Monetary Policy

Part 2: Conventional Monetary Policy

Lecture 6: Monetary Policy Rules, The Complete IS-MP-PC Model

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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

Learning Objective of Today‘s Lecture

1. Understanding endogenous reactions of central banks to macroeconomic variables via simple monetary policy rules.

2. Completing the model via adding a policy rule: IS-MP-PC model

3. Studying demand and supply shocks in the IS-MP-PC model

4. Understand how the dynamics differ with anchored or adaptive inflation expectations.

Literature

Required reading

- Karl Whelan (2020). Lecture Notes on Macroeocnomics, Chapter 1 "Introducing the IS-MP-PC model", pp. 25-36. https://www.karlwhelan.com/Macro2/Whelan-Lecture-Notes.pdf

Optional reading

- Taylor (1993). "Discretion Versus Policy Rules in Practice", *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214.
- Clarida, Galí and Gertler (2000), "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory", *Quarterly Journal of Economics* 115(1): 147-180.
- Orphanides (2001), "Monetary Policy Rules Based on Real-Time Data" *American Economic Review* 91(4): 964-985.
- Orphanides (2004), "Monetary Policy Rules, Macroeconomic stability, and Inflation: A View From the Trenches" *Journal of Money, Credit and Banking* 36(2): 151-175.

6.1 Monetary Policy Rules

The Taylor Rule

No central bank strictly follows a policy rule, but they are important benchmarks. Discussions on interest rate setting often evolve around monetary policy rules.

- Which interest rate is implied by a specific policy rule?
- What is the current realization of the output gap?
- What is not captured in the rule?
- What are reasons to respond differently to inflation or the output gap compared to what a rule would imply?

The most influential monetary policy rule is the Taylor rule (Taylor, 1993)

$$i_t = r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta x_t$$

- $x_t = y_t - y_t^*$: output gap
- Neutral level: $i^* = r^* + \pi^*$
- Taylor (1993) found that $\alpha = \beta = 0.5$ and $r^* = \pi^* = 2\%$ describe US monetary policy in the late 1980s and early 1990s well

$$i_t = 2 + \pi_t + 0.5(\pi_t - 2) + 0.5x_t$$

The Taylor principle: If we observe an increase of inflation by 1%, increase the nominal interest rate by more than 1% (by $1 + \alpha$) in order to increase the real interest rate and thereby affect economic activity and inflation

- Intuition: raise nominal interest rate more than the increase in inflation → increase in the real interest rate → decrease in economic activity → with a lag decrease of inflation
- Ensures that monetary policy is stabilizing inflation. Leads to stable solutions in a wide range of macroeconomic models

The Taylor Rule Describes U.S. Monetary Policy Quite Well

The Taylor rule is calibrated to fit U.S. data from 1987 to 1993.

- Such a calibrated rule is also a good first description of interest rate setting for other central banks.
- Almost all central banks are nowadays successful in stabilizing inflation (inflation rates above 10% are rare). As we will see in more detail, an important requisite for this is sticking to the Taylor principle.

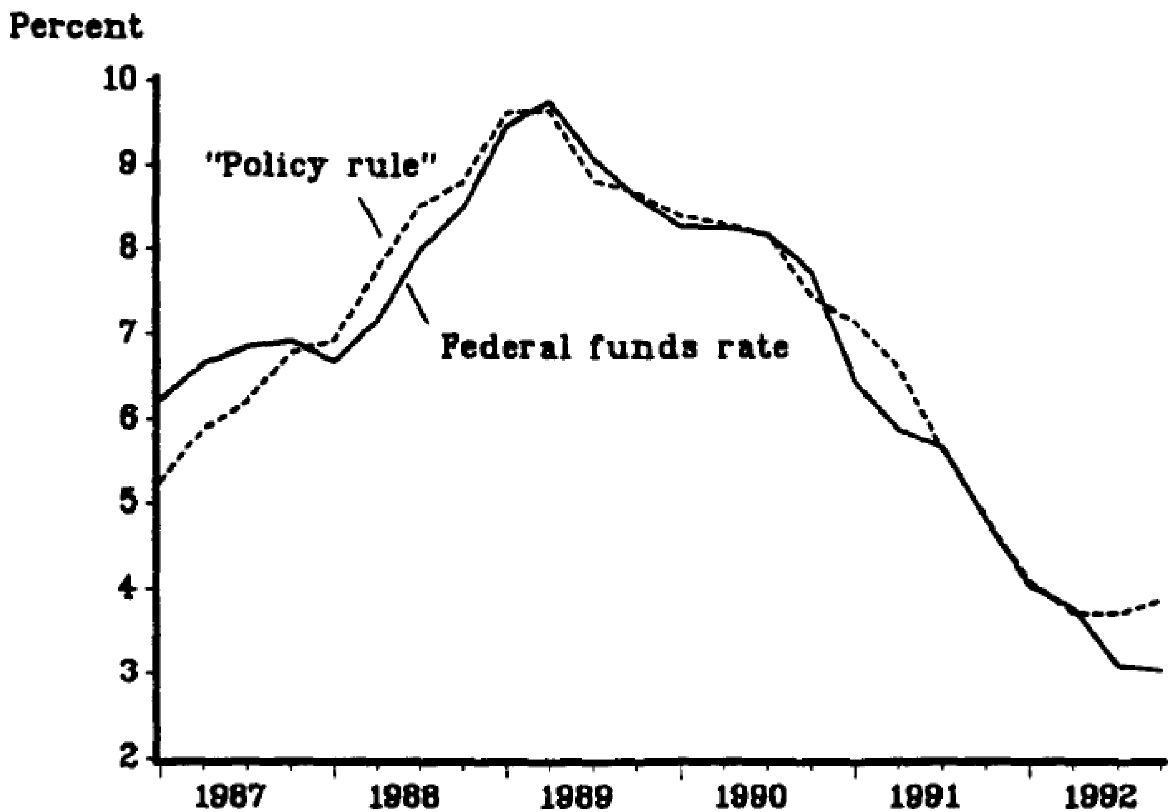


Figure 1. Federal funds rate and example policy rule.

Source: Taylor (1993). "Discretion versus policy rules in practice", Carnegie-Rochester Conference Series on Public Policy 39: 195-214.

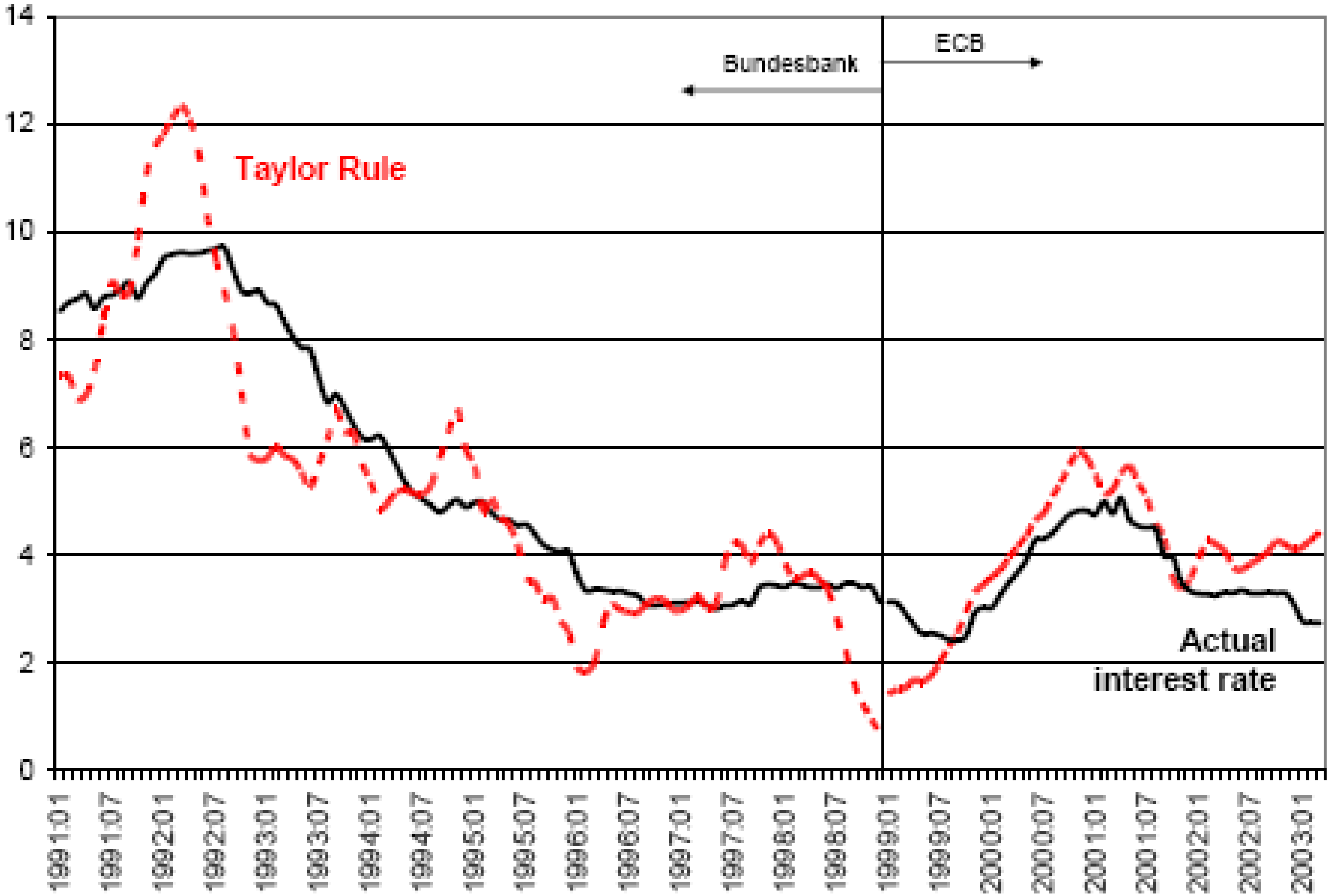
Backside of John Taylor‘s business card

Monetary Policy Rule

		% Deviation of Real GDP from Potential GDP		
		-2	0	2
Inflation Rate (percent)	0	.5	1	2
	2	3	4	5
	4	6	7	8
	6	9	10	11
	8	12	13	14

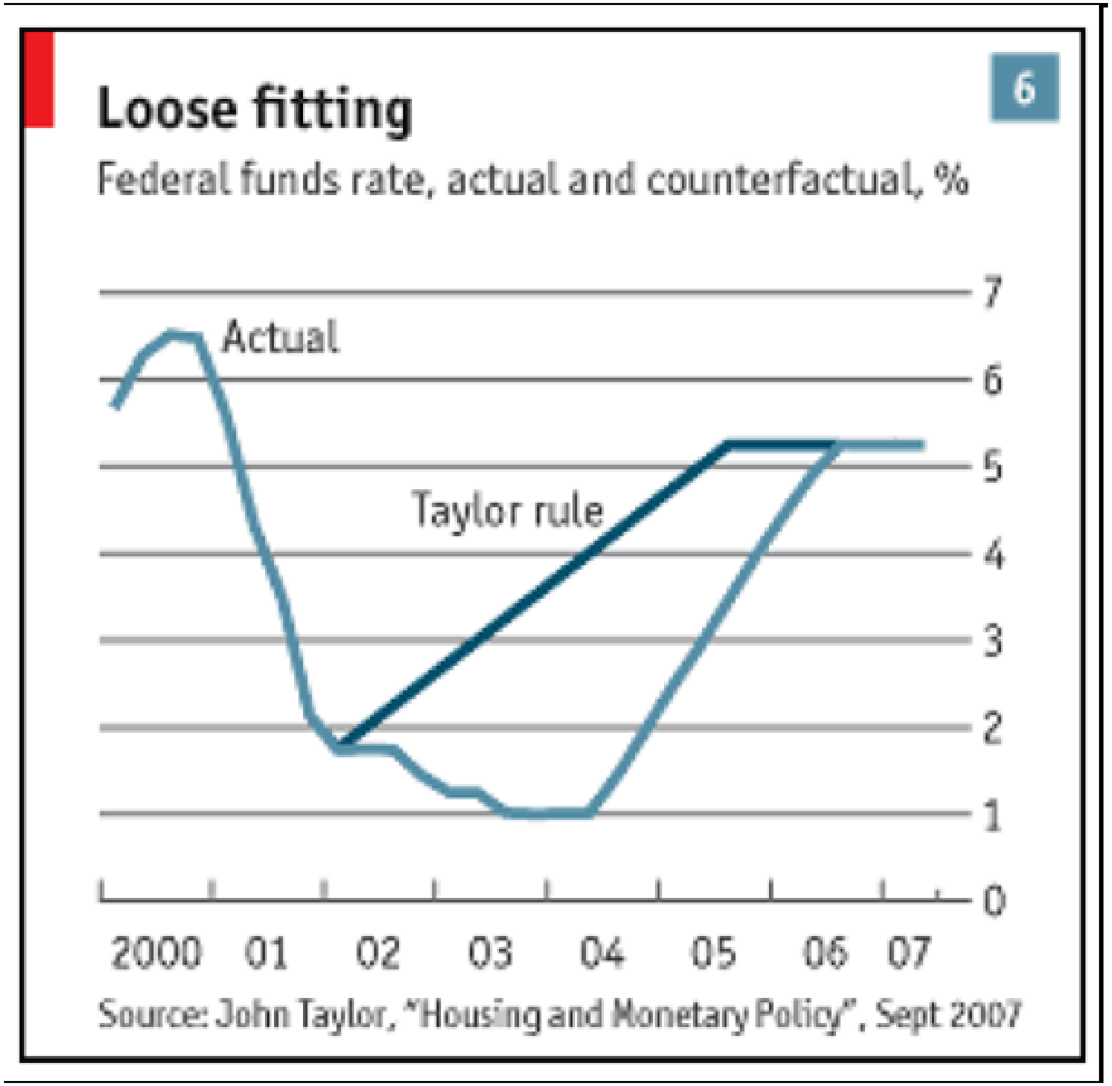
(The entries in red show the interest rate for each inflation rate and real GDP deviation.)

Taylor Rule and ECB policy



Sauer, S. and J.-E. Sturm (2003), *Using Taylor rules to understand ECB monetary policy*, Munich: CESifo Working Paper, 1110, December.

Fed Fund's rate pre housing crisis



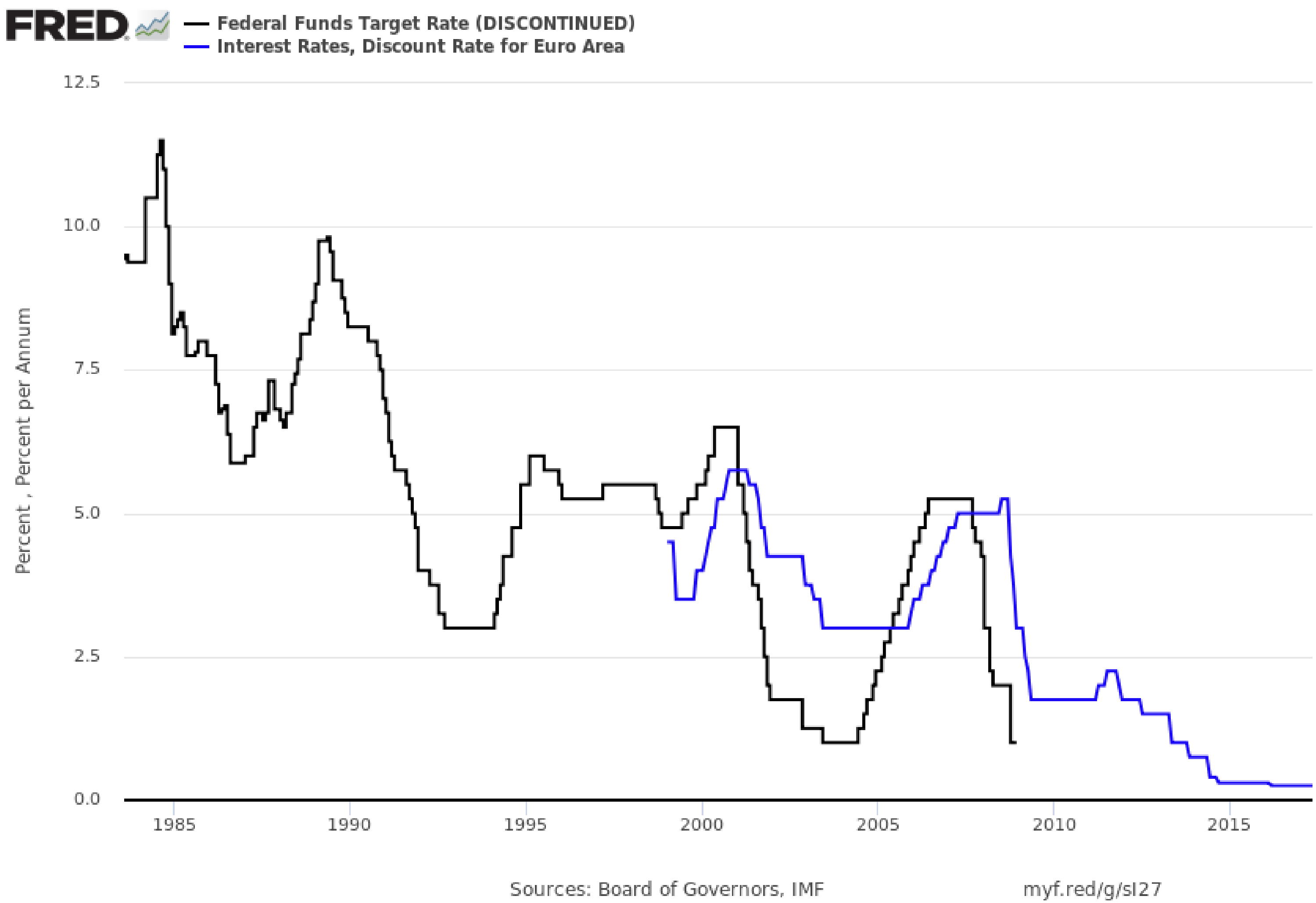
The Taylor rule is an important benchmark for policy discussions

Examples for the US

- Janet Yellen, Jan 17: https://www.federalreserve.gov/newsevents/speech/files/yellen20170119a.pdf
- Stanley Fisher, Feb 17: https://www.federalreserve.gov/newsevents/speech/files/fischer20170211a.pdf
- Monetary Policy Report July 17 (Fed-president Yellen): Monetary Policy Rules and Their Role in the Federal Reserve's Policy Process (p. 36): https://www.federalreserve.gov/monetarypolicy/files/20170707_mprfullreport.pdf
- Monetary Policy Report Feb 18 (Fed-president Powell): Monetary Policy Rules and Their Role in the Federal Reserve's Policy Process (p. 35): https://www.federalreserve.gov/monetarypolicy/files/20180223_mprfullreport.pdf
- Jerome Powell, Feb and March 18 testimony US House on Representatives : "In evaluating the stance of monetary policy, the FOMC routinely consults monetary policy rules that connect prescriptions for the policy rate with variables associated with our mandated objectives. Personally, I find these rule prescriptions helpful. Careful judgments are required about the measurement of the variables used, as well as about the implications of the many issues these rules do not take into account." https://www.federalreserve.gov/newsevents/testimony/files/powell20180227a.pdf
- New Fed-Website, March 18: Policy Rules and How Policymakers Use Them: https://www.federalreserve.gov/monetarypolicy/policy-rules-and-how-policymakers-use-them.htm
- (Failed) Initiative of the Republicans on establishing a law that requires the Fed to specify explicit monetary policy rules that describe their interest rate setting: Monetary Policy Transparency and Accountability Act of 2017: https://www.congress.gov/bill/115th-congress/house-bill/4270

Interest Rate Smoothing

- Simple Taylor Rule has difficulties to capture gradual adjustment of interest rates
- Most interest rate changes represent “continuations“ in the direction of policy



Policy Rules With Interest Rate Smoothing

Ultimate target rate:

$$i_t^* = r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta x_t$$

Gradual adjustment:

$$i_t = \rho i_{t-1} + (1-\rho) i_t^*$$

Combine the two equations:

$$i_t = \rho i_{t-1} + (1-\rho)[r^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta x_t]$$

Interest rate smoothing may be optimal even if the objective of the central bank is to stabilize inflation and output, but not the interest rate volatility.

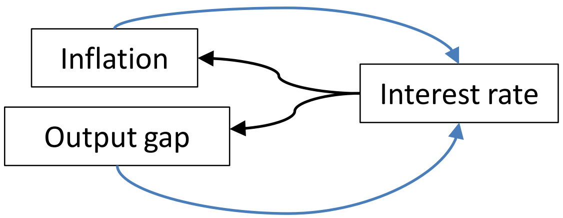
Three explanations of interest-rate smoothing:

- Forward-looking behavior of market participants
- Measurement error associated with key macroeconomic variables
- Uncertainty regarding relevant structural parameters

Estimation of Policy Rules

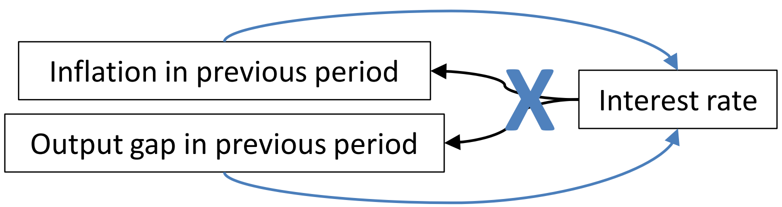
Can we get a more precise description of historical interest rate setting by estimating the parameters of policy rules?

Yes, but estimation gets complicated by a simultaneity problem: the interest rate responds to changes inflation and the output gap, and it is changed with the goal to affect inflation and the output gap.

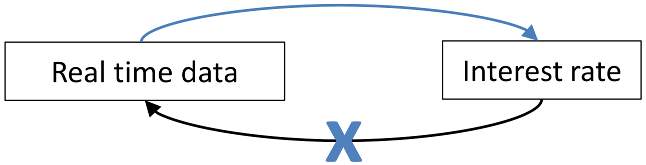


Two solutions:

1. Use instrumental variable estimation to get unbiased estimates. Instruments that are correlated with the endogenous variables (inflation, output gap), but are uncorrelated with the error term are needed. One can use lagged macroeconomic variables. These are correlated with the endogenous variables but have been determined in the past and are therefore not affected by the current interest rate.



2. Model the information set of the central bank using real-time data. For example, for the Fed often the Greenbook projections, i.e. the staff estimates of the current and future state of the economy are used. These are determined before setting the interest rate. Hence, they influence the interest rate, but the interest rate does not affect these. In this case there is not endogeneity problem and one can use OLS estimation.



Policy Rule Estimates Based on Revised Data

Clarida, Galí and Gertler (2000), "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory", Quarterly Journal of Economics.

- They estimate monetary policy rules for the U.S. using revised data and IV estimation.
- The consider two samples. The first sample from 1960 to 1979 corresponds to an era of unstable inflation. The second sample from 1979 to 1996 corresponds to an era of stable inflation.
- The estimate a rule of the following type:

$$i_t = (1-\rho)[r^* + \pi^* + \beta\pi_t + \gamma x_t] + \rho i_{t-1} + \varepsilon_t$$

TABLE II
BASELINE ESTIMATES

	π^*	β	γ	ρ
Pre-Volcker	4.24	0.83	0.27	0.68
	(1.09)	(0.07)	(0.08)	(0.05)
Volcker-Greenspan	3.58	2.15	0.93	0.79
	(0.50)	(0.40)	(0.42)	(0.04)

Standard errors are reported in parentheses. The set of instruments includes four lags of inflation: output gap, the federal funds rate, the short-long spread, and commodity price inflation.

- The inflation reaction coefficient β is much larger in the second subsample than in the first one. The Taylor principle is only fulfilled in the second subsample.
- They present a model similar to the IS-MP-PC to show that only a policy rule that fulfills the Taylor principle leads to stable inflation.

Policy Rule Estimates Based on Real-Time Data

Orphanides (2004), "Monetary policy rules, macroeconomic stability, and inflation: A view from the trenches" *Journal of Money, Credit and Banking*.

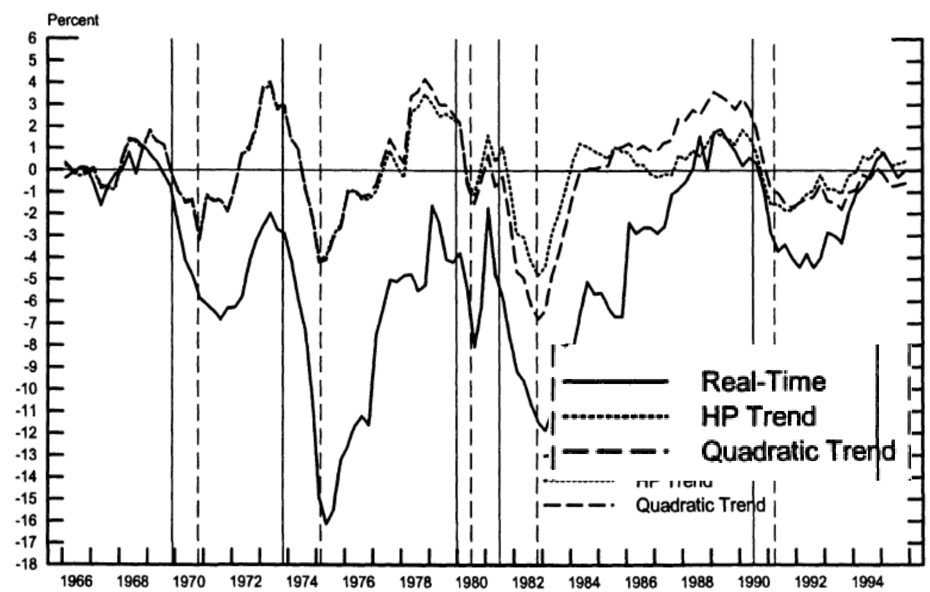
- Similar to Clarida, Galí and Gertler, Orphanides splits up the sample to a pre- and post-Volcker sample. Policy rules are estimated based on real-time Greenbook data
- Reaction to inflation fulfills the Taylor principle in both samples.
- Reaction to output gap much higher in the first compared to the second sample.
- Together with real-time misperception of a highly negative output gap, this let to too low interest rates and leading to high inflation in the 1970s.
- Punchline: A too activist (focus on output gap) policy in combination with output gap measurement problems can be destabilizing.
- Either put less weight on output gap or use policy rules with output growth rather than the output gap.

TABLE 1

ESTIMATED POLICY RULES

	α	β	γ	ρ
1966:1–1979:2	3.36	1.48	0.57	0.71
	(2.02)	(0.47)	(0.26)	(0.10)
1979:3–1995:4	0.30	2.12	0.14	0.73
	(1.61)	(0.48)	(0.18)	(0.05)

Output Gap Estimates: Real-time and Revised



6.2 Monetary Policy Rule in the IS-MP-PC Model

The IS-MP-PC Model and Monetary Policy

- We have developed a model consisting of a Phillips curve and an IS curve in lecture 4:

$$\pi_t = \pi_t^e + \gamma\,(y_t - y^*) + \varepsilon_t^\pi$$
$$y_t = y_t^* - \alpha(r_t - r^*) + \varepsilon_t^y$$

- This is the basis for the IS-MP-PC model. So far, we have assumed that monetary policy is set exogenously and that is can control directly the real rather than the nominal interest rate.

- Even in this case, the analysis showed that changes in r are necessary to stabilize the economy after demand or supply shocks.

- The inflation targeting framework in the previous lecture has shown that a systematic response to inflation and the output gap via a monetary policy rule is the solution to an optimization problem of a central bank with a preference to stabilize inflation (and output).

- The previous slides show that monetary policy rules play an important role in practice, though no central bank strictly follows a policy rule.

- Let’s complete the IS-MP-PC model via introducing a monetary policy rule.

Model Element Three: MP-Curve

Our version of the monetary policy (MP) curve will be the following:

$$i_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*)$$

- We assume $\beta_\pi > 1$
- The MP-curve is a little bit simpler than the Taylor rule which will help us to develop intuition and facilitates including the MP-curve in our graphical analysis.
- The central bank increases (decreases) i_t whenever inflation is above (below) target.
- If $\pi_t = \pi^*$, then the nominal interest rate is at its natural level $i^* = r^* + \pi^*$.
- Note that we study the realistic case in which the central bank uses the *nominal* rather than the real interest rate as the policy instrument. In order to plot in the (π_t, y_t) space the three equations of the model, we will combine the IS and the MP curve to an IS-MP curve (in some books also labeled as an AD curve).
- Alternatively, one could derive an LM curve from a money supply and money demand graph. Our analysis is simpler and closer to how monetary policy is actually conducted. This does not mean that money supply and demand play no role in determining inflation. However, setting a particular interest rate implies a certain money supply, so that the same inflation effects can be studied without modeling money supply and demand explicitly. By specifying a money demand function we could, however, figure out at any time the money supply required to implement a specific interest rate.

The Complete IS-MP-PC Model

The model consists of three equations:

1. The Phillips curve: $\pi_t = \pi_t^e + \gamma\,(y_t - y^*) + \varepsilon_t^\pi$
2. The IS curve: $y_t = y_t^* - \alpha(i_t - \pi_t - r^*) + \varepsilon_t^y$
3. The MP curve: $i_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*),$

Additional variables are implicitly defined.

- Real interest rate via a simplified Fisher equation: $r_t = i_t - \pi_t$
- The output gap: $x_t = y_t - y_t^*$

The determination of long-run values y^*, $r^*$and π^* was discussed in lectures 2/3. These values are taken as given here and we will mainly focus on temporary deviations from a long-run steady state (or balanced growth path)

We will now combine the information in the IS and the MP curve into one equation that shows a relation between inflation and output (or the output gap) on the demand side.

The IS-MP curve

Replace i_t in the IS curve with the MP curve:

$$y_t = y_t^* - \alpha([r^* + \pi^* + \beta_\pi(\pi_t - \pi^*)] - \pi_t - r^*) + \varepsilon_t^y$$

Solving the brackets:

$$y_t = y_t^* - \alpha r^* - \alpha\pi^* - \alpha\beta_\pi(\pi_t - \pi^*) + \alpha\pi_t + \alpha r^* + \varepsilon_t^y$$

Canceling out r^* and re-writing yields the IS-MP curve:

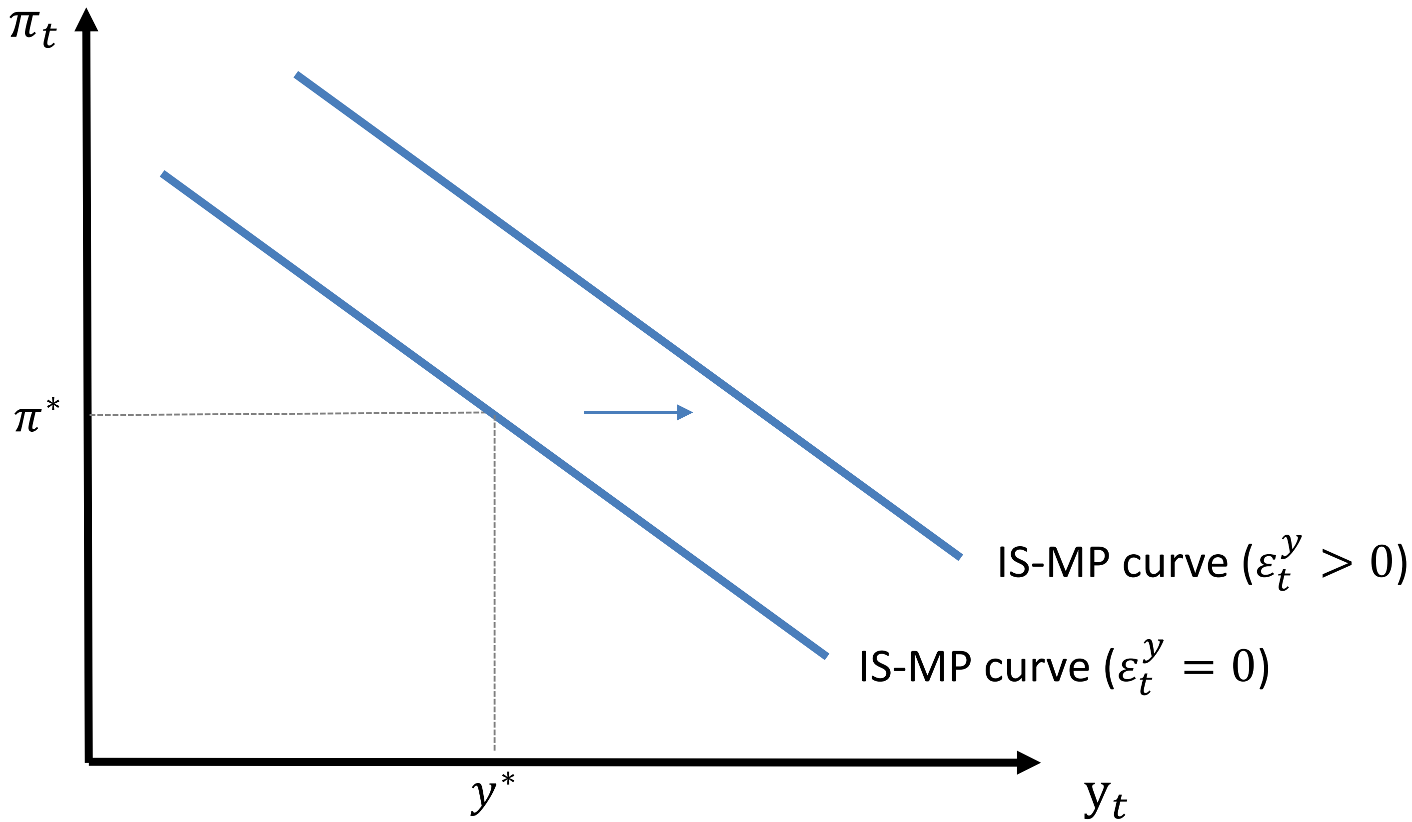
$$y_t = y_t^* - \alpha(\beta_\pi - 1)(\pi_t - \pi^*) + \varepsilon_t^y$$

- We will see later that for monetary policy to be stabilizing, β_π needs to be larger than one (Taylor principle is fulfilled). We can safely assume that $\alpha > 0$ (investment and consumption react negatively to an increase in the real interest). So, if $\beta_\pi > 1$ and $\alpha > 0$ this implies $\alpha(\beta_\pi - 1) > 1$, so that there is a negative relation between inflation and output.
- Intuition: Whenever inflation increases, the central bank will react via the Taylor rule with an increase in the nominal interest rate ($\beta_\pi > 0$). If this increase is sufficiently large (if the Taylor principle is fulfilled, $\beta_\pi > 1$, so that the real interest rate increases), output will decrease via the IS-curve.
- The slope of the IS-MP curve depends on β_π. The more the central bank reacts to a change inflation with a change in the interest rate, the flatter is the IS-MP curve (if you draw π_t on the vertical and y_t on the horizontal axis and we assume that $\beta_\pi > 1$). Intuition: The more the central bank increases the interest rate in response to an increase in inflation, the larger is the drop in output.

The IS-MP curve graphically (Taylor principle holds, $\beta_\pi > 1$)

The slope of the IS-MP curve depends on whether the Taylor principle is fulfilled or not. We assume for now that this is the case, so that the IS-MP curve is downward sloping.

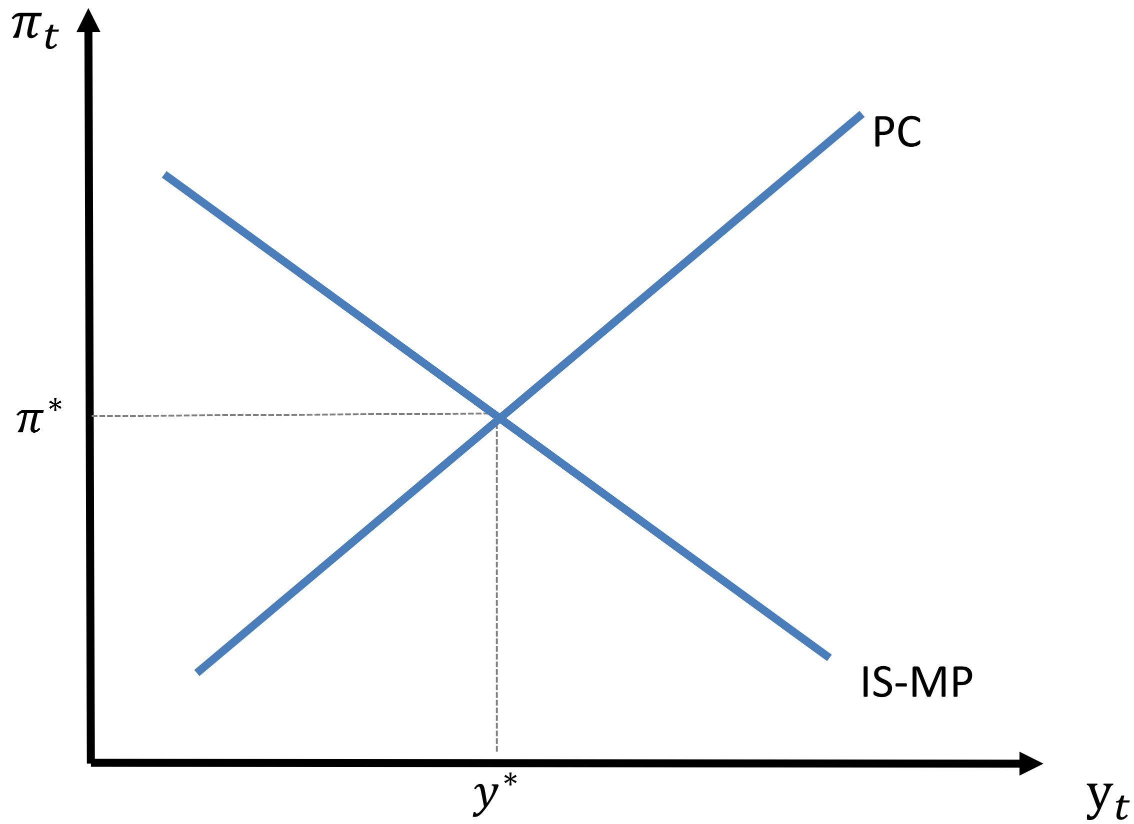
A positive demand shock ε_t^y moves the IS-MP curve to the right. For a *given* rate of inflation, more output is demanded. We will see next how interactions with the PC curve affect the dynamics.



The IS-MP-PC Model Graph

Putting the IS-MP curve and the Phillips curve in one graph shows the complete model.

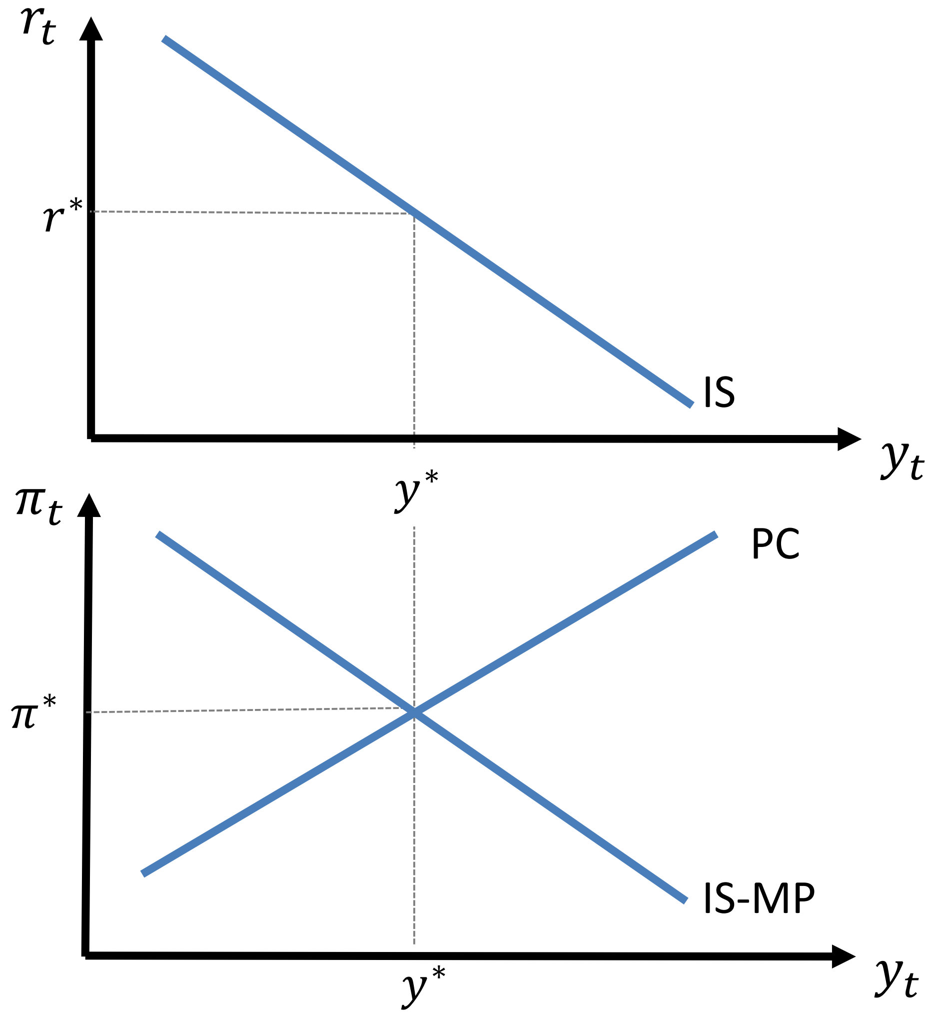
Here, we assume that inflation equals the inflation target and no shocks have occurred.



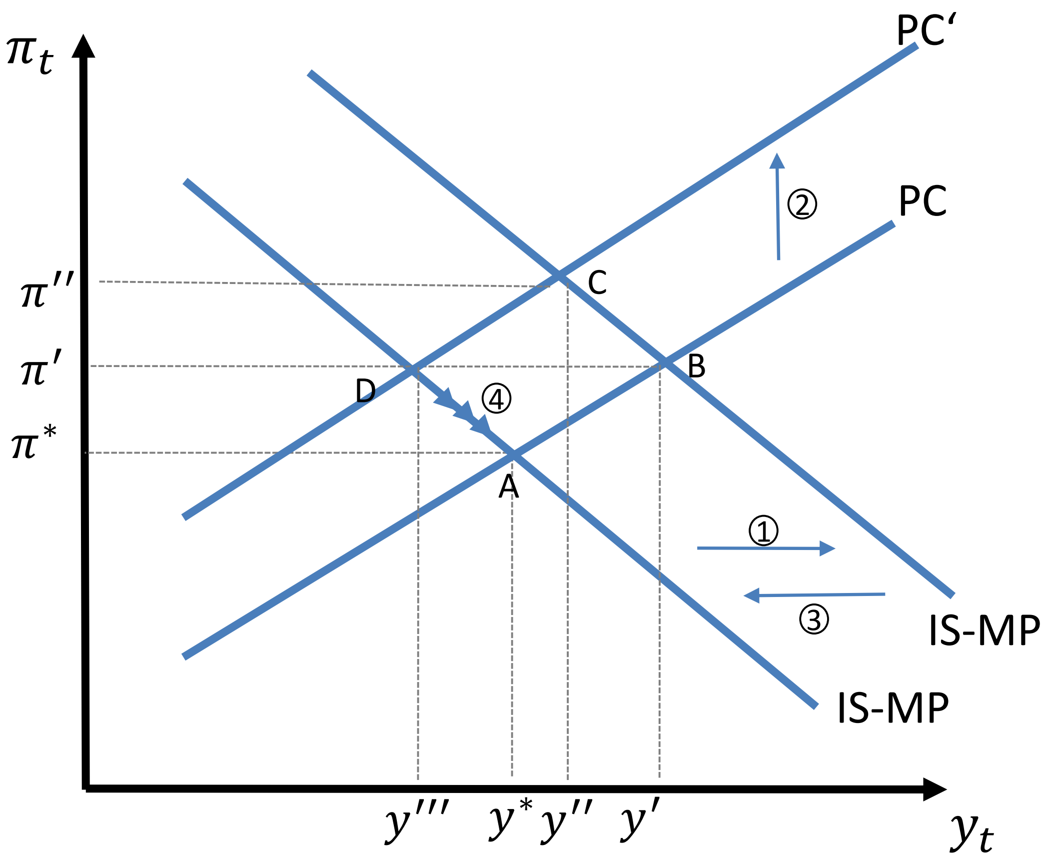
IS-MP-PC Extended Graphical Representation

While the previous graph shows all relevant parts of the model, sometimes it might be helpful to add a graph that shows the IS-curve and the real interest rate realization to disentangle joint dynamics of the demand side and monetary policy summarized by the IS-MP curve.

Exercise: Draw the movements of/along the IS curve and the movements in r for the graphs on the following slides.



A Temporary Demand Shock With Adaptive Inflation Expectations



Starting point A: long-run equilibrium.

1. A positive demand shock shifts the IS and thereby the IS-MP curve to the right. Inflation increases via the PC curve in response to the positive output gap. The central bank reacts via the MP-curve with an increase in the nominal interest rate. We assume that the Taylor principle is fulfilled, so that the real interest increases.

   Overall, the economy moves to point B. Note that output and inflation increase less compared to not increasing r.

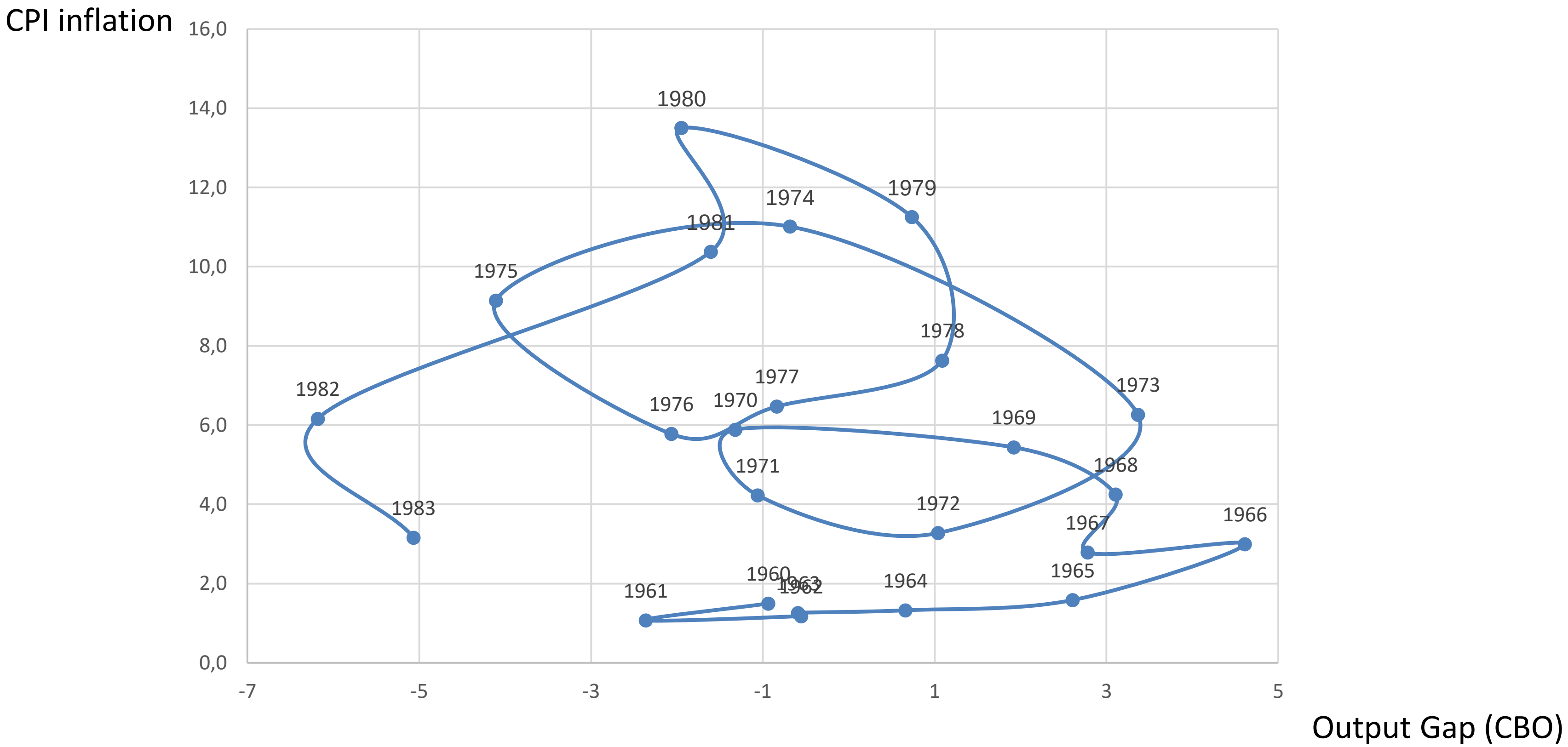
2. Inflation expectations adjust upwards, shifting up the PC and inflation. The central bank reacts by increasing the interest rate further. The economy moves to point C.
3. Let’s assume that the demand shock fades out now. The IS-MP curve moves back to its original location, but the PC curve stays elevated. The economy moves to point D. Output is below potential and inflation is elevated.
4. Inflation expectations go slowly back to target, so that the economy moves down the IS-MP curve, finally going back to y^*.

Counterclockwise Inflation-Output Loops

If temporary demand shocks dominate and inflation expectations are adaptive, then inflation-output combinations move counterclockwise.

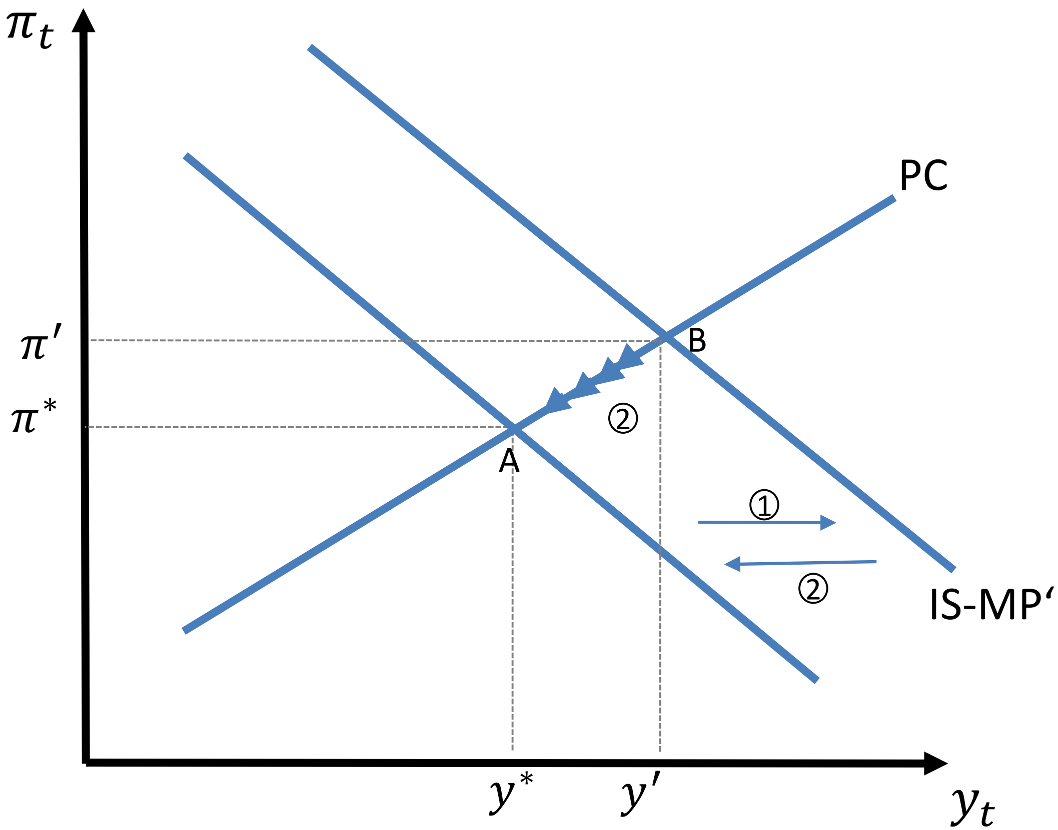
Positive (negative) demand shock is followed by a recession (boom) induced by an increase (decrease) in r by the central bank to bring inflation back to target.

This is what we observe empirically for example in the US between 1960 and 1983



Source: FRED, own computation

A Temporary Demand Shock With Anchored Inflation Expectations



Starting point A: long-run equilibrium.

1. A positive demand shock shifts the IS and thereby the IS-MP curve to the right. Inflation increases via the PC curve in response to the positive output gap. The central bank reacts via the MP-curve with an increase in the nominal interest rate. We assume that the Taylor principle is fulfilled, so that the real interest increases. The economy moves to point B.

   As long as inflation expectations are anchored at the inflation target, the PC does not move. As long as the positive demand shock persists, the economy remains in point B.

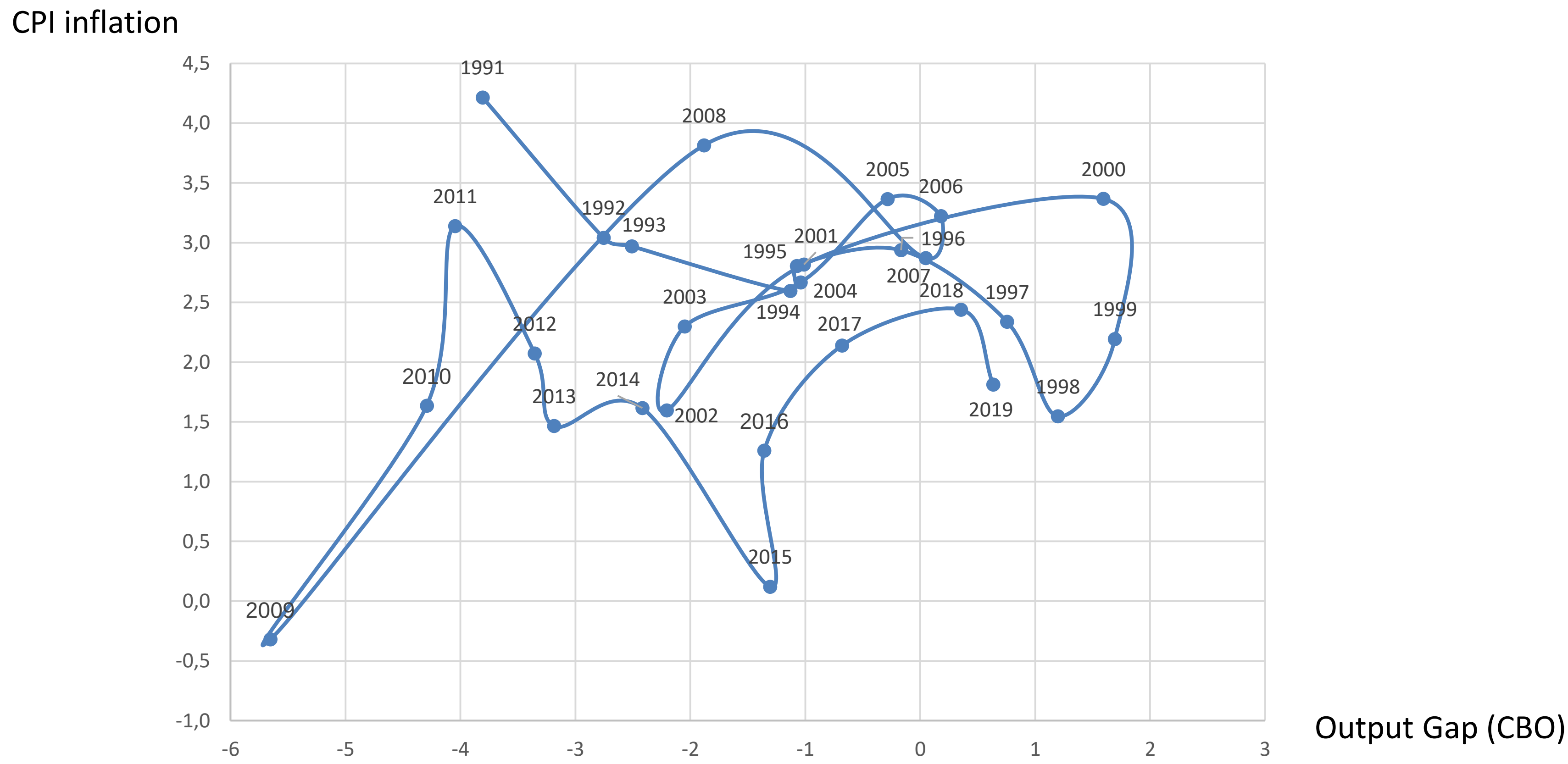
2. Let’s assume that the demand shock fades out now. The IS-MP curve moves back to its original location. The economy moves directly back to point A.

No Inflation-Output-Loop With Anchored Inflation Expectations

If temporary demand shocks dominate and inflation expectations are anchored at the inflation target, inflation and output move in the same direction.

After a shock inflation returns to target and the output gap closes without any further loops.

This is what we observe empirically for example in the US over the last 30 years.



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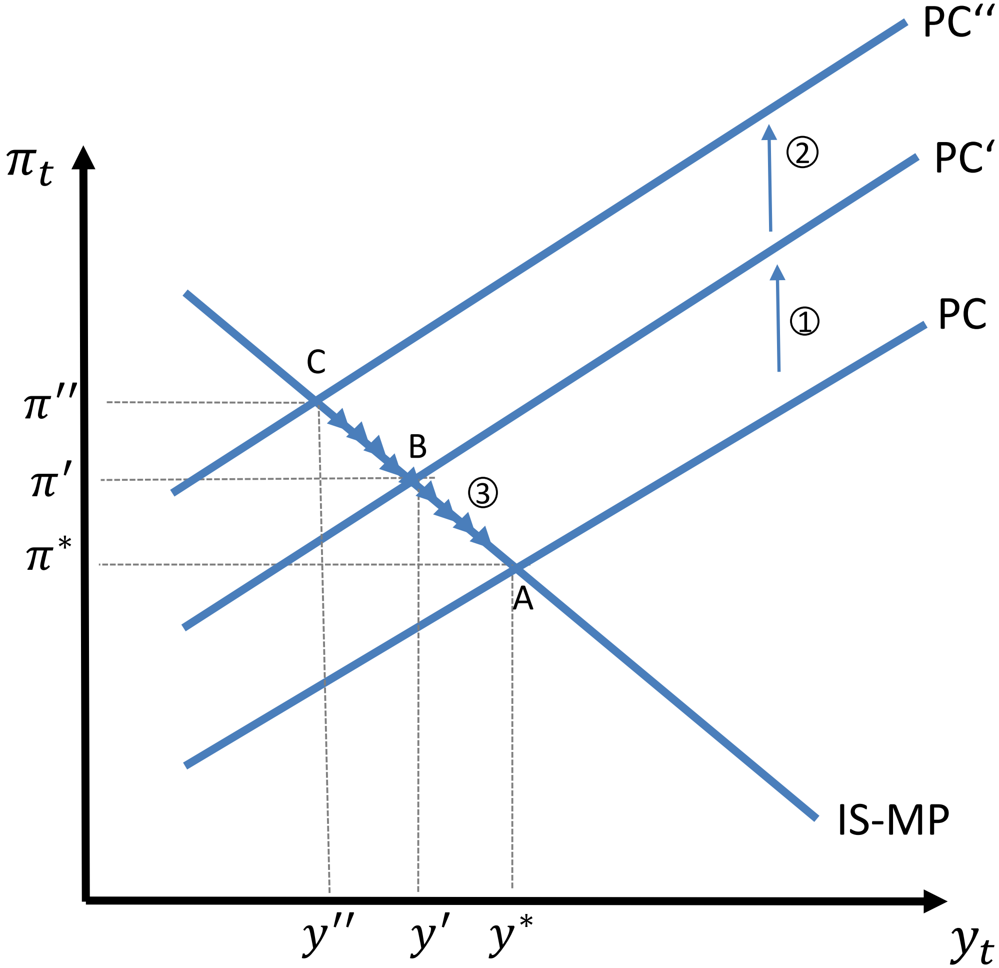
A Temporary Supply Shock With Adaptive Inflation Expectations



Starting point A: long-run equilibrium.

1. A positive supply shock shifts the PC upwards and increases thereby inflation. The central bank reacts via the MP-curve with an increase in the nominal interest rate. We assume that the Taylor principle is fulfilled, so that the real interest increases and output decreases.

   Overall, the economy moves to point B. The size of the decrease in output depends on the slope of the IS-MP curve, which in turn depends on β_{π}.

2. Inflation expectations adjust upwards, shifting up the PC and inflation. The central bank reacts by increasing the interest rate further, so that output contracts further mitigating the increase in inflation. The economy moves to point C.

3. Let's assume that the supply shock fades out now. The PC immediately shifts down by the size of the shock, but overall it stays elevated due to increased inflation expectations (this is not directly shown in the graph). Inflation expectations go slowly back to target, so that the economy moves down the IS-MP curve shifting down the PC curve finally going back to y^*.

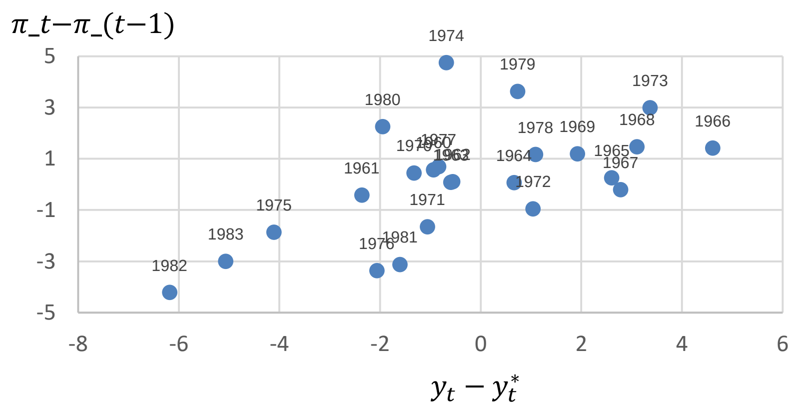
Implications of Adaptive Expectations for the Phillips Curve

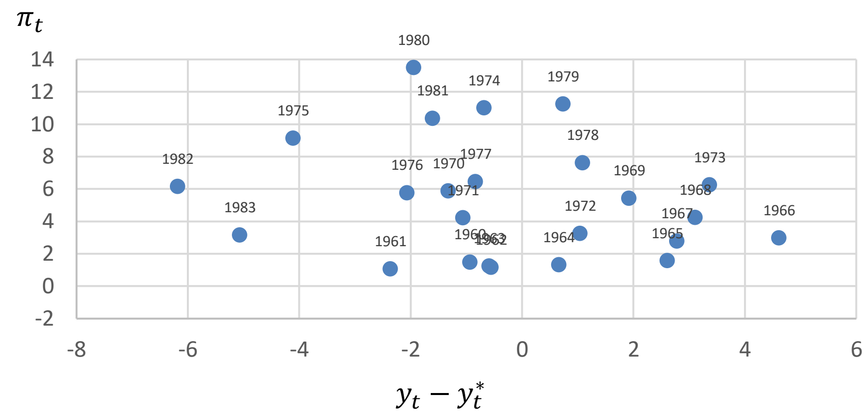
With adaptive expectations $(\pi_t^e = \pi_{t-1})$ the Phillips curve is a relation between the change rather than the level of inflation and the output gap:

$$\Leftrightarrow \ \pi_t - \pi_{t-1} = \gamma\,(y_t - y^*) + \varepsilon_t^{\pi}$$

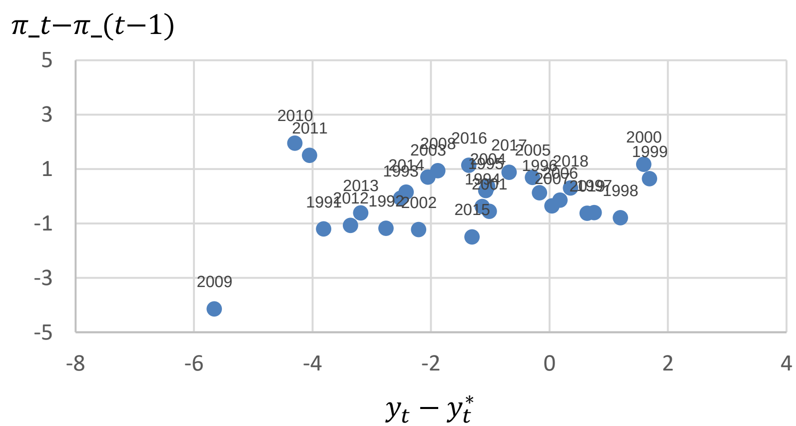
Empirically, there seems to be evidence for adaptive expectations for a U.S. based sample from 1960 to 1983, but not from 1990 to 2019. The output gap is measured using the CBO estimates of potential output and inflation is year-over-year CPI inflation.

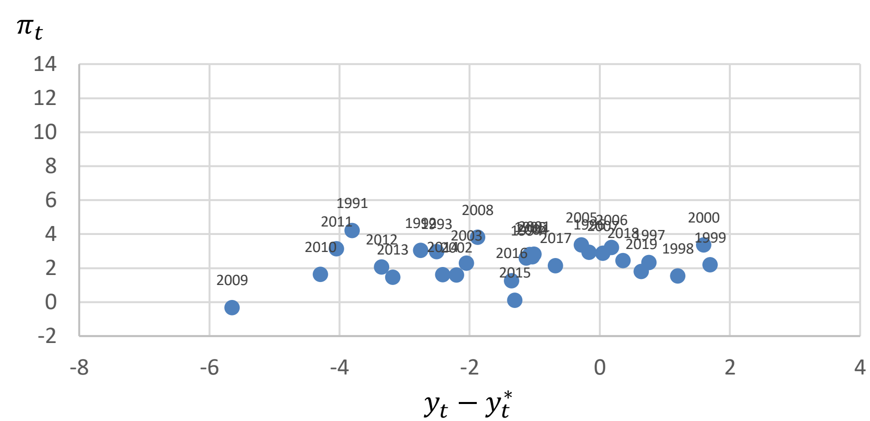
1960 - 1983





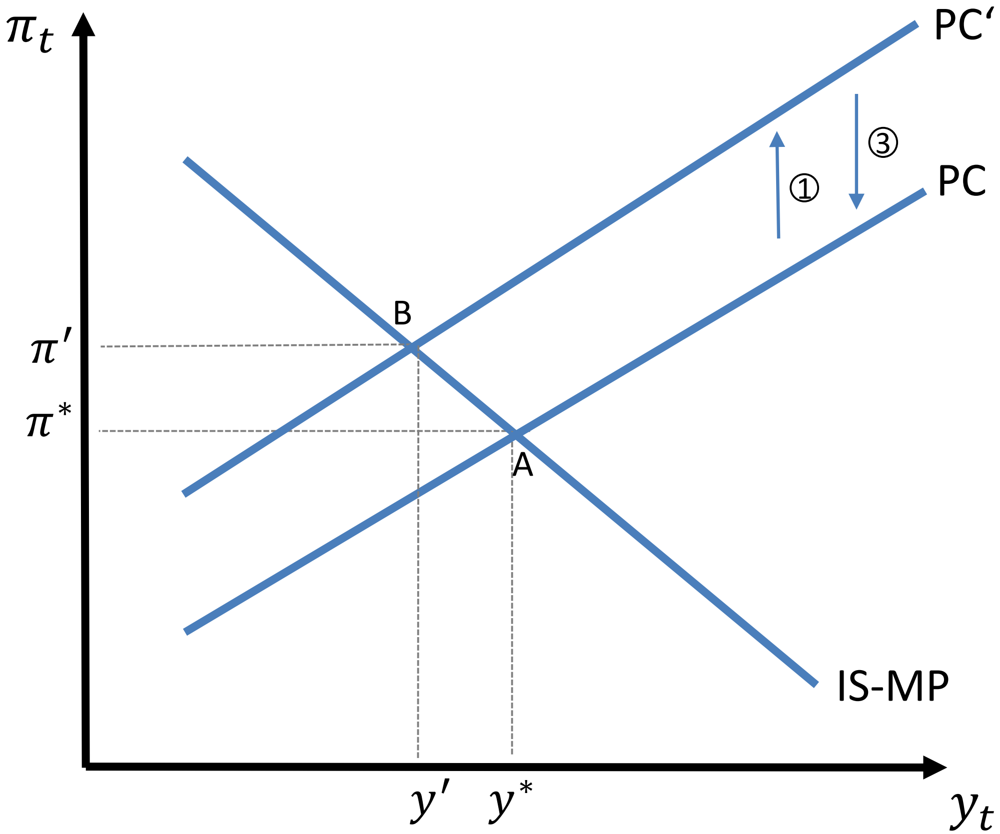
1990 - 2019





Source: FRED, own computation

A Temporary Supply Shock With Anchored Inflation Expectations



Starting point A: long-run equilibrium.

1. A positive supply shock shifts the PC upwards and increases thereby inflation. The central bank reacts via the MP-curve with an increase in the nominal interest rate. We assume that the Taylor principle is fulfilled, so that the real interest increases.

   Overall, the economy moves to point B. The size of the decrease in output depends on the slope of the IS-MP curve, which in turn depends on β_π.

2. If inflation expectations remain at π^*, there is no further shift in the PC. Inflation remains constant at $\pi' > \pi^*$ as long as the supply shock has not faded out. There is no further reaction of the central bank, so that output remains at $y' < y^*$. The economy remains in point B.

3. Let’s assume that the supply shock fades out now. The PC immediately shifts down to its original location as inflation expectations are anchored at π^*. The central bank lowers interest rates to their original values, so that they economy moves directly back to y^*.

An Extended Taylor Rule

So far, we have used a policy rule in which the nominal interest rate responds to deviations of inflation from target only.

- The Svensson model in the previous lecture showed, however, that even in the case of strict inflation targeting the interest rate responds to the output gap, because it has implications for future inflation.
- The widely used Taylor rule includes a response to inflation and the output gap.

Therefore, let's see how the IS-MP curve changes if we use a more general Taylor rule:

$$i_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*) + \beta_y(y_t - y_t^*)$$

Substituting in the IS curve yields

$$y_t = y_t^* - \alpha\left(\left[r^* + \pi^* + \beta_\pi(\pi_t - \pi^*) + \beta_y(y_t - y_t^*)\right] - \pi_t - r^*\right) + \varepsilon_t^y$$

Re-arranging gives

$$y_t - y_t^* = -\frac{\alpha(\beta_\pi - 1)}{1 + \alpha\beta_y}(\pi_t - \pi^*) + \frac{1}{1 + \alpha\beta_y}\varepsilon_t^y$$

The essential form of the IS-MP curve is unchanged, so that we can continue working with the simpler MP curve.

Lessons from the IS-MP-PC model

Many of the lessons from the IS-MP-PC model are the same as for the simpler IS-PC model with exogenous interest rate

- Following a demand shock, output and inflation move in the same direction and can therefore be stabilized jointly.
- Following a supply shock, there is a trade-off between stabilizing inflation and output. Stabilizing inflation destabilizes output and stabilizing output destabilizes inflation. The policymaker needs to choose which output and inflation combination to target. This affects the parametrization of the monetary policy rule.
- In the case of adaptive expectations, following a demand shock, inflation is permanently affected even after the shock has faded out. The central bank needs to generate a recession to bring inflation back to its original value.
- In the case of anchored expectations, inflation goes directly back to its original level after a demand shock.
- Adaptive expectations lead to larger inflation and output movements following a supply shock compared to anchored expectations.

What is not clear yet is how the central bank can achieve an anchoring of expectations.

- We will study this next based on algebraically solving the IS-MP-PC model
- Key insights will be: (1) a monetary policy rule that fulfills the Taylor principle and (2) credibility that the central bank will not deviate from this rule will lead to inflation expectations being anchored at the inflation target.

Summary

- Central banks react systematically to inflation and output via a monetary policy rule.
- Taylor principle: nominal interest rate reacts more than one-to-one to changes in inflation to affect the real interest rate which in turn affects output.
- If the Taylor principle is fulfilled, inflation is stabilized across a wide range of macroeconomic models.
- Estimation of monetary policy rules is complicated by a simultaneity problem. Solutions: IV-estimation or usage of real-time data.
- Based on estimated policy rules the literature finds two possible explanations for the high inflation period in the 1970s: 1. Taylor principle not fulfilled, 2. large reaction to mismeasured output gap.
- Adding a monetary policy rule, the IS-MP-PC model consists of three equations for explaining three endogenous variables.
- Combining the IS and MP equations yields the IS-MP curve showing a relation between inflation and output. A graphical representation together with the PC is possible.
- For lessons from the IS-MP-PC model see the previous slide.