Queen Mary
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Macro for Policy

Monetary Policy in Theory

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Agenda

A prerequisite for the successful conduct of monetary policy is a satisfactory understanding of the monetary transmission mechanism – the ensemble of economic forces that link the monetary policy instrument to the aggregate performance of the economy.

by Greg Kaplan, Benjamin Moll and Giovanni L. Violante (2018)

– The primary policy instrument was the short-term nominal interest rate .
– The longer-term nominal interest rate is increasingly becoming the major instrument.

How does the change in nominal interest rate propagate through aggregate economy?

Key ingredients

1. Price stickiness (NKPC)
2. Consumption-saving decision (IS curve)
3. Monetary policy rule (MP)

Calvo (1983): setting

Each period, $(1-\theta)$ fraction of firms can reset their prices while θ fraction of firms keep their prices unchanged (constant probability assumption). When firms reset their prices, they choose z_t (log price) to minimizes the "loss function":

$$L(z_t) = \sum_{k=0}^{\infty} (\theta\beta)^k E_t (z_t - p^*_{t+k})^2,$$

where $0 < \beta < 1$, p^*_{t+k} is the log optimal price that the firm would set in period $t+k$ if there were no price rigidity.

- $E_t(z_t - p^*_{t+k})^2$: the expected loss in profits for the firm at time $t+k$ due to the fact that it will not be able to set a frictionless optimal price that period, it will lose profits relative to what it would have been able to obtain if there were no price rigidities
- Future losses are discounted by $(\theta\beta)^k$.The firm only considers the expected future losses from the price being fixed at z_t. The chance that the price will be fixed until $t+k$ is θ^k, which used by the firm to discount future losses together with β.

Calvo (1983): optimal pricing

The optimality condition follows:

$$L'(z_t) = 2\sum_{k=0}^{\infty}(\theta\beta)^k E_t(z_t - p^*_{t+k}) = 0$$

$$\underbrace{\sum_{k=0}^{\infty}(\theta\beta)^k}_{=\frac{1}{1-\theta\beta}\text{(geometric sum)}} z_t = \sum_{k=0}^{\infty}(\theta\beta)^k E_t p^*_{t+k}$$

$$\frac{z_t}{1-\theta\beta} = \sum_{k=0}^{\infty}(\theta\beta)^k E_t p^*_{t+k}$$

$$z_t = (1-\theta\beta)\sum_{k=0}^{\infty}(\theta\beta)^k E_t p^*_{t+k}$$

- the firm's optimal solution is to set its price equal to a weighted average of **the frictionless prices**

Calvo (1983): markup over marginal cost

The firm desires to set its price as a constant markup over marginal cost:

$$p_t^* = \mu + mc_t$$

From the optimal solution,

$$z_t = (1 - \theta\beta)\sum_{k=0}^{\infty}(\theta\beta)^k E_t(\mu + mc_{t+k})$$

$$= (1 - \theta\beta)(\mu + mc_t) + (1 - \theta\beta)(\theta\beta)E_t(\mu + mc_{t+1}) + (1 - \theta\beta)(\theta\beta)^2 E_t(\mu + mc_{t+2}) + \cdots$$

$$= \theta\beta E_t z_{t+1} + (1 - \theta\beta)(\mu + mc_t)$$

Calvo (1983): the New-Keynesian Phillips Curve

The aggregate price level in this economy is the weighted average of last period's aggregate price level and the newly reset price:

$$p_t = \theta p_{t-1} + (1-\theta) z_t$$

and this could be rearranged to:

$$z_t = \frac{1}{1-\theta}(p_t - \theta p_{t-1})$$

$$z_t = \theta\beta E_t z_{t+1} + (1-\theta\beta)(\mu + mc_t)$$

$$\frac{1}{1-\theta}(p_t - \theta p_{t-1}) = \frac{\theta\beta}{1-\theta}(E_t p_{t+1} - \theta p_t) + (1-\theta\beta)(\mu + mc_t)$$

Calvo (1983): NKPC

- Using the inflation rate definition: $\pi_t = p_t - p_{t-1}$,

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\mu + mc_t - p_t)$$

- Re-arrangement gives:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \widehat{mc}_t$$

$$\text{where } \kappa = \frac{(1-\theta)(1-\theta\beta)}{\theta}$$

$$\widehat{mc}_t = \mu + mc_t - p_t$$

- The current inflation depends on the expected inflation rate, $E_t \pi_{t+1}$ and real marginal cost, $mc_t - p_t$ (**New Keynesian Phillips Curve**).

Households

Consider an economy consisting of a representative household choosing consumption, c_t, and asset holding, a_{t+1}, every period:

$$E\sum_{t=0}^{\infty}\beta^t u(C_t) \tag{1}$$

$$\text{subject to} \quad : \quad C_t + A_{t+1} = R_t A_t + Y_t \;\; \text{for } t = 0, 1, ... \tag{2}$$

$$a_t > 0 \;\; \text{is given.} \tag{3}$$

The consumption Euler equation

$$U'(C_t) = \beta E_t[U'(C_{t+1})]R_t \tag{4}$$

and we consider the following specification:

$$U(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma} \tag{5}$$

thus, we have:

$$C_t^{-\gamma} = \beta E_t[C_{t+1}^{-\gamma}]R_t \tag{6}$$

Log-linearization

Before we go further from equation (6) in the previous slide, there is a bit of math information which is useful for our purpose, although this is beyond the scope of the module.

- A first-order Taylor expansion around $z_0 = f(x_0, y_0)$:
  $z = f(x, y)$ then $z - z_0 = f_x(x_0, y_0)(x_t - x_0) + f_y(x_0, y_0)(y_t - y_0)$

- Consider $z = x^\alpha y^\beta$ and want to get an expression of $\tilde{z} = \frac{z - z_0}{z_0}$.
  $z - z_0 = \alpha x_0^{\alpha-1} y_0^\beta (x_t - x_0) + \beta x_0^\alpha y_0^{\beta-1} (y_t - y_0)$

  Dividing by z_0, we get
  $\tilde{z} = \frac{z - z_0}{z_0} = \frac{\alpha x_0^{\alpha-1} y_0^\beta}{x_0^\alpha y_0^\beta}(x_t - x_0) + \frac{\beta x_0^\alpha y_0^{\beta-1}}{x_0^\alpha y_0^\beta}(y_t - y_0)$
  $= \alpha \frac{(x_t - x_0)}{x_0} + \beta \frac{(y_t - y_0)}{y_0} = \alpha \tilde{x} + \beta \tilde{y}$

The Euler equation expressed in percentage terms

We apply the previous steps to the Euler equation.

$$C_t^{-\gamma} = \beta E_t[C_{t+1}^{-\gamma}]R_t \tag{7}$$

$$-\gamma C_*^{-\gamma-1}(C_t - C_*) = \beta R_* E_t[-\gamma C_*^{-\gamma-1}(C_{t+1} - C_*)] + \beta C_*^{-\gamma}(R_t - R_*) \tag{8}$$

$$-\gamma C_*^{-\gamma}\frac{(C_t - C_*)}{C_*} = \beta R_* E_t[-\gamma C_*^{-\gamma}\frac{(C_{t+1} - C_*)}{C_*}] + \beta R_* C_*^{-\gamma}\frac{(R_t - R_*)}{R_*} \tag{9}$$

$$-\gamma \tilde{C}_t = \beta R_* E_t[-\gamma \tilde{C}_{t+1}] + \beta R_* \tilde{R}_t \tag{10}$$

C_* and R_* are the full employment level consumption and interest rate, respectively.
Thus, $\tilde{C}_t = \frac{(C_t - C_*)}{C_*}$ represents the percentage deviation from full employment level.

The Euler equation expressed in percentage terms (cont'd)

We use the fact that $\beta R_* = 1$ when the economy is st full employment.
Using this result, we write Equation (10) as:

$$-\gamma \tilde{C}_t = E_t[-\gamma \tilde{C}_{t+1}] + \tilde{R}_t \quad (11)$$

$$\tilde{C}_t = E_t[\tilde{C}_{t+1}] - \phi \tilde{R}_t \quad (12)$$

Now, the aggregate recourse constraint says $C_t = Y_t$.

Let us define $x_t = \frac{(Y_t - Y_*)}{Y_*}$ as output gap,
and, $\tilde{R}_t = i_t - E_t[\pi_{t+1}]$ from the Fisher equation

$$x_t = E_t[x_{t+1}] - \phi\{i_t - E_t[\pi_{t+1}]\} \quad (13)$$

Fisher equation

Wallace(2012):

The arbitrage would be to (1) sell the data t good for money obtaining P_t units of money, (2) lend the money at i_t thereby acquring $(1+i_t)P_t$ units of money at date $t+1$, and (3) use that money to buy date $t+1$ good in the amount $(1+i_t)\frac{P_t}{P_{t+1}}$. An alternative is to lend the date t good at the real rate r_t. This gives $1+r_t$ units of the date $t+1$ good.

This leads to $(1+r_t) = (1+i_t)\frac{P_t}{P_{t+1}} = (1+i_t)E_t(\Pi_{t+1})^{-1}$.
Taking log in both sides, $log(1+r_t) = log(1+i_t) - logE_t(\Pi_{t+1})$.
We use the approximation as $log(1+i_t) \approx i_t$, so $r_t = i_t - E_t(\pi_{t+1})$.
It also follows that $i_* = r_*$, and using this yields $r_t - r_* = i_t - i_* - E_t(\pi_{t+1})$.
Finally, we use $\tilde{R}_t \approx log(1+r_t) - log(1+r_*) = r_t - r_*$.
Hence, $\tilde{R}_t \approx i_t - i_* - E_t(\pi_{t+1}) \approx i_t - E_t(\pi_{t+1})$.
We consider i_* is very small.

Three equations NK model

One remaining block is monetary policy rule.

- Firm problem: NKPC (New Keynesian Phillips curve)

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa x_t \tag{14}$$

- Households Euler equation: IS curve

$$x_t = E_t[x_{t+1}] - \phi\{i_t - E_t[\pi_{t+1}]\} \tag{15}$$

- A monetary policy rule: the Taylor rule

Monetary policy rules

A monetary policy rule: the Taylor rule

- The Taylor (1993) rule is defined as
  $R_t = 2 + \pi_t + 0.5(\pi_t - 2) + 0.5Y_t$
- The Taylor (1999) rule is defined as
  $R_t = 2 + \pi_t + 0.5(\pi_t - 2) + 1.0Y_t$

  where R_t is the federal funds rate, π_t is the percent change of inlfation, and y_t is the output gap. The output gap in turn is approximated using Okuns law; specifically, $Y_t = 2.3(5.6 - U_t)$ is estimatedby the staff member of the Board.

For further references see

- https://fredblog.stlouisfed.org/2014/04/the-taylor-rule/
- Taylor (1993), Discretion versus Policy Rules in Practice, Carnegie-Rochester Conference Series on Public Policy, vol. 39 (December), pp. 195-214
- Taylor (1999), A Historical Analysis of Monetary Policy Rules, in John B. Taylor, ed., Monetary Policy Rules, (Chicago: University of Chicago Press), pp. 319-341.

NK models for ECOM181

- NKPC (New Keynesian Phillips curve)

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa x_t \tag{16}$$

- IS curve

$$x_t = E_t[x_{t+1}] - \phi\{i_t - E_t[\pi_{t+1}]\} \tag{17}$$

- A monetary policy rule (a simpler one here)

$$i_t = \delta \pi_t + \varepsilon_t \tag{18}$$

System of equations

$$A_0 E_t X_{t+1} = A_1 X_t + B_0 \varepsilon_t, \quad (*)$$

Find A_0, A_1 and B_0 as your practice.

Solution and simulation

- If you solve a linear system as in equation (*) , you can determine how each variable, x_t, π_t and i_t behave following a shock to ε_t, which we consider as an action by the monetary authority/central bank.
- Under a set of reasonable parameters, a positive monetary shock (e.g. 1 percent shock to ε_t) increases the nominal interest rate, i_t, causing inflation, π_t and the output gap, x_t fall.
- For this propagation channel to be true, how the real interest rate should behave following a positive monetary shock?

Impulse response analysis

Aggregate dynamics following a positive monetary shock (1 % shock to ε_t).

Miao (2014) "Economics dynamics in discrete time"

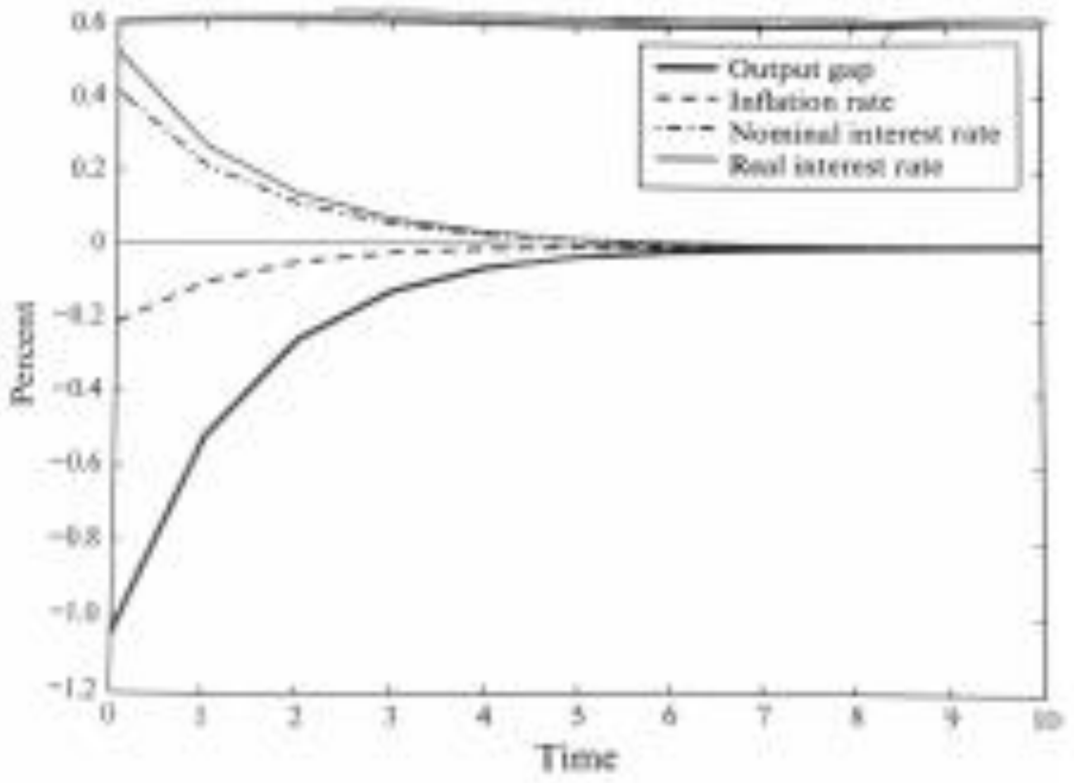


Figure 19.1
Impulse responses to a positive 1 percent shock to monetary policy

Another look at the transmission mechanism

"The Neo-Fisher Eect in the United States and Japan"
by Martin Uribe (2017).

In accordance with conventional wisdom, a temporary increase in the nominal interest rate causes an increase in the real interest rate and a decrease in inflation and output.

In response to a permanent increase in the nominal interest rate, inflation increases quickly to its long-run value (less than a year), and the adjustment is characterized by low real interest rates and no output loss.

"A credible increase in the nominal interest rate that is expected to be sustained for a prolonged period of time can give rise to an immediate increase in inflationary expectations."...?

The SVAR Model

$$Y_t = \begin{bmatrix} y_t \\ \pi_t \\ i_t \end{bmatrix}$$

- y_t: the logarithm of real output per capita
- π_t: the inflation rate, expressed in percent per year
- i_t: the nominal interest rate, expressed in percent per year

Denote $\tilde{Y}_t$ as the deviation of Y_t from the unconditional mean.

The SVAR Model: shocks

$$\tilde{Y}_t = \sum_{i=1}^{L} B_i \tilde{Y}_{t-i} + C u_t$$

$$u_t = \begin{bmatrix} x_t^m \\ z_t^m \\ x_t^n \\ z_t^n \end{bmatrix}$$

- x_t^m: a permanent monetary shock.
- z_t^m: a transitory monetary shock.
- x_t^n: a permanent nonmonetary shock.
- z_t^n: a transitory nonmonetary shock.

Data and Estimation

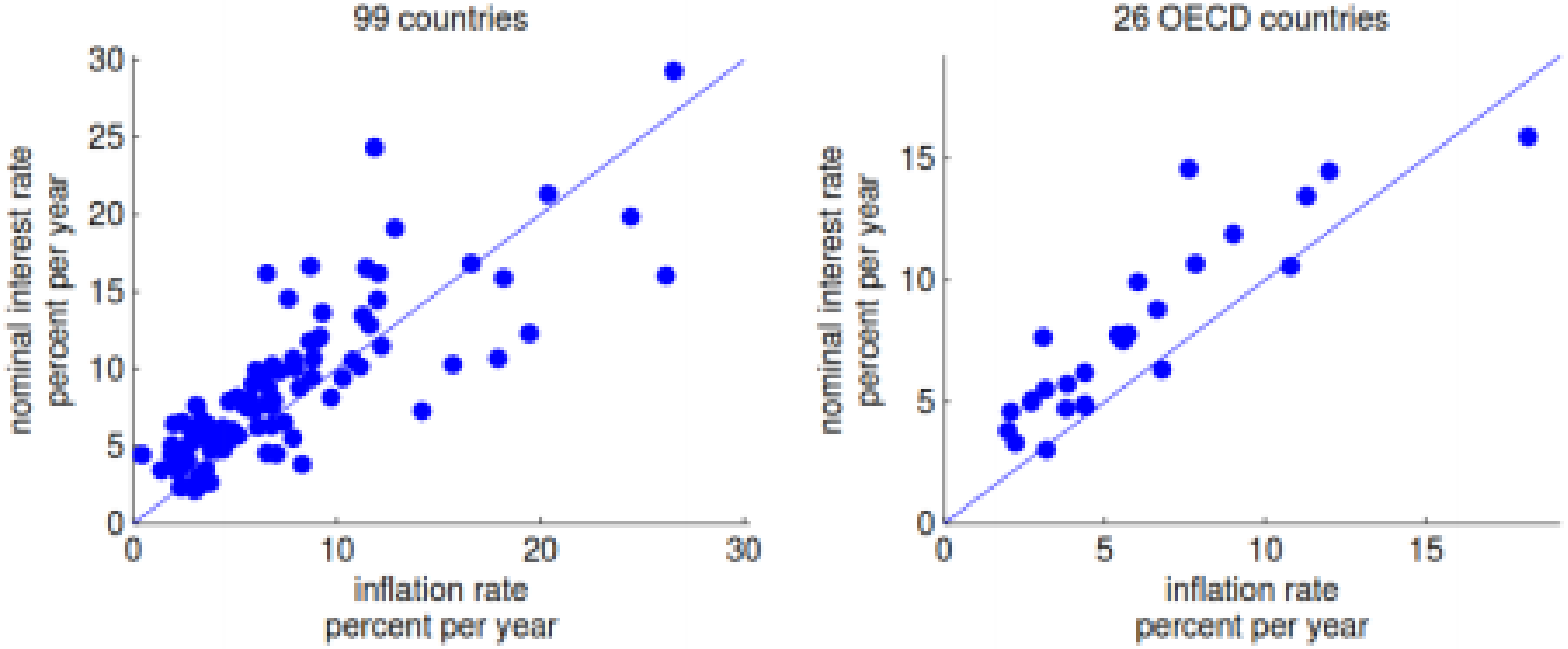
The data are quarterly observations of the growth rate of output per capita, the nominal-interest-rate-inflation differential, and the change in the nominal interest rate.

United States: Sample 1954.4 to 2016.4. Ouput is proxied by real GDP per capita. Inflation is proxied by the Implicit GDP Deflator inflation rate. The nominal interest rate is the Effective Federal Funds Rate.

Japan: I consider two samples, 1975.1 to 2016.4 and 1955.3 to 2016.4. Ouput is proxied by real GDP per capita. Inflation is proxied by the Implicit GDP Deflator inflation rate. The interest rate is the discount rate until 1995:2 and the call rate thereafter.

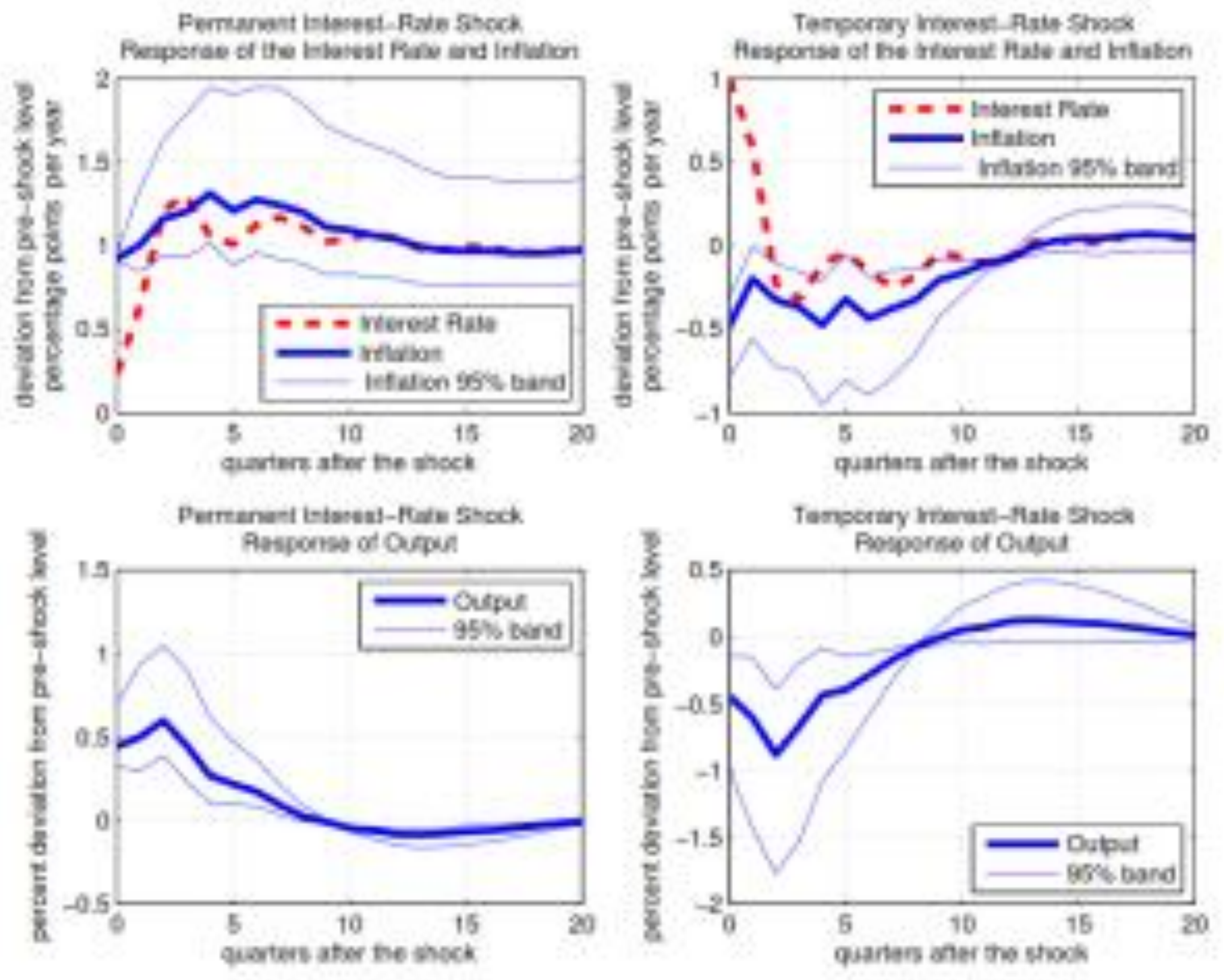
Fisher equation in the data

Average Inflation and Nominal Interest Rates: Cross-Country Evidence (Uribe, 2017)



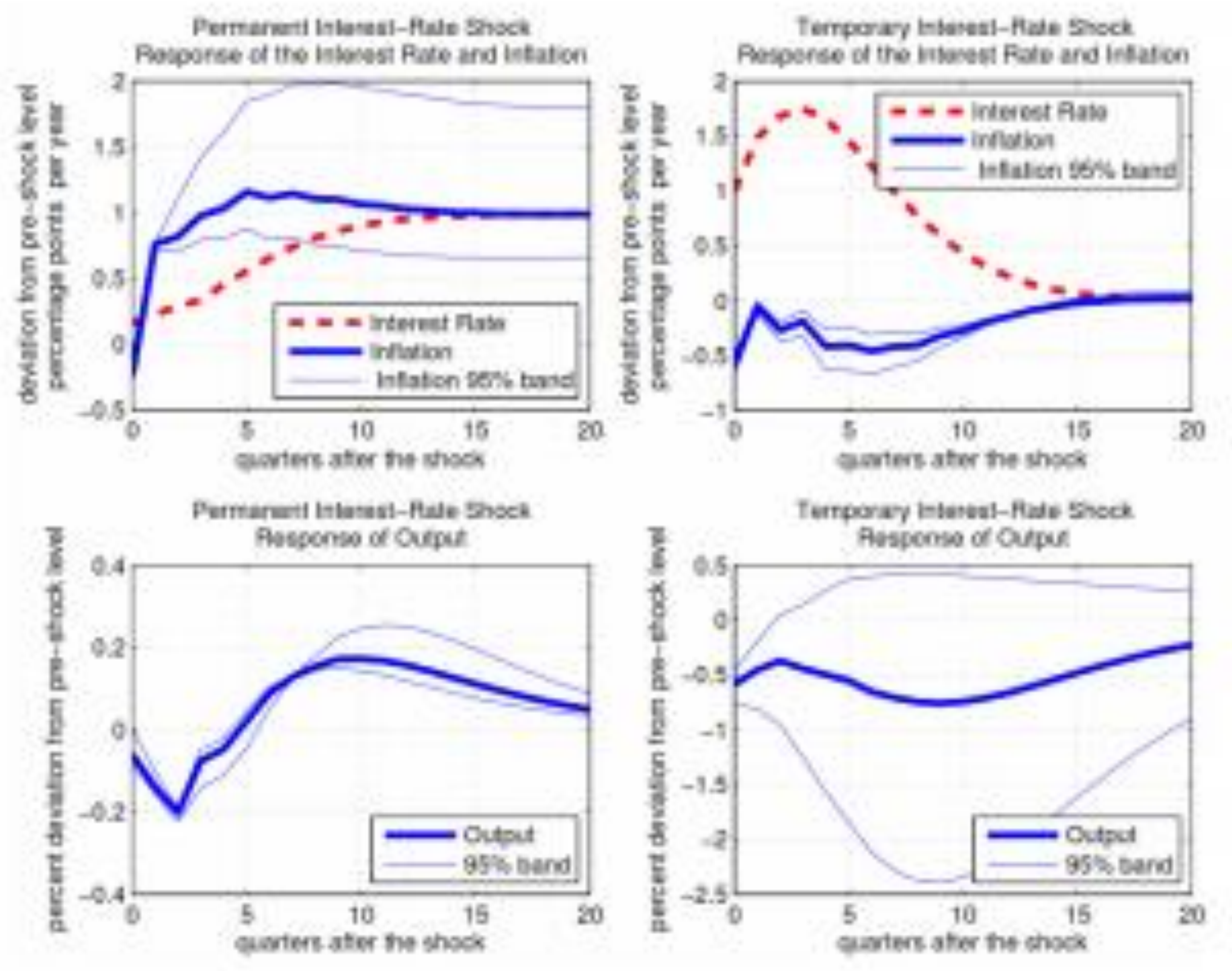
Impulse response analysis: US

Impulse Responses to Interest-Rate Shocks: United States (Uribe, 2017)



Impulse response analysis: JP

Impulse Responses to Interest-Rate Shocks: Japan (Uribe, 2017)



The current monetary policy?

Discussions of how monetary policy can lift an economy out of chronic below-target inflation are almost always based on the logic of how transitory interest-rate shocks affect real and nominal variables

Within this logic, a central bank trying to reflate a low-inflation economy will tend to set interest rates as low as possible.

Committed to low interest rates?

Business

Interest rates to stay at 'extraordinary' low levels, says Draghi

Mario Draghi told the European Parliament that the eurozone still needs "extraordinary" support from the central bank. CREDIT: STEPHANIE LECOCQ/EPA

BoJ launches new form of policy easing

Bank sets cap on 10-year bond yields and vows to overshoot 2% inflation target

Haruhiko Kuroda at a press conference following the BoJ's decision © Reuters

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