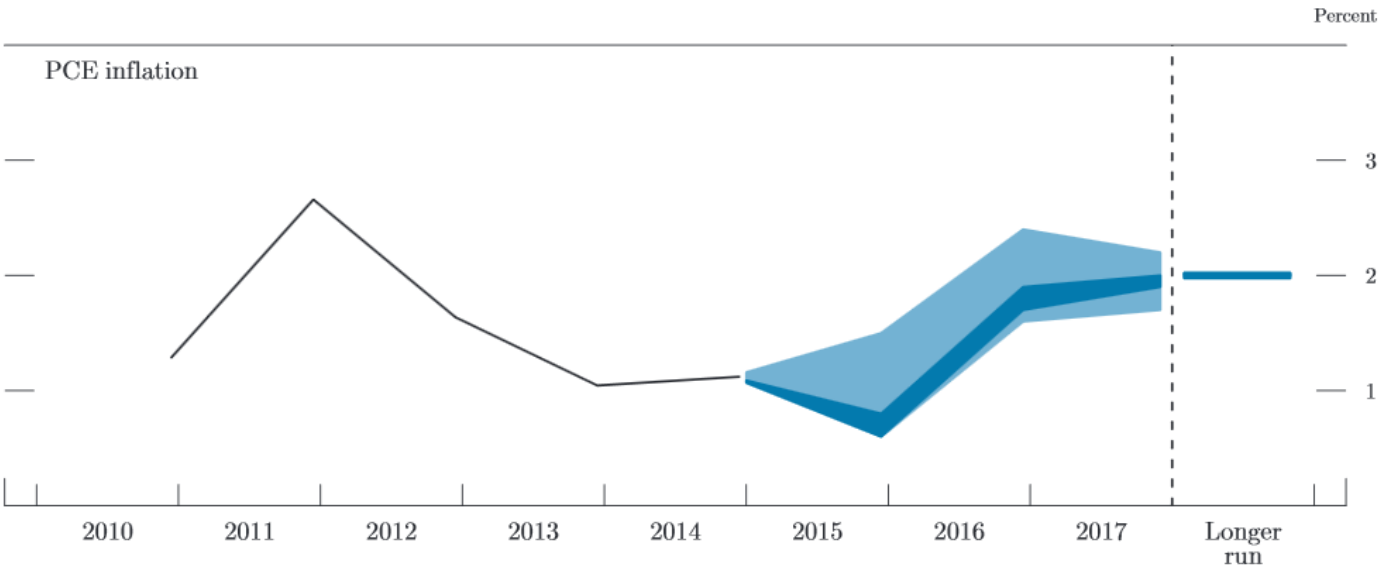
- Every other FOMC meeting (March / June / September / December)

- 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 18th 2015

What's in FOMC's Crystal Ball?

From the March 2015 FOMC statement :

- The Committee expects that, **with appropriate policy accommodation**, economic activity will expand at a moderate pace, with labor market indicators continuing to move toward levels the Committee judges consistent with its dual mandate.
- Inflation is anticipated to remain near its recent low level in the near term, but the Committee expects inflation to rise gradually toward 2 percent over the medium term as the labor market improves further and the transitory effects of energy price declines and other factors dissipate.

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

How Does Monetary Policy Affect the Economy?

- 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, …)
  - Amount of lending
- Financial conditions influence households' and businesses' spending decisions, and hence **aggregate demand**, production, employment, and ultimately inflation
- But policy affects the economy with "long and variable lags" (M. Friedman)

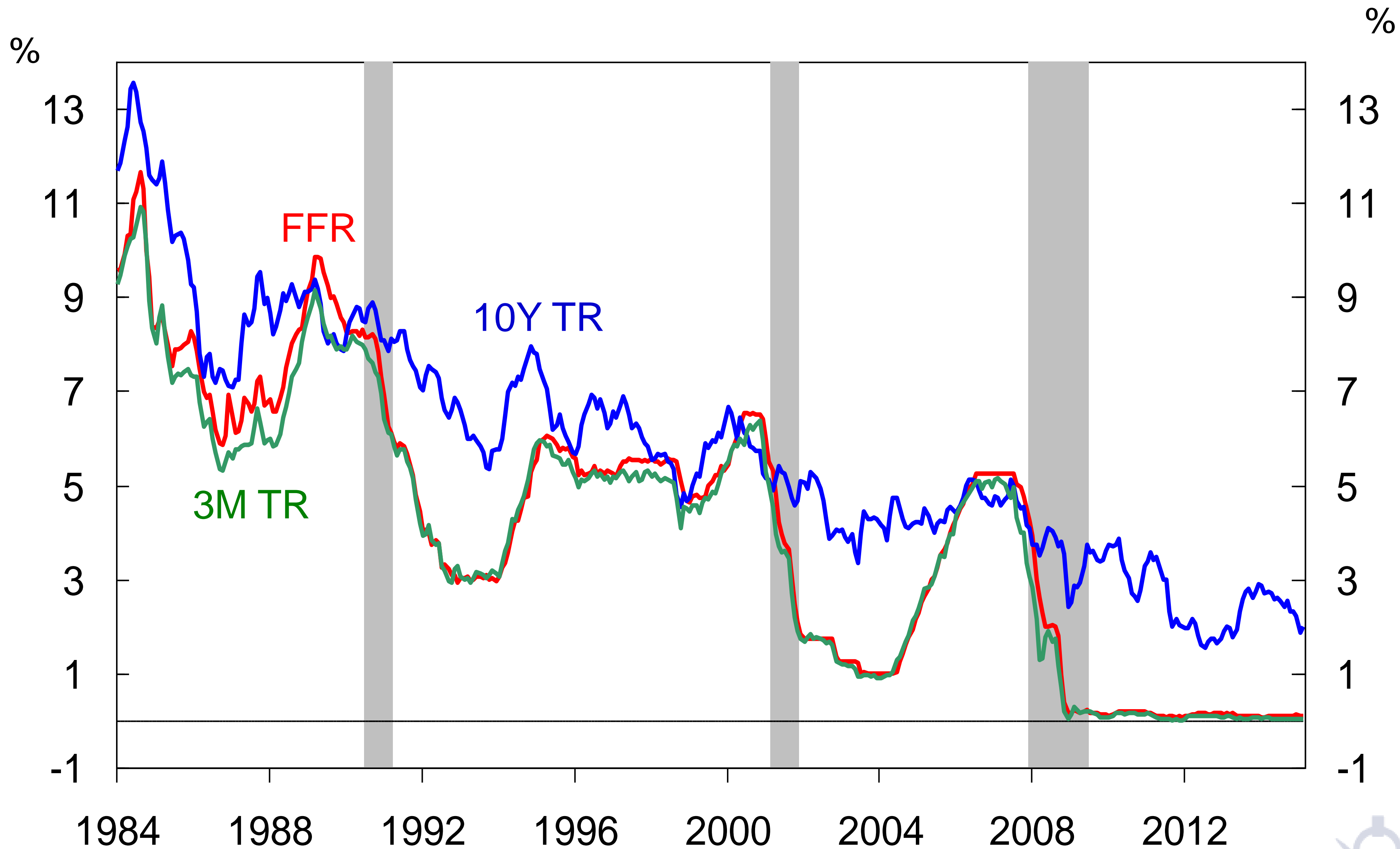
Policy Instruments – Conventional Policy

- Federal funds rate (FFR)
  - Rate at which banks borrow and lend reserves overnight in federal funds market
  - Reserves = deposits that banks hold in their account at Federal Reserve

- FOMC sets target for FFR
  - Chooses target rate that it believes is most consistent with its monetary policy objectives

- FRBNY increases (decreases) the level of reserves in order for actual rate to be close to target
  - Buys (sells) securities from (to) banks in exchange for reserves

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



Source: Federal Reserve Board

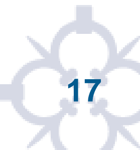
Policy Instruments – Unconventional Policy

- 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



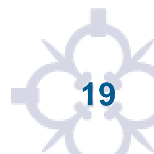
Economic Forecasts

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
- Econometric models and comparisons to past episodes used 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?

- 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
- Forecast of details provides a consistency check for aggregate forecast
  - Are aggregates consistent with our sense of the likely path?
  - Are sectors consistent with past cycles or model-implied paths?
- 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., 2015: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):

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

  - Y_t vector of small number of key macroeconomic time series
  - A_1, A_2 … matrices estimated using linear regressions

- Factor models:

$$X_t = B\ Y_t\ + u_t$$

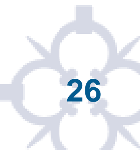
$$Y_t = A_1\ Y_{t-1} + A_2\ Y_{t-2} + \ldots + e_t$$

  - X_t may contain a very large number of data series
  - Y_t contains some potentially latent "factors"
  - Estimate matrices A_1, A_2 …,B, and vectors of factors Y_t, Y_{t-1}...

Why VARs or Factor Models?

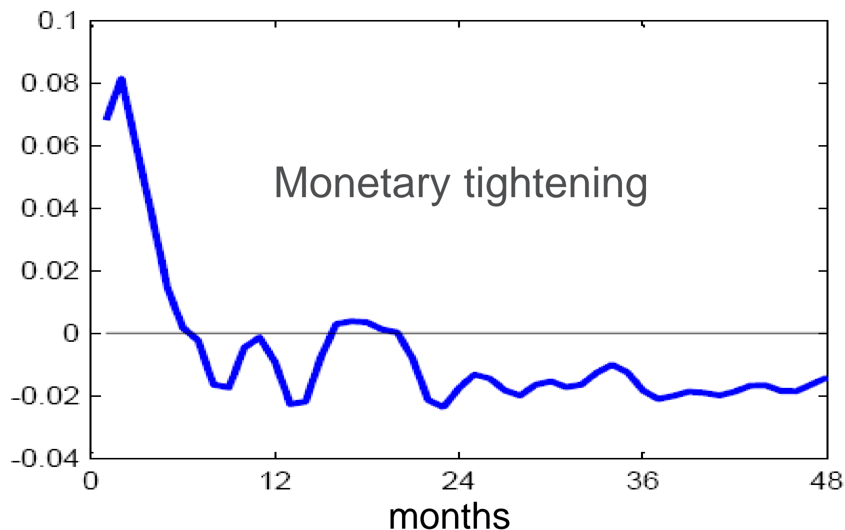
- Exploit historical relationships between various data series
- Impose few restrictions
- Good to explain dynamic effects of shocks (e.g., FFR increase, oil-price shock, …) on key variables
- Factor models can trace impact of shocks on broad set of variables
- Provide relatively good forecasts

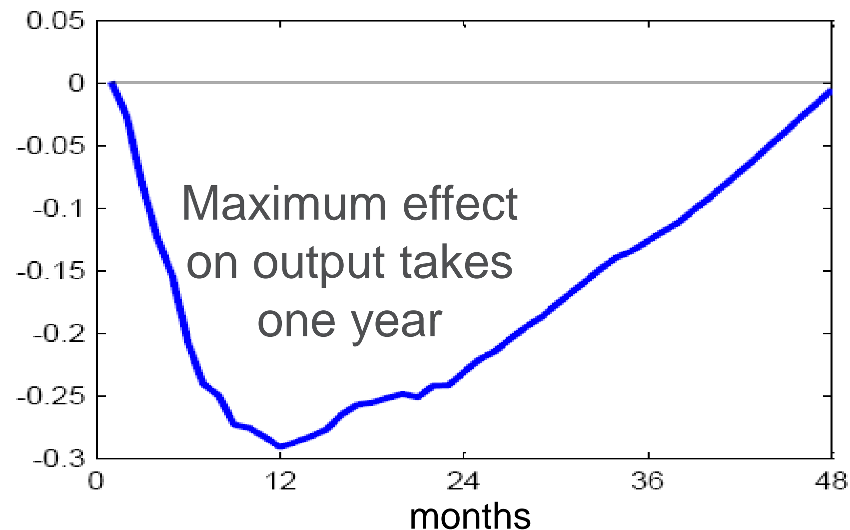
- Downsides:
  - Black box: Don't provide a "narrative"
  - Assume that historical relationship will continue to hold
  - May be inappropriate for alternative policy simulations

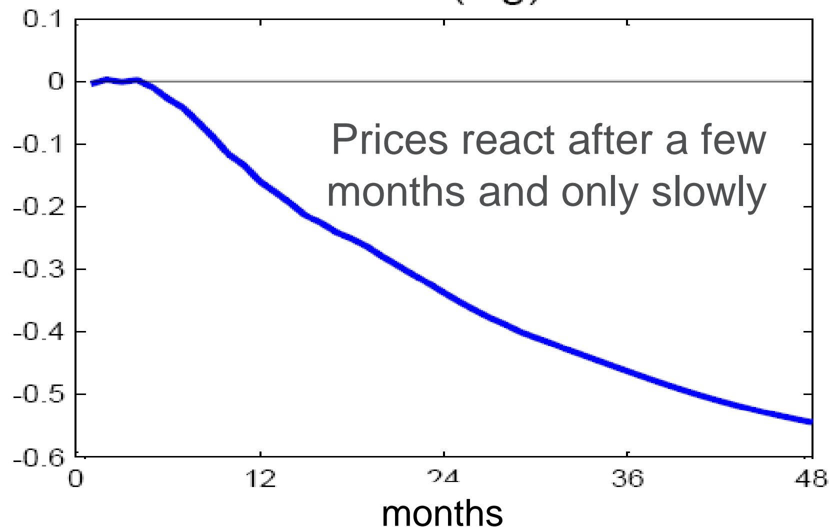


Typical Exercise: Effects of Monetary Policy

Estimated responses to monetary tightening







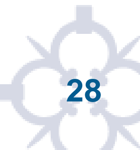
Monetary policy affects the economy with a lag

Source: Boivin, Giannoni, Mihov (2009), *American Economic Review*

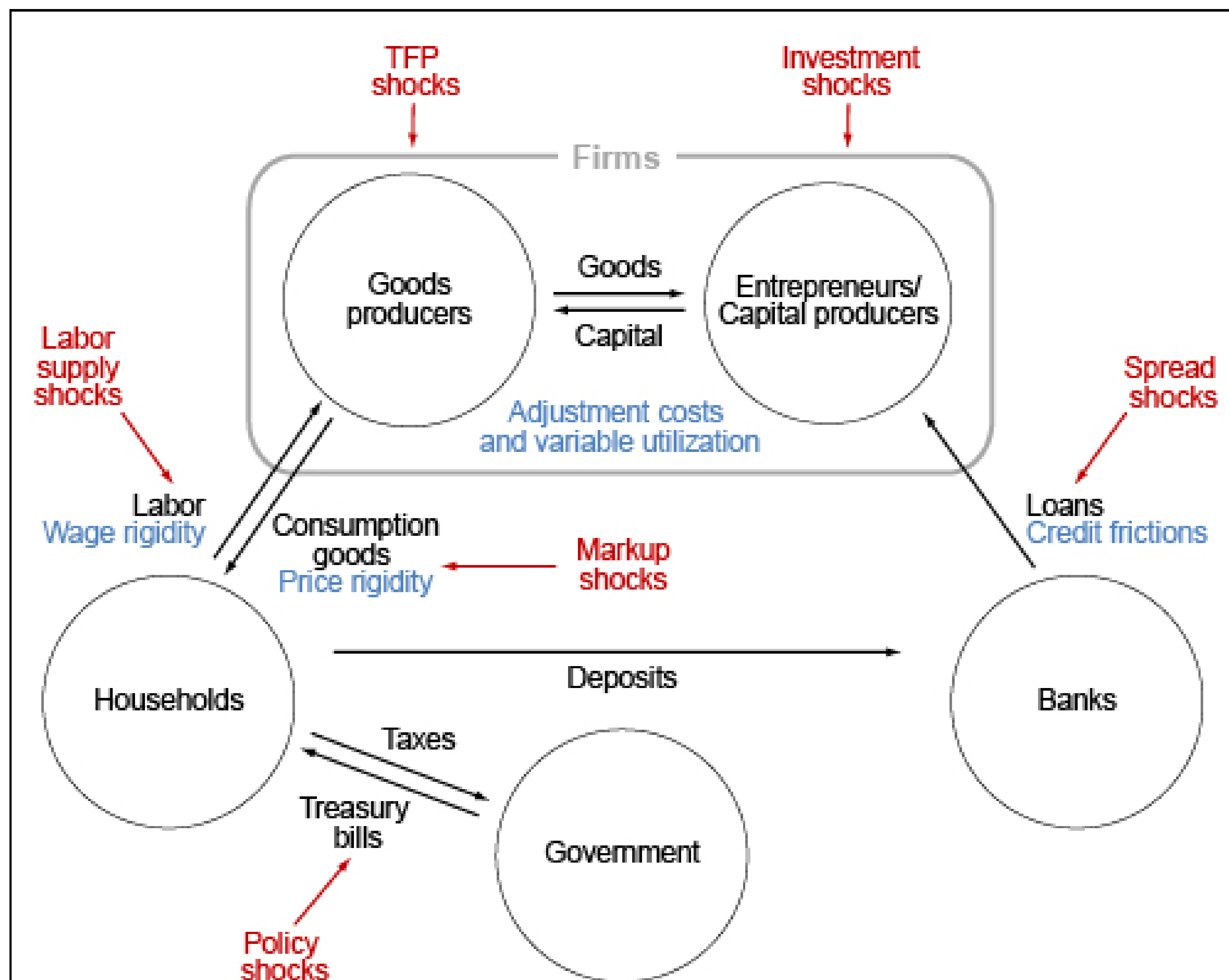
Dynamic Stochastic General Equilibrium (DSGE) Models

- Stylized representation of reality
- 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



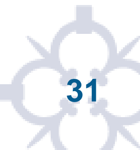
DSGE Model Estimation

- Model parameters and underlying shocks estimated via Bayesian methods
  - Combine prior information on the parameters with information about key data series

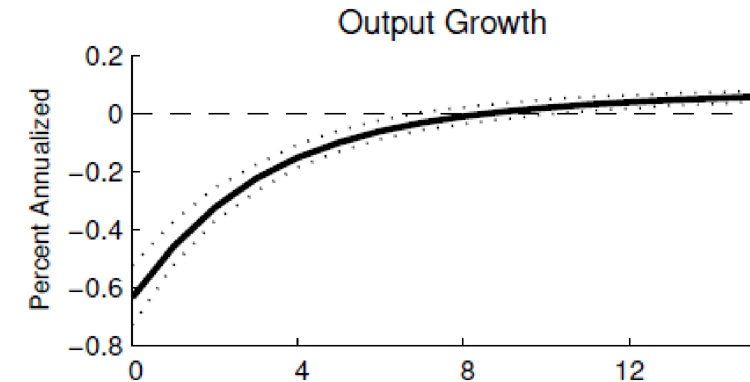
- Data series used in current FRBNY-DSGE model:
  - Real GDP, Consumption, Investment
  - GDP deflator, PCE core deflator
  - Wages, hours worked, total factor productivity
  - Federal funds rate (FFR), 10-year yield, spread (Baa-10y yield)
  - FFR expectations, inflation expectations

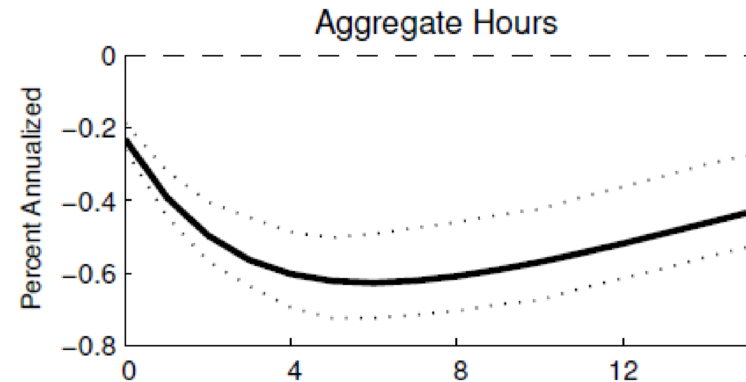
Why a DSGE Model?

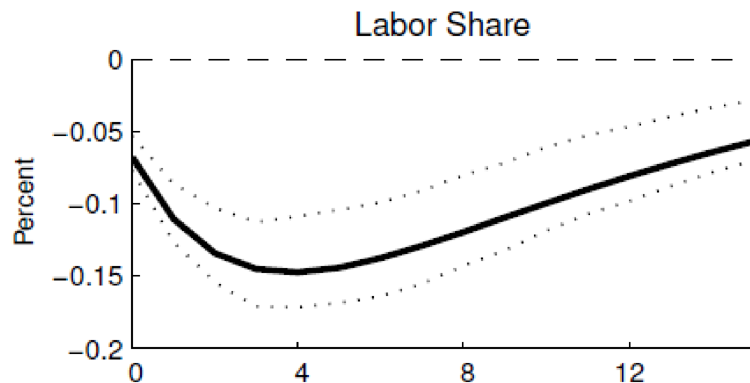
- Coherent story for understanding macroeconomic outcomes
- Optimally combines theoretical knowledge with data
- Laboratory for policy experiments
  - Economic relationships expected to remain invariant to experiments
    - In contrast, (non-structural) empirical relationships are likely to change with 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 recent policy
- Recent DSGE models tend to perform relatively well for forecasting
  - Especially at the horizon of several quarters out

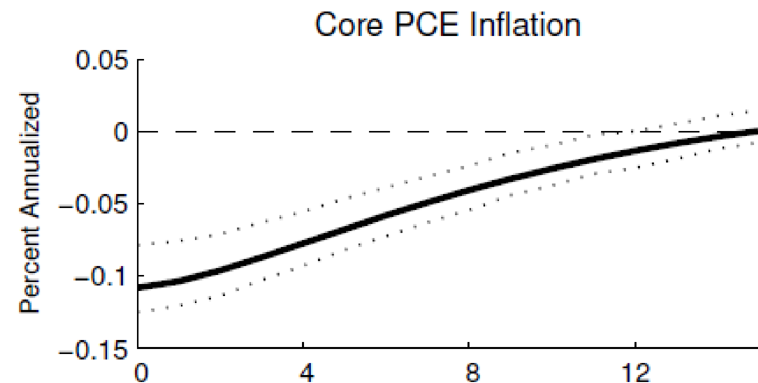


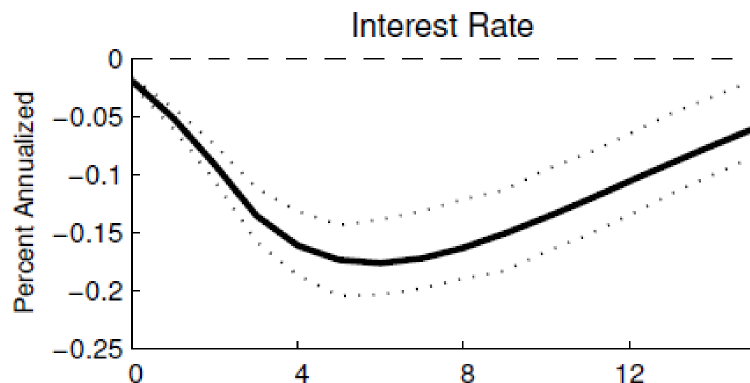
Transmission Mechanism: I. Spread Shocks

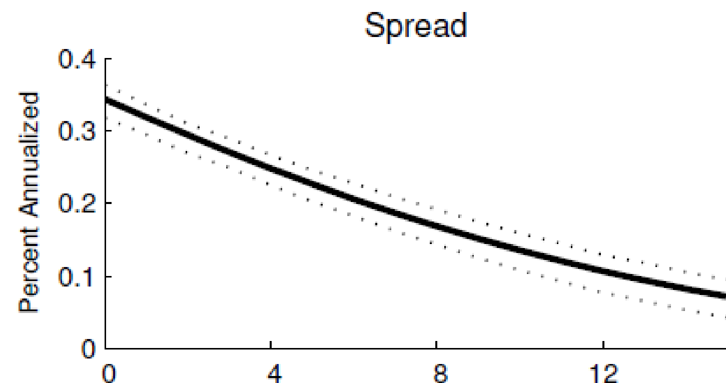




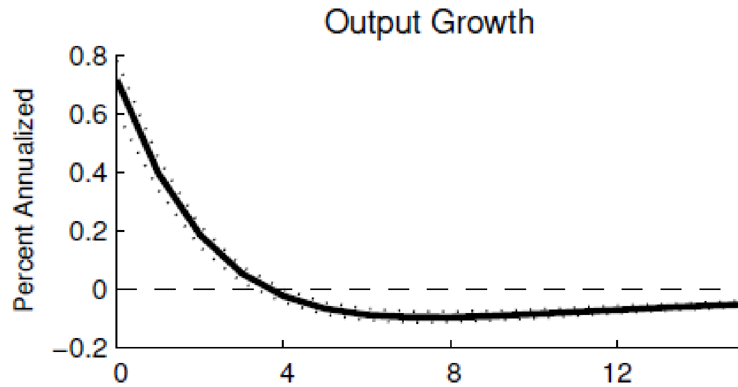


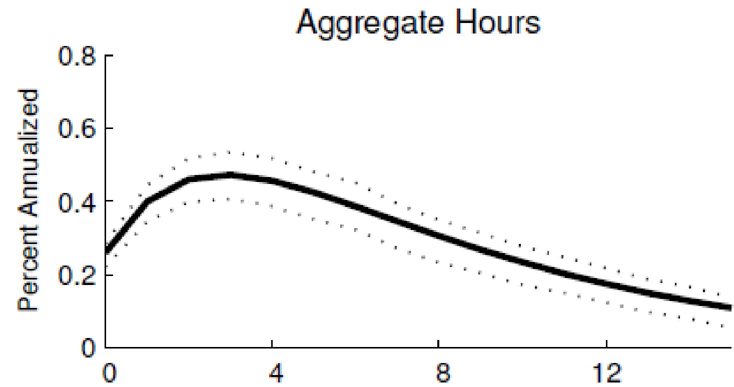


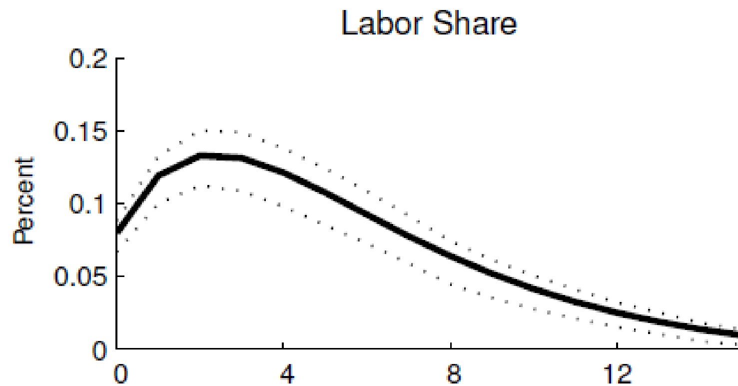


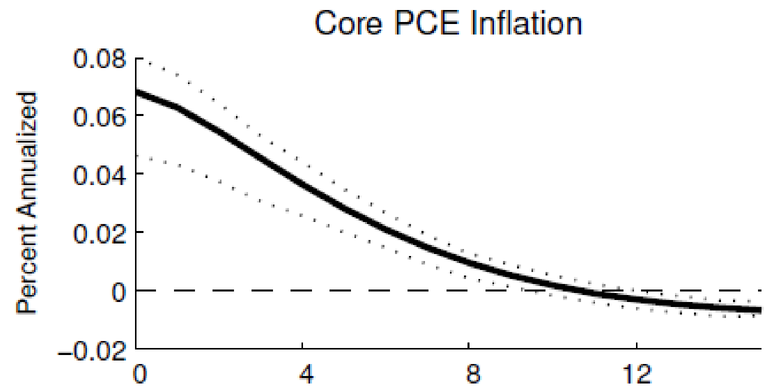


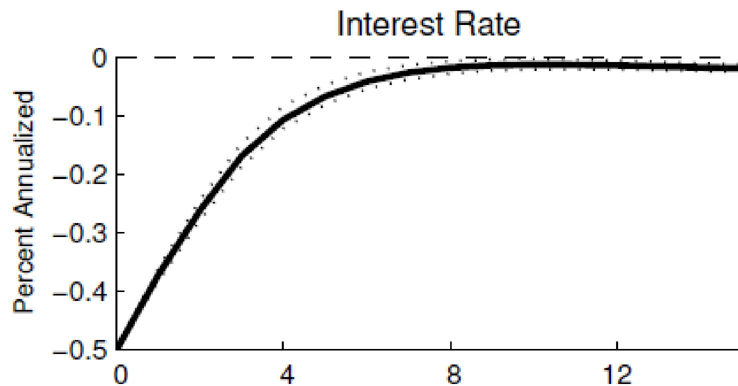
Transmission Mechanism: II. Policy Easing

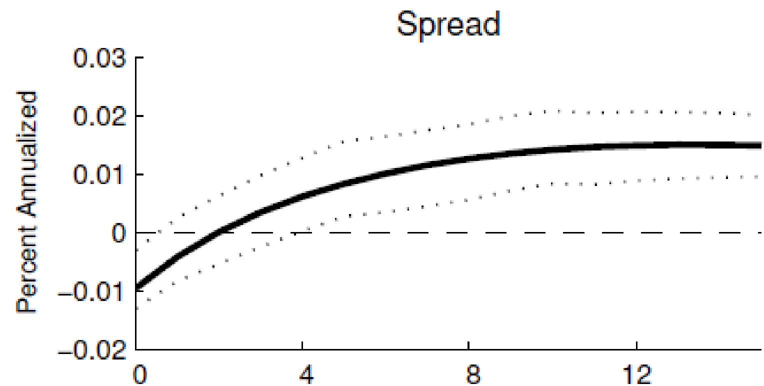










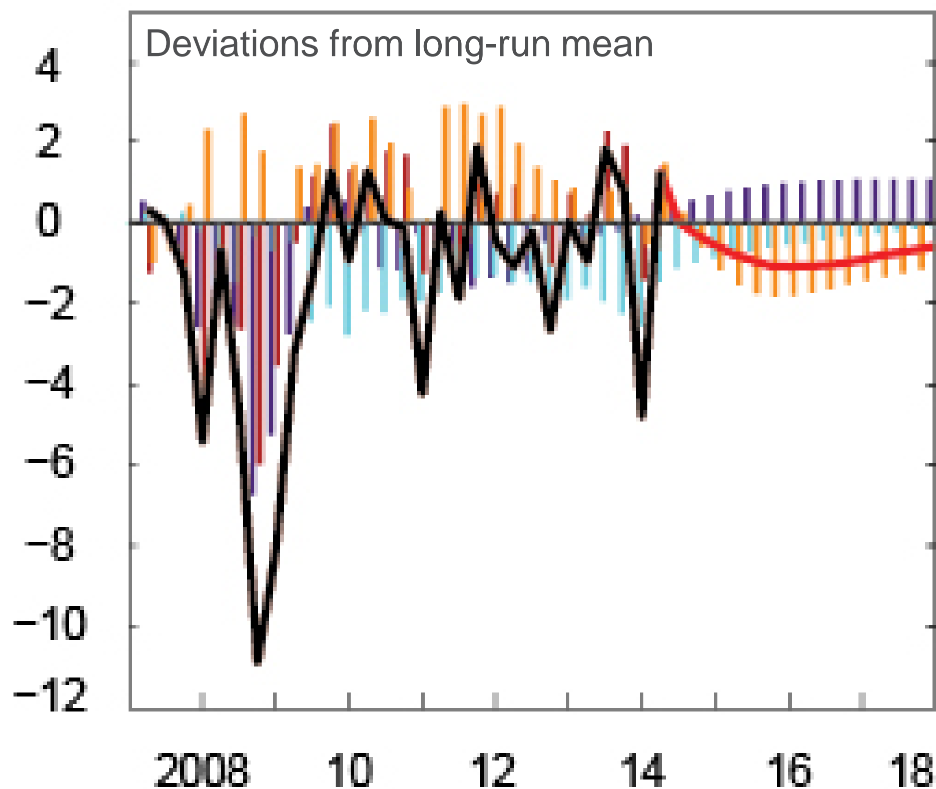


Explaining the Great Recession

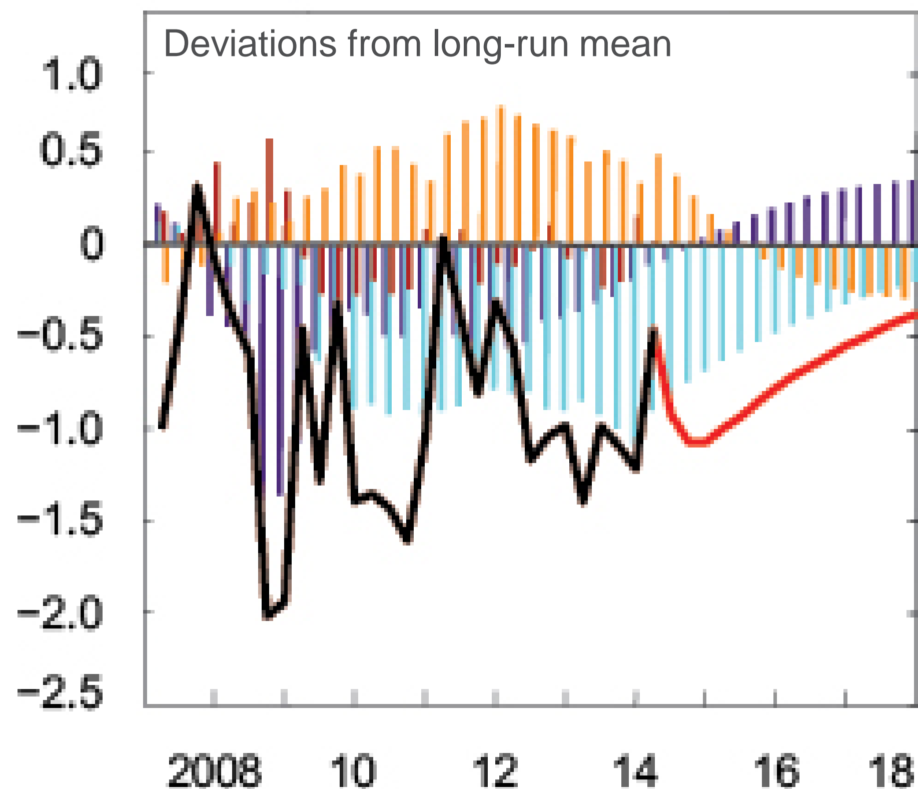
Shock Decomposition of Output Growth and Inflation

■ Spread ■ Investment ■ Total factor productivity ■ Monetary policy

Output growth, percentage change, quarter to quarter, annualized



Core PCE inflation, percentage change, quarter to quarter, annualized



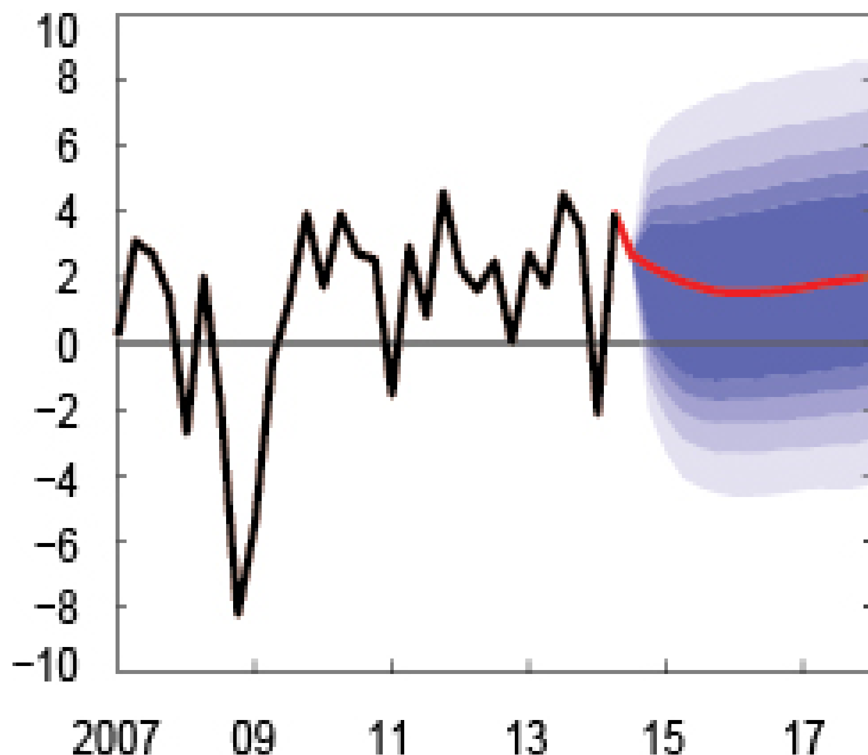
Take-Away from the Great Recession

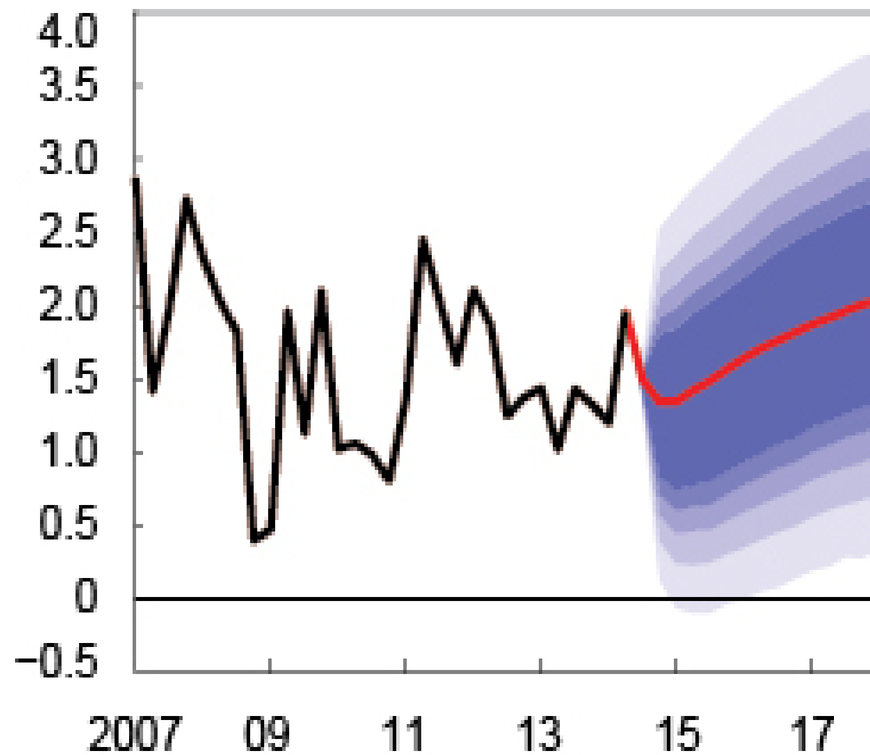
- Great Recession: large collapse in economic activity
  - Caused mainly by financial shock
  - Total factor productivity (hence potential output) fell sharply but has largely recovered
  - Shock to investment demand has resulted in protracted low output growth
  - Monetary policy has provided considerable stimulus (largely via forward-guidance)

- Sharp drop in output during Great Recession is consistent with mild decrease in inflation
  - Policy accommodation has maintained inflation expectations anchored

DSGE Model Forecasts (2014)

Forecasts of Output Growth and Inflation





- Model has been predicting sluggish recovery in economic activity and relatively weak inflation

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

Forecast-Targeting as a Monetary Policy Strategy

- Policy affects the economy with "long and variable lags" (M. Friedman)

➔ Essential to **forecast** evolution of economy
and to set **policy** accordingly

- Key steps:
  - Assess current state of economy
  - Forecast economy's evolution, conditional on a particular policy path
  - Choose most desirable policy path
    - i.e., path of policy instruments that results in most desirable forecast of target variables relative to their long-run goals

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 → 2%

Target inflation rate → 2% (in $0.5(\pi - 2\%)$)

Output gap → $(Y - Y^{FE})/\,Y^{FE}$

- 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 FFR and financial conditions
  - 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:

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

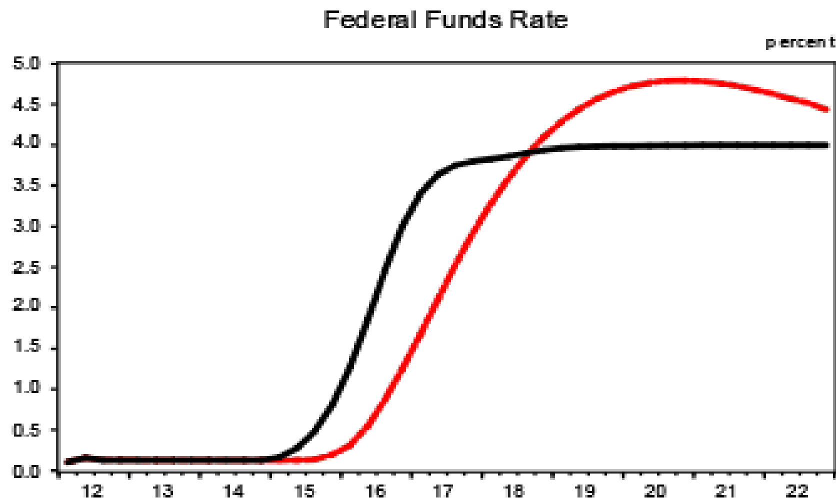
  - Captures (squared) deviations of inflation from objective, unemployment u from normal level u*, and changes in FFR (Δi)

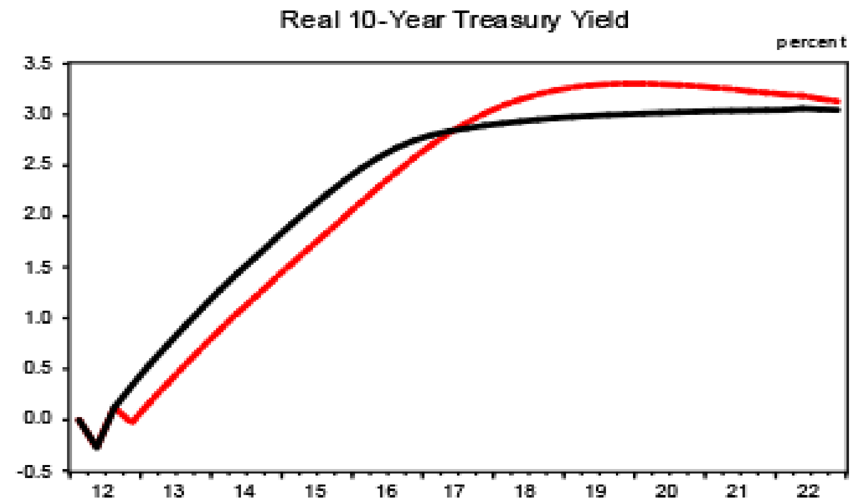
- Model characterizes behavior of economic agents
  - Can be viewed as set of constraints that the Fed is facing when setting policy

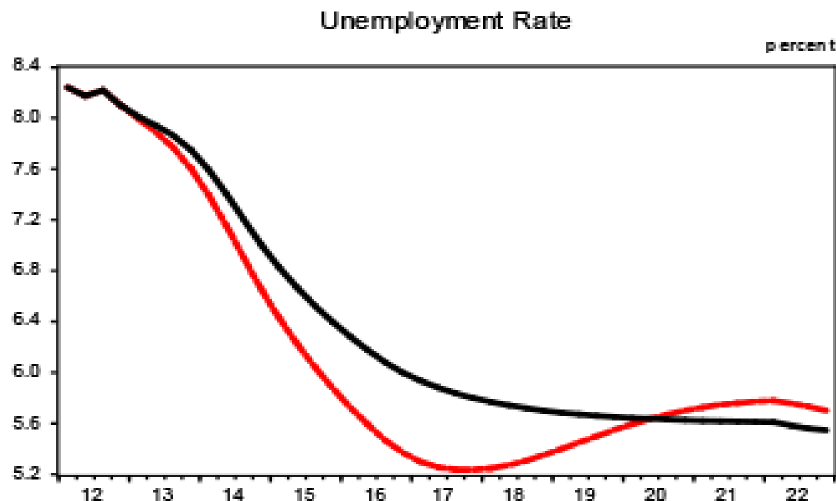
- Optimal policy = path of FFR that minimizes the objective subject to the constraints imposed by behavior of economic agents

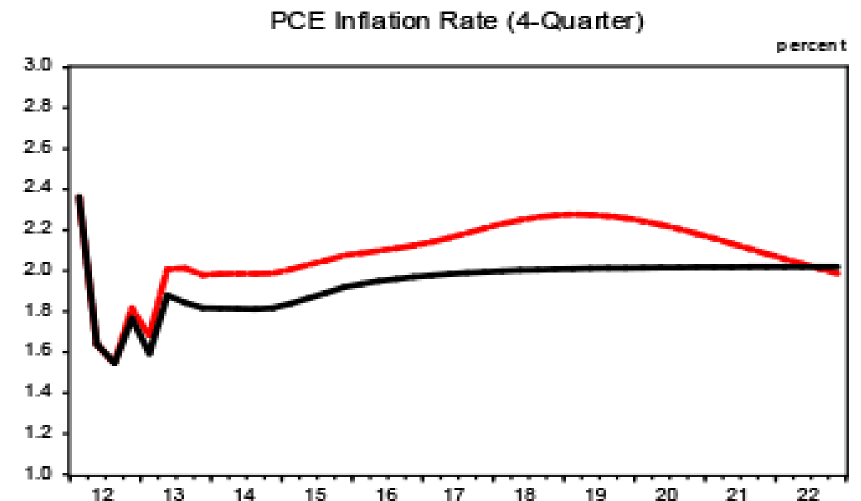
Optimal Policy Using Board’s FRB/US Model (2012)

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)

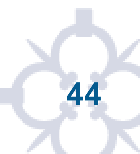
- Optimal FFR path implies more accommodation than SEP
  - Delayed FFR lift-off
  - Lower real 10-year Treasury yield for several years
  - Faster decline in unemployment rate
  - Faster return of inflation to 2%

- 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