Monetary Policy

Part 2: Conventional Monetary Policy

Lecture 5: Monetary Policy Framework: Optimal Rate of Inflation, Inflation Targeting

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Outline

Part 1: Basic Macroeconomic Concepts

Part 2: Conventional Monetary Policy

- Lecture 5: Monetary Policy Framework: Optimal Rate of Inflation, Inflation Targeting
- Lecture 6: Monetary Policy Rules, The Complete IS-MP-PC Model
- Lecture 7: Solving the IS-MP-PC Model, Rational Expectations, Time-Inconsistency and Credibility

Part 3: Monetary Policy at the Zero Lower Bound on Nominal Interest Rate

Part 4: Monetary and Fiscal Interactions

Part 5: Financial Stability (if time permits)

Mock Exam

Summary of Our Basic Macroeconomic Framework

Long run: Supply side driven, real and nominal variables are determined separately

Monetary policy has no effect on real variables in the long run:

- Availability of labor and capital and the technology level to combine these input factors determine output.
- Wages and real interest rate (return to capital to be precise) depend on MPL and MPK and labor and capital supply (exogenous labor supply and savings rate in the Solow model).
- Inefficiencies in the labor market (WS-equation, efficiency wages etc.) and the product market (PS-equation, price mark-ups) lead to involuntary unemployment (NAIRU) and reduce potential output.

Monetary policy completely determines nominal variables in the long run:

- Inflation is determined by money supply (Quantity Theory).
- Nominal interest rate is determined by the Fisher equation: $i \approx r + \pi^e$. It can be derived as an arbitrage condition between returns on real (e.g. stocks) and nominal (e.g. bonds) assets.

Summary of Our Basic Macroeconomic Framework

Short run: Mostly demand driven, though temporary supply shocks also play a role

- Supply side: Expectation augmented Phillips curve. In the short run expectations are constant and the Phillips curve is upward (downward) sloping when plotted in terms of the output gap (unemployment gap). In a boom, production and inflation increase, in a recession they decrease. In the long run, the Phillips curve is vertical at potential output (or NAIRU). How expectations are determined is crucial for the long-run level of inflation and this depends on the credibility of the central bank.
- Demand side: The IS curve shows a negative relation between the real interest rate and demand induced by the consumption-saving decision of households and financing cost of investment.
- The central bank sets the interest rate (so far, we have assumed that it controls the real interest rate directly), in this determines the output gap via the IS curve, which in turn determines inflation via the Phillips curve.
- In the long run, the economy returns to steady state ($y = y^*, u = u_n, \pi = \pi^e$) if either shocks fade out or the central bank readjust the real interest rate to stabilize the economy. If shocks are permanent and there is no stabilization via the central bank, then inflation can spiral up- or downwards.
- Importantly, in the short run prices and real activity are interlinked, while they can be analyzed separately in the long run.

Learning Objective of Today‘s Lecture

So far, we have assumed that monetary policy is set exogenously. Today, we want to develop a framework how monetary policy is typically conducted to stabilize the economy systematically.

1. Studying some stylized empirical facts on monetary policy effects
2. Understanding the main goals of monetary policy
3. Understanding why many central banks choose 2% as the long-run inflation target
4. Understanding the concept of inflation targeting
5. Understanding the rational for monetary policy rules

Literature

Required reading

- Svensson, Lars E.O. (1997). “Inflation forecast targeting: implementing and monitoring inflation targets”, *European Economic Review,* 41(6): 1111-1146 (**read Sections 1 and 2**)
- Press release on new strategy of the US central bank from August 27, 2020: https://www.federalreserve.gov/newsevents/pressreleases/monetary20200827a.htm

Optional reading

- Roberto Billi and George Kahn (2008). “What is the Optimal Inflation Rate? Federal Reserve Bank of Kansas City, Economic Review, Second Quarter 2008.
- Ben Bernanke and Frederic Mishkin (1997). “Inflation Targeting: A New Framework for Monetary Policy? Journal of Economic Perspectives 11(2): 97-116.

5.1 Monetary Policy Objectives

Central Bank Goals: Some Suggestions from Theory

Our long-run framework suggests

1. The central bank needs to choose a long-run target for inflation as inflation is determined by money supply in the long run.
2. The central bank should not aim at increasing output above potential or decreasing the unemployment rate below the NAIRU in the long run.

Our short-run framework suggests

1. The central bank needs a strategy for minimizing inflation fluctuations. This includes the anchoring of inflation expectations.
2. The central bank can in the short run affect real GDP and the unemployment rate. This can be used to minimize business cycle fluctuations or for temporarily steering the economy away from potential output and the NAIRU.

Let's start with the long-term goals first. In addition to relying on theory, we will look at the empirical evidence next.

Money Growth and Inflation in the Long Run

Average values 1960-1990, 110 Countries

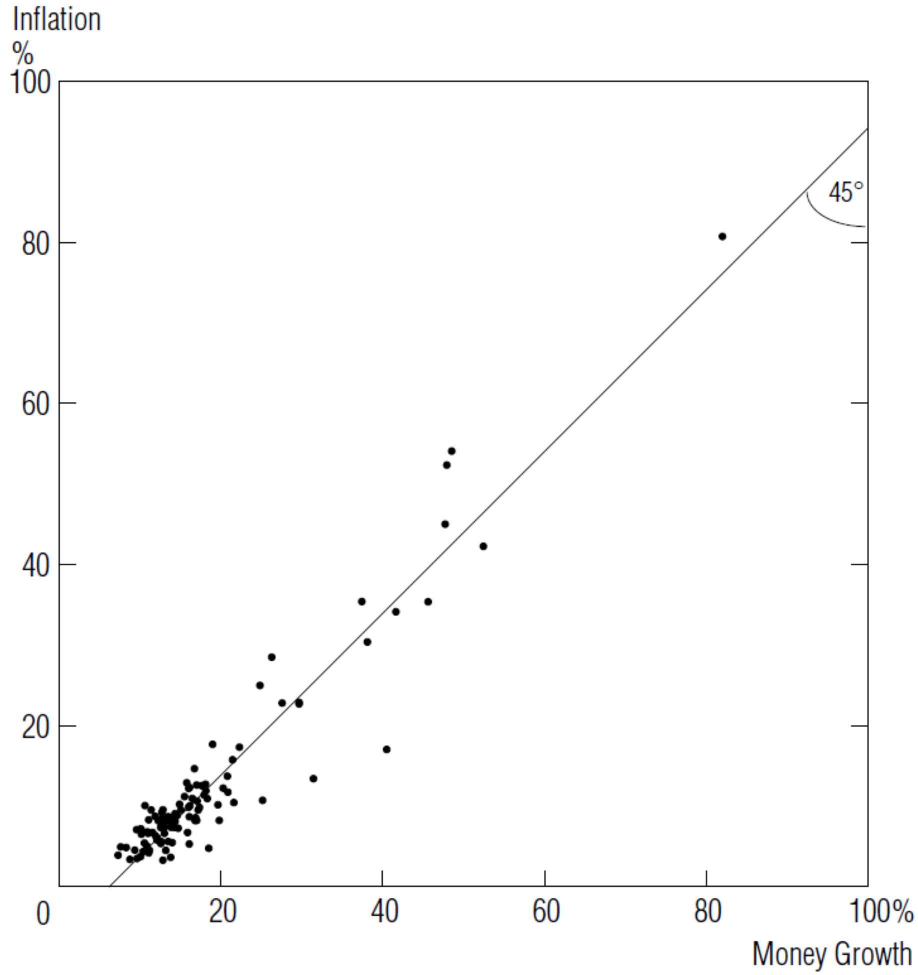
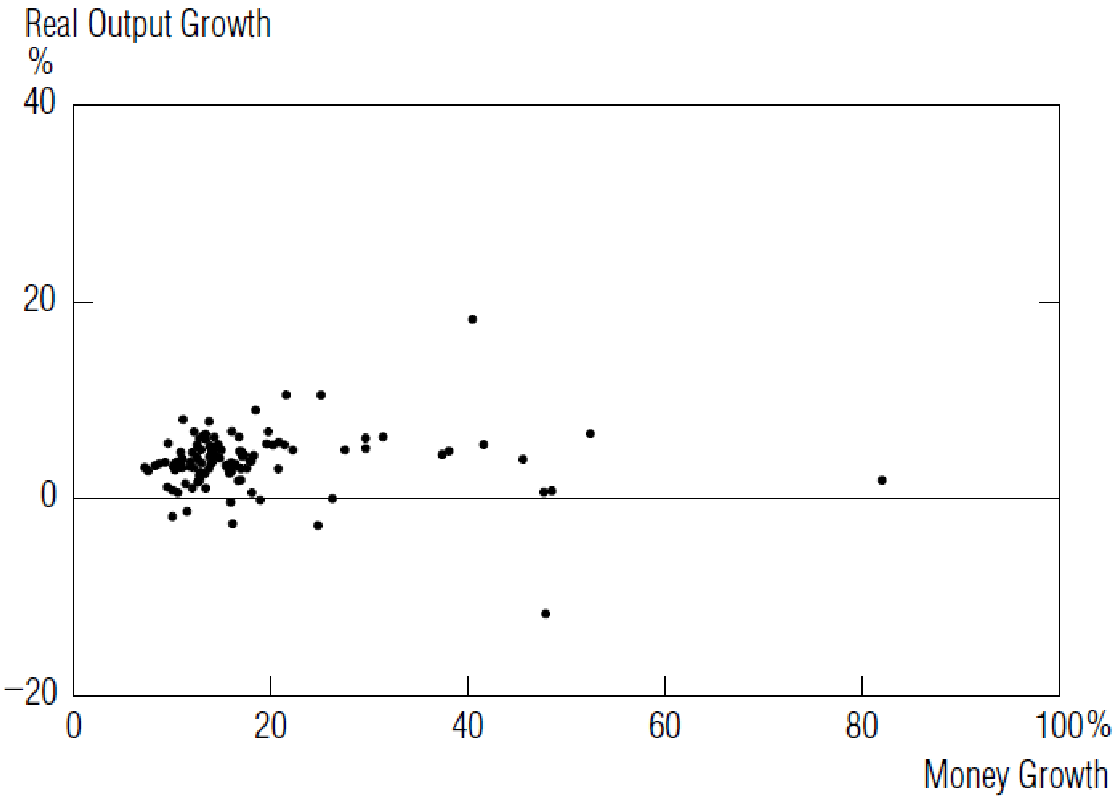


Abbildung: McCandless und Weber, "Some Monetary Facts", Federal Reserve Bank of Minneapolis Quarterly Review, 1995

Money Growth and Real Output Growth in the Long Run

McCandless and Weber (1995): average annual growth rates, 1960-1990, 110 countries

Money, real output growth: no correlation



Goals of Central Banks in Practice: U.S. Central Bank

- Statutory objectives established by the Congress: maximum employment, stable prices, and moderate long-term interest rates
- FOMC defined goals (January 2012):
  - Inflation: 2% PCE inflation rate is most consistent over the longer run with the Federal Reserve's statutory mandate
  - Maximize employment
  - Fed: “Monetary policy can influence the level of employment over the medium run.”
  - Fed: “The maximum level of employment that the economy can sustain in the longer run, without inflation accelerating, is determined by nonmonetary factors that affect the structure and dynamics of the job market, such as population trends and technological innovation. These factors may change over time and may not be directly measurable.”
  - As a result, the FOMC does not specify a fixed goal for maximum employment
- Hierarchy: Under circumstances in which the Committee judges that the two objectives are not complementary, it follows a balanced approach in promoting them. This is called the “dual mandate” and differs from many other central banks which have price stability as their primary goal.

Recent Changes of the Fed's Strategy

The Fed so far aimed at reaching an inflation target of 2%.

- An occasionally binding zero lower bound (ZLB) on nominal interest rates limits the stabilization possibilities during economic downturns and/or during periods of low inflation.
- It might be difficult to anchor inflation expectations at 2%, if on average inflation turns out to be lower due to this constraint.

The Fed has therefore announced a new framework on August 27, 2020, of targeting *average inflation*

1. The Fed "seeks to achieve inflation that averages 2 percent over time. Following periods when inflation has been running persistently below 2 percent, appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time.“
2. On the employment goal: Policy decision will be informed by its "assessments of the shortfalls of employment from its maximum level." The previous goal referred to "deviations from its maximum level.“

Goals of Central Banks in Practice: European Central Bank

- Treaty establishing the European Community, Article 105 (1): To maintain price stability is the primary objective of the Euro system
- „Without prejudice to the objective of price stability“, the Euro system will also „support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community“. These include a „high level of employment“ and „sustainable and non-inflationary growth“.
- The Treaty establishes a clear hierarchy of objectives for the Euro system. It assigns overriding importance to price stability.

Goals of Central Banks in Practice: European Central Bank

In July 2021 the Governing Council approved the ECB's new monetary policy strategy, which aims to adapt to a higher probability of hitting the lower bound in the future. The main new items are:

- Symmetric inflation target of 2%. Symmetry means that upper and lower deviations are equally undesirable. The idea is to firmly anchor expectations at 2% and avoid ambiguities.
- Especially forceful or persistent reaction to disinflationary shocks, which may also imply a transitory period in which inflation is moderately above target.
- A broader toolkit including the so-called unconventional instruments used in the last years (negative interest rates, forward guidance, asset purchase programmes, long-term refinancing operations) - that will be addressed in part 3 of the course.
- A more systematic evaluation of potential financial vulnerabilities, focusing on the monetary policy transmission mechanism (particularly via the bank lending, risk-taking and asset pricing channels).
- Commitment to an ambitious climate-related action plan (including climate change in the ECB‘s reference models, develop new indicators, introduce disclosures as a requirement for eligibility for private sector assets, include climate change risks in control frameworks, etc.)

5.2 The Optimal Rate of Inflation

The Optimal Rate of Inflation: Arguments for Zero Inflation

Unanticipated Inflation

- Redistribution from creditors to debtors might be undesirable
- Resources and time needed to hedge against unexpected changes in inflation
- Discourages saving, which in turn might hamper investment and growth

Anticipated Inflation

- Relative price distortions occur if not all prices adjust instantaneously → inefficient use of resources
- Cost of price changes (relabeling, customer relations, strategic complementarities)
- Effective tax rates increase in inflation if tax brackets are not indexed to inflation.

The Optimal Rate of Inflation: Arguments for Positive/Negative Inflation

Positive Inflation

- Inaccurate inflation measures due to various biases may overstate true inflation (by about 1 %).
- Downward nominal wage rigidities make it hard for firms to cut wages when demand falls.
- Zero lower bound on interest rates is reached faster and more often the lower the inflation target.
- Danger of deflation: Deflation increases real debt burdens and contributes to asset sales as households and firms struggle to service their debt. This depresses asset prices and raises defaults on loans, which in turn amplifies the downturn.

Deflation

- Milton Friedman argued that the opportunity cost of holding money faced by private agents, i.e. the nominal interest rate, should equal the social cost of creating additional fiat money.
- If the marginal cost of creating additional money is zero or approximately zero, the nominal interest rate should be zero.
- Together with a positive real interest rate (ex. 2 %), this implies via the Fisher equation deflation:

$$\underbrace{i}_{0} \approx \underbrace{r}_{2} + \underbrace{\pi}_{-2}$$

- The results of the optimal inflation rate being equal to minus the long-run real interest rate is known as the Friedman rule. This results holds in frictionless (flex price) models without zero lower bound constraint.

Optimal Rate of Inflation

Optimal rate of inflation should maximize the economic well-being of the public

- Need a measure of economic well-being: welfare function
- Need a model to check which inflation rate leads to maximal welfare given different frictions

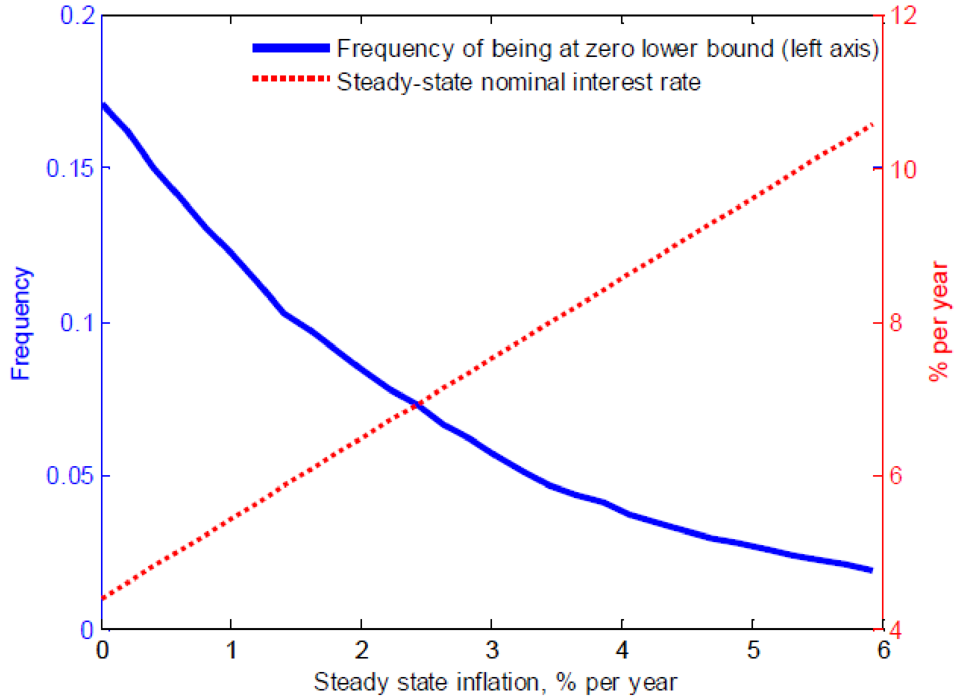
Coibion, Gorodnichenko and Wieland (2011) use a New Keynesian model

- They simulate the model for different inflation targets
- Staggered price setting leads to relative price distortions with positive inflation that lower welfare. This calls for an optimal inflation rate of zero (note that also deflation as in the Friedman rule would lead to relative price distortions; the Friedman rule would be indeed optimal only in a flexible price model like the Real Business Cycle Model)
- Hitting the zero lower bound (ZLB) leads to welfare losses as monetary policy cannot stabilize the economy during these periods. This calls for high inflation to avoid hitting the ZLB.
- Accounting for both aspects implies that the optimal inflation rate is above zero for avoiding hitting the ZLB too often, but also not too high to avoid large relative price distortions.
- A realistic calibration of the model leads to an optimal inflation rate of 1.2 %. Accounting for the downward measurement bias in observed inflation, this corresponds to about 2 % observed inflation and yields a theoretical justification for inflation targets chosen by many central banks.

Steady State Inflation and Frequency of Hitting the ZLB

Higher steady state inflation implies a higher steady state nominal interest rate. If it is sufficiently high, the central bank will hit the ZLB only if large adverse shocks occur.

Figure 1. Frequency of being in the Zero Lower Bound and Steady-State Nominal Interest Rate

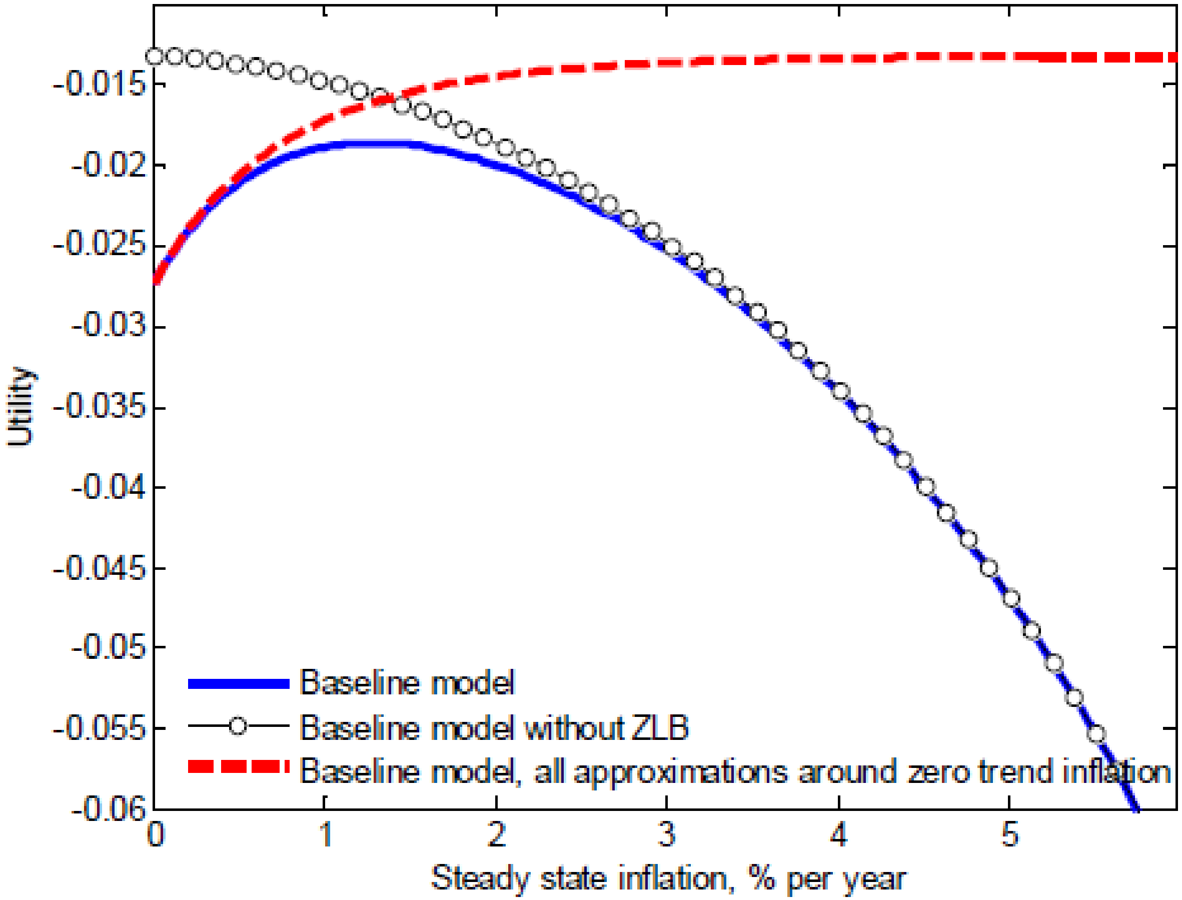


Note: The figure plots the steady-state level of the annualized nominal interest rate (right axis) implied by the baseline model of section 3 for different steady-state inflation rates. In addition, the figure plots the frequency of hitting the zero bound on nominal interest rates (left axis) from simulating the baseline model at different steady-state inflation rates. See section 3.2 for details.

Source: Coibion, Gorodnichenko and Wieland (2011)

Optimal Rate of Inflation in a New Keynesian Model

- The vertical axis shows welfare (negative number due to log utility).
- The red line shows a model version with ZLB, but without relative price distortion effect → $\pi^{opt} > 5\ \%$
- The black line (circles) shows a version with relative price distortions, but without ZLB → $\pi^{opt} = 0\ \%$
- The blue line shows the full model with ZLB and relative price distortions → $\pi^{opt} = 1.2\ \%$



Source: Coibion, Gorodnichenko and Wieland (2011)

Higher Inflation Target?

“The crisis has shown that interest rates can actually hit the zero level, and when this happens it is a severe constraint on monetary policy that ties your hands during times of trouble. As a matter of logic, higher average inflation and thus higher average nominal interest rates before the crisis would have given more room for monetary policy to be eased during the crisis and would have resulted in less deterioration of fiscal positions. What we need to think about now is whether this could justify setting a higher inflation target in the future.“

Olivier Blanchard, February 2010

With a model like the one of Coibion, Gorodnichenko and Wieland one can evaluate the welfare cost of changing the inflation target.

- The change in utility is hard to interpret. Therefore, one transforms it into consumption equivalence units. Which permanent reduction in consumption would yield the same change in utility?
- Raising the inflation target rate from 1.2 % to 4 % per year is equivalent to permanently reducing consumption by nearly 2 % according to the model.
- Open research question: Is 2 % still optimal, when modeling de-anchoring of long-term inflation expectations after crises? We will return to this question in part 3 of the course.

5.3 Monetary Policy in the Short Run: Inflation Targeting

Inflation Targeting

- So far, we have a model consisting of an IS curve and a PC curve. Monetary policy has been assumed to be exogenous.
- Now we will derive an optimal systematic reaction of monetary policy to inflation and the output gap. We will focus here on one of the most widely used monetary policy frameworks: inflation targeting.
- Inflation targeting central banks announce a target for inflation and use policy instruments to achieve this target.
- Often the focus is on deviations of *forecasted* inflation from the inflation target due to the transmission lag of monetary policy. In a (often monthly) monetary policy report inflation forecasts are shown (often as fan charts that include different uncertainty bands). The central bank raises/cuts interest rates if the inflation forecast is above/below target. This highly transparent approach is often viewed as an effective way to anchor inflation expectations.
- The stabilization of output/employment might be an additional goal.
- A growing number of countries adopted inflation targeting since the 1990s: New Zealand 1990, Canada 1991, UK 1992, Sweden 19993, Peru 1994, South Africa 2000, Norway 2001, Hungary 2001, … (see http://www.centralbanknews.info/p/inflation-targets.html for a full list)
- Other monetary policy strategies are for example monetary targeting, price level targeting, nominal GDP targeting and exchange rate targeting (widely used to achieve a fixed exchange rate)

Strict and Flexible Inflation Targeting

The central bank aims to adjust its instrument (we will focus here on the nominal interest rate i_t) to minimize the loss function taking into account how the instrument affects output and inflation via the IS and the PC curve.

Strict inflation targeting: The central bank only cares about stabilizing inflation

$$\text{Loss function: } L(\pi_t) = \frac{1}{2}(\pi_t - \pi^*)^2$$

- The central bank cares equally about upward and downward deviations of inflation from its target.
- Increased importance of bringing inflation back to its target the further it is away from it
- The ½ in front of the loss function makes the functional form of the first order conditions simpler without changing the result as it is just a scaling parameter of the loss function.

Flexible inflation targeting: The central bank cares about inflation and output stabilization.

$$\text{Loss function: } L(\pi_t) = \frac{1}{2}[(\pi_t - \pi^*)^2 + \lambda x_t^2]$$

$x_t = y_t - y_t^*$: output gap

$\lambda = 0$: strict inflation targeting

$\lambda > 0$ captures relative weight on output stabilization

$\lambda = 1$: equal weighting of inflation and output stabilization

In reality, the case of flexible inflation targeting prevails. Nevertheless, we will start with deriving optimal monetary policy for the strict inflation targeting case as it is much simpler. Afterwards, we will generalize the results to flexible inflation targeting.

The IS and the PC Curve

- To simplify the problem as much as possible, we will disregard expectations and focus on a backward-looking Phillips curve and IS-curve. The setup is the same as in the required reading (Svensson (1997)).

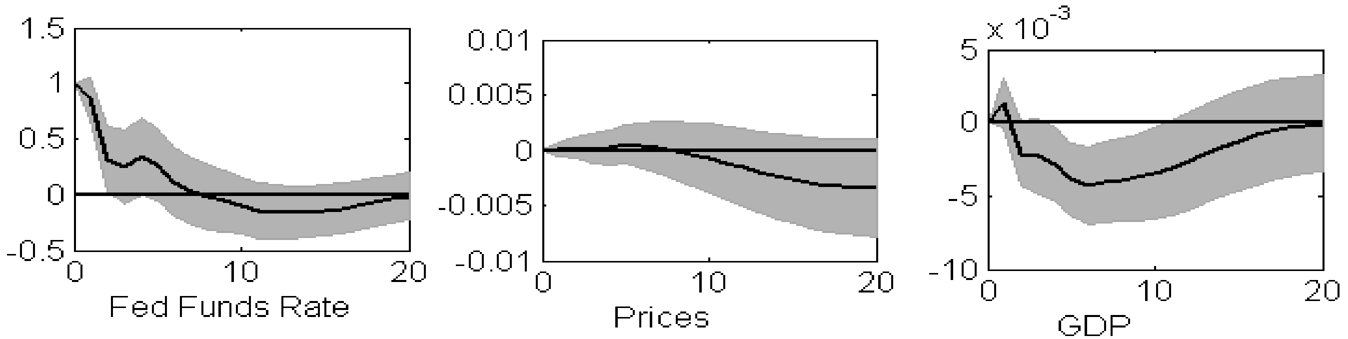
$$\pi_t = \pi_{t-1} + \alpha\, x_{t-1} + \varepsilon_t^{\pi}$$
$$x_t = \beta_1 x_{t-1} - \beta_2 (i_{t-1} - \pi_{t-1}) + \varepsilon_t^{y}$$

- Both equations are written in terms of the output gap $x_t = y_t - y_t^*$ and we set $r^* = 0$ so that it does not show up in the IS curve.

- Variables are to be interpreted as percentage deviations from steady state, i.e. in the long run $y_t = \pi_t = i_t = 0$ when they return to steady state values.

- To capture empirically observed persistence in the output gap, a lagged output gap has been added to the IS-equation. Periods are interpreted as years. The timing of this setup captures roughly the timing of the empirically observed transmission lag of monetary policy: $i_t \rightarrow y_{t+1} \rightarrow \pi_{t+2}$.

- For example, monetary policy transmission based on impulse response functions to a monetary policy shock in a Vector Autoregression based on US data (quarters on the horizontal axis) shows a similar timing:



Simplifying the IS and PC Curve

Let's re-write the equations to reflect that i_t affects x_{t+1} and x_{t+1} affects π_{t+2}

$$\pi_{t+2} = \pi_{t+1} + \alpha\, x_{t+1} + \varepsilon^{\pi}_{t+2}$$
$$x_{t+1} = \beta_1 x_t - \beta_2(i_t - \pi_t) + \varepsilon^{y}_{t+1}$$

Let's simplify the optimization problem by combining the IS and the PC curve into one constraint. Plug IS into PC:

$$\pi_{t+2} = \pi_{t+1} + \gamma\, \overbrace{(\beta_1 x_t - \beta_2(i_t - \pi_t) + \varepsilon^{y}_{t+1})}^{x_{t+1}} + \varepsilon^{\pi}_{t+2}$$

Next, we plug in the PC for π_{t+1}:

$$\pi_{t+2} = \overbrace{\pi_t + \alpha\, x_t + \varepsilon^{\pi}_{t+1}}^{\pi_{t+1}} + \alpha(\beta_1 x_t - \beta_2(i_t - \pi_t) + \varepsilon^{y}_{t+1}) + \varepsilon^{\pi}_{t+2}$$

Solving the brackets yields:

$$\pi_{t+2} = (1 + \alpha\beta_2)\pi_t + \alpha(1 + \beta_1)x_t - \alpha\beta_2 i_t + (\varepsilon^{\pi}_{t+1} + \varepsilon^{y}_{t+1} + \varepsilon^{\pi}_{t+2})$$

Collecting coefficients we get:

$$\pi_{t+2} = a_1\pi_t + a_2 x_t - a_3 i_t + (\varepsilon^{\pi}_{t+1} + \varepsilon^{y}_{t+1} + \varepsilon^{\pi}_{t+2})$$

With $a_1 = (1 + \alpha\beta_2); a_2 = \alpha(1 + \beta_1); a_3 = \alpha\beta_2$

The Optimization Problem

Interpret inflation targeting as implying that the central bank's objective in period t is to choose a sequence of current and future interest rates $i_t, i_{t+1}, i_{t+2}, \dots, i_\infty$ to minimize the intertemporal loss function:

$$\min_{i_t, i_{t+1},\dots} E_t \sum_{t=0}^{\infty} \delta^t L(\pi_t - \pi^*) = \min_{i_t, i_{t+1},\dots} E_t \sum_{t=0}^{\infty} \delta^t \frac{1}{2}(\pi_t - \pi^*)^2$$

subject to

$$\pi_{t+2} = a_1\pi_t + a_2 x_t - a_3 i_t + (\varepsilon_{t+1}^{\pi} + \varepsilon_{t+1}^{y} + \varepsilon_{t+2}^{\pi})$$

- The output gap is assumed to not enter the loss function → strict inflation targeting.
- Shocks are in expectation zero.
- i_t affects $\pi_{t+2}, \pi_{t+3},\dots$ but not π_t or π_{t+1}. i_{t+1} affects $\pi_{t+3}, \pi_{t+4},\dots$ but not π_{t+1} or π_{t+2}. Hence, one can simplify the problem to a period-by-period problem:

$$\min_{i_t} E_t \delta^2 \frac{1}{2}(\pi_{t+2} - \pi^*)^2$$

subject to

$$\pi_{t+2} = a_1\pi_t + a_2 x_t - a_3 i_t + (\varepsilon_{t+1}^{\pi} + \varepsilon_{t+1}^{y} + \varepsilon_{t+2}^{\pi})$$

Solution of the Optimization Problem: Inflation Forecast Targeting

Taking the first order condition and setting it equal to zero yields the optimality condition (you need to account for the inner and outer derivative of the term in brackets):

$$-\delta^2 a_3(E_t\pi_{t+2} - \pi^*) = 0$$

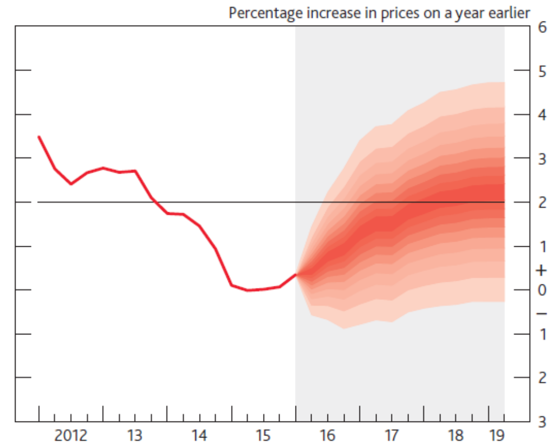
Simplifying yields

$$E_t\pi_{t+2} = \pi^*$$

Intuition: "Inflation Forecast Targeting". Set the interest rate in period t in a way that inflation in two periods (that is, when the effect of the interest rate on inflation first occurs) equals the inflation target in expectations. There might be shocks occurring during the transmission lag that might affect π_{t+2}, but that the central bank cannot anticipate.

The same problem would be solved in $t+1$, $t+2$ etc. implying to set i_{t+1} such that $E_t\pi_{t+3} = \pi^*$, i_{t+2} such that $E_t\pi_{t+4} = \pi^*$ and so on, so that in each period the central bank needs to set the interest rate in a way that expected inflation in two years time equals the inflation target.

Making Inflation Forecast Targeting Operational



Possibility 1: Targeting Rule $E_t \pi_{t+2} = \pi^*$

- The first order condition is called a “targeting rule”
- The central bank uses its preferred model(s) and expert judgement to set the interest in a way that the inflation forecast in two years equals the inflation target.
- This is what many central banks do in practice

Possibility 2: Instrument Rule

- The central bank specifies the expected value of inflation in two years with all the available information that has in t. Using the previous specification:

$$\pi_{t+2} = a_1 \pi_t + a_2 x_t - a_3 i_t + (\varepsilon_{t+1}^{\pi} + \varepsilon_{t+1}^{y} + \varepsilon_{t+2}^{\pi})$$

- The idea is to derive an explicit formula on how the interest rate should be adjusted in response to current variables, so that expected inflation in two years time equals the inflation target:

$$E_t \pi_{t+2} = a_1 \pi_t + a_2 x_t - a_3 i_t = \pi^*$$

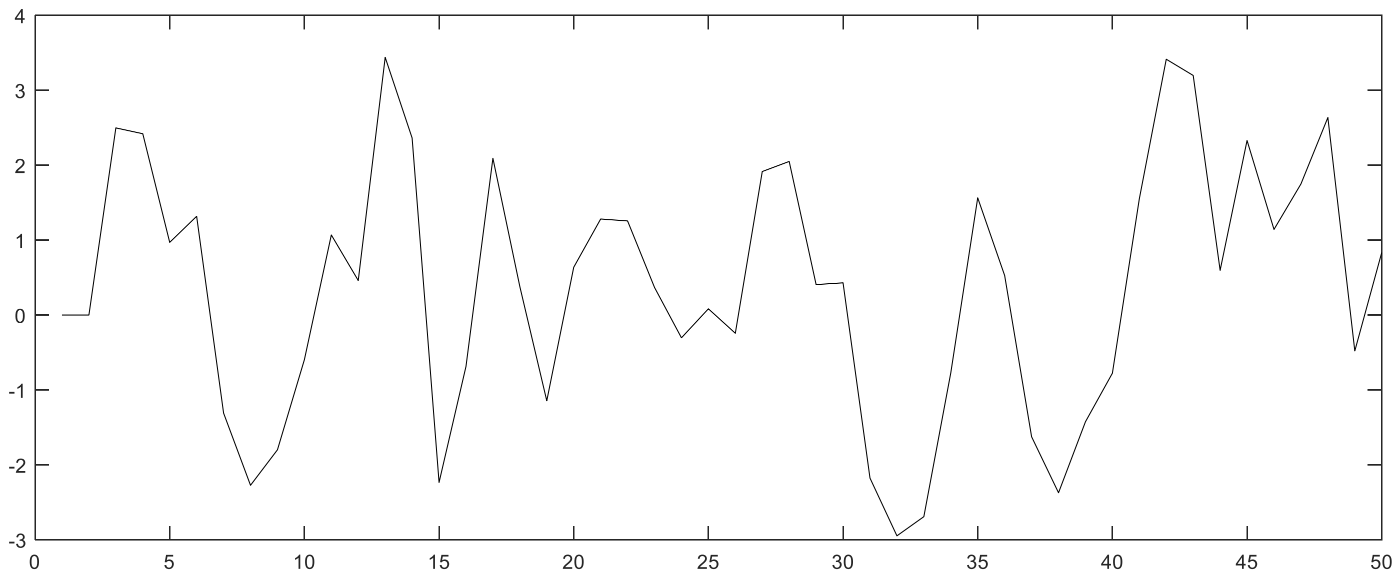
- Solving and re-writing yields an instrument rule:

$$i_t = \frac{1}{a_3}(a_1 \pi_t + a_2 x_t - \pi^*) = \pi_t + \frac{1}{\alpha_1 \beta_2}(\pi_t - \pi^*) + \frac{1 + \beta_1}{\beta_2} x_t$$

Instrument Rule as the Optimal Solution to Strict Inflation Targeting

Instrument rule: $i_t = \pi_t + \frac{1}{\alpha_1 \beta_2}(\pi_t - \pi^*) + \frac{1+\beta_1}{\beta_2} x_t$

- Although the output gap doesn‘t enter in the loss function, the central bank reacts to it.
- The reason is that the output gap is a good indicator of future inflation: π_{t+2} and $E_t(\pi_{t+2})$ depend on y_t (and on π_t)
- Inflation deviates randomly from target because of shocks that occur after the interest rate is set: $\pi_{t+2} - E_t \pi_{t+2} = \pi_{t+2} - \pi^* = \varepsilon_{t+1}^{\pi} + \varepsilon_{t+1}^{y} + \varepsilon_{t+2}^{\pi}$
- Sample path of inflation under strict inflation targeting implemented via the above instrument rule with an inflation target of $\pi^* = 0$ (and $\varepsilon^{\pi} \sim N(0,1), \varepsilon^{y} \sim N(0,1)$):



Targeting Rule vs Instrument Rule

First order conditions are targeting rules

- General condition that the central bank should fulfill
- Can be implemented using different models and one can use more information to forecast inflation than contained in one specific model
- No explicit recipe how to adjust the interest rate
- Possibility in making mistakes in interest rate setting as no precise formula is given
- Commitment to target rule in reality not totally implausible

Instrument rules

- Precise formula how to set the interest rate given a specific model
- Less flexible and possibly less robust than targeting rule
- Interest rate setting might be inefficient if the model is misspecified
- No central bank would commit to a narrowly defined instrument rule

Flexible Inflation Targeting

So far, we have assumed that the central bank does not care about economic activity, but plenty of evidence points that they actually do.

- Change loss function: $L(\pi_t) = \frac{1}{2}[(\pi_t - \pi^*)^2 + \lambda x_t^2]$
- First order condition is: $E_t\pi_{t+2} = \pi^* - \frac{\lambda}{\delta\alpha k} E_t x_{t+1}$ (k is given in the Svensson paper)
- Interpretation: Two-year inflation forecast should equal the inflation target if the expected output gap is zero. Otherwise, it should exceed the inflation target proportionally to one-year forecast of the output gap.
- Example of an expected recession $E_t x_{t+1} = -5\%$. In this case, the interest rate should decrease, so that $E_t\pi_{t+2}$ is higher than π^* to lean against the expected recession, rather than stabilizing inflation fully at the cost of experiencing a recession.
- Instrument rule is: $i_t = \pi_t + \left(\frac{\beta_1}{\beta_2} + \frac{\delta k \alpha^2}{\beta_2(\lambda + \delta k \alpha^2)}\right) x_t + \frac{\delta k \alpha}{\beta_2(\lambda + \delta k \alpha^2)}(\pi_t - \pi^*)$
- Much smaller interest rate movements compared to strict inflation targeting since the central bank does not want the output gap move too much. It takes longer for inflation to go back to steady state, but the volatility of the output gap is smaller.

Summary

In the long run inflation is controlled by the central bank. Hence, one needs to think about which inflation rate to target.

- High inflation → various welfare costs like relative price distortions.
- Low inflation → ZLB binds often
- Optimal inflation in New Keynesian models turns out to be around 2% and this is also the target used by many central banks.

How should the central bank stabilize inflation around target?

- Transmission lag of monetary policy makes targeting expected inflation appealing.
- The model by Svensson shows that inflation forecast targeting turns out to be optimal.
- Can be implemented via a targeting rule or an instrument rule.
- Inflation will still fluctuate due to shocks that are uncontrollable as they occur during the transmission lag.
- Recent discussion on changing the monetary policy framework to incorporate persistent ZLB periods. More on this in Part 3.