Lecture slides 1: IS-TR, IS-LM, and AD-AS models

Niku Määttänen, University of Helsinki and Helsinki GSE

Macroeconomics 1, Autumn 2025

Introduction

We revisit the textbook IS-TR, IS-LM, and AD-AS models.

- These models (or similar ones) should already be familiar to you, so we can proceed quickly.

The aim is to develop a strong intuition for key short-run macroeconomic relationships and provide a solid foundation for studying New Keynesian (NK) models.

- NK models involve optimizing behavior by firms and households but feature broadly similar aggregate relationships to these textbook models.

Introduction

Short-run

- Prices are rigid
- Output depends (partly) on the demand side
- Monetary policy matters for output (and employment)

Long-run

- prices are flexible
- output is determined by the supply side
- money is neutral.

This distinction is part of the so called "neoclassical synthesis".

- It's a simplification, of course. E.g. rules out "hysteresis" effects or the adverse supply-side effects of very high or volatile inflation. But still useful!

Structure

1. Keynesian Cross
   - Focuses on aggregate demand and output.
   - Provides the simplest framework to understand demand multiplier effects.
2. IS-TR Model
   - IS: Negative relationship between interest rates and output via aggregate demand.
   - TR: Taylor Rule. Positive relationship between interest rates and output based on a monetary policy rule.
3. IS-LM Model
   - IS: As in the IS-TR model.
   - LM: Positive relationship between interest rates and output based on money market equilibrium and a fixed money supply.

4. AD-AS Model
   - AD: Aggregate Demand. Relationship between output (gap) and inflation (or price level) via monetary policy (or money market equilibrium) and the demand side.
   - AS: Aggregate Supply. Positive relationship between output and inflation via price rigidities and the supply side. Expectations-augmented Phillips curve.
5. Shocks in the AD-AS Model
   - Examples include supply and demand shocks, disinflation, and counter-cyclical fiscal policy.

General Remarks

We focus on a large economy (e.g., the US or the Euro area) and abstract from mechanisms related to changes in the real exchange rate.

- Some exercises will involve a small open economy (recall the Mundell-Fleming model).

We will switch between considering the price level (IS-LM) and inflation (IS-TR).

- The difference between these approaches is not fundamental in this context.

Output (GDP) and the output gap (relative deviation from potential/natural output) can often be used interchangeably.

- Long-run average output is unaffected by short-run dynamics.

These models are interrelated. For example, the IS-TR (or IS-LM) model is nested within the AD-AS model.

- In the IS-TR model, some variables are simply held fixed.

We will derive most of the relationships graphically.

- This approach is quite general and, hopefully, intuitive.
- Later in the course, we will shift focus to analytical and numerical solutions.

Short-Run Equilibrium in the Goods Market

In national accounting, supply always equals demand. We express this as:

$$Y = C + I + G + NX,$$

where Y denotes output (GDP), C is private consumption, I is investment, G is government consumption, and NX is net exports.

However, I includes changes in inventories, meaning that part of the output may not be consumed or truly invested.

We seek an equilibrium where supply equals "desired demand" (DD).

Desired demand refers to aggregate demand with "planned investment" (I_p), i.e., excluding (unplanned) changes in inventories.

Two-Way Link Between Output and Demand

Assume that output is determined by demand.

Demand depends on output because output equals aggregate income, so we write $DD = DD(Y)$.

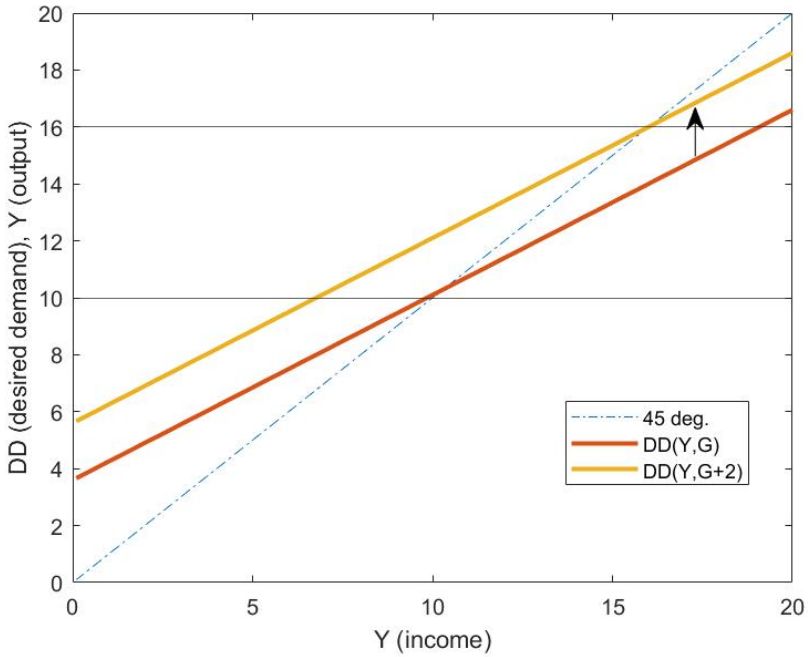
Private consumption likely to depend positively, and net exports negatively, on output, so we write:

$$DD(Y) = C(Y[+]) + I_p + G + NX(Y[-])$$

The net effect (the effect of an increase in output on aggregate demand) is likely to be a strictly positive relationship between DD and Y. (Why?)

However, an increase in Y is likely to increase DD by less than one-to-one. (Why?) $\Rightarrow$ Unique short-run equilibrium Y^*: $Y^* = DD(Y^*)$.

Keynesian Cross



Changes in, for example, G and I_p shift the DD line (or curve) vertically.

Equilibrium output changes by more than one-to-one.

Intuition

If output exceeds (falls short of) desired demand, inventories will increase (decrease), creating pressure on firms to reduce (increase) production.

Extreme assumption: Output is fully demand-determined and can always increase.

- The idea is that firms adjust output, not prices, in response to demand shocks.
- As a result, demand shocks have significant effects on output.
- Reasonable assumption for the very short run or during a recession?

What if supply cannot adjust at all? In this case, output cannot increase following, for example, an increase in G.

Consider a demand shock in the context of the Solow model, where full employment and a fixed capital stock constrain output in the short run.

What mechanisms, in the real world, would ensure that $Y = DD(Y)$ is also compatible with fixed $Y = f(K, N)$?

Model vs. Empirics

In this model, the "fiscal multiplier" related to G is always greater than one.

Empirically, dY/dG appears to be 0.5-1 during "normal times" and 1-3 in deep recessions (see, for example, Ramey 2019).

In reality, there is usually some "crowding out" due to supply-side constraints.

In some (non-linear) models, the multiplier depends on the state of the economy.

Additionally, as we will see, monetary policy reactions may mitigate the impact of fiscal stimulus or contraction.

IS Curve

IS: Investment equals saving. This defines the relationship between (short-run equilibrium) output and the interest rate i.

- Previously, we kept the interest rate (and many other factors) fixed.

It makes sense to assume that $I_p(i[-])$ (planned investment depends negatively on i), and possibly $C(i[-])$ as well. $\Rightarrow$ Short-run equilibrium output decreases as i increases.

Graphically: a higher i shifts the $DD(Y)$ curve downward.

- Less aggregate demand for any given level of output.

The IS curve is downward sloping, reflecting a negative relationship between the interest rate and short-run equilibrium output.

- It shows combinations of the interest rate and output that are consistent with the short-run equilibrium in the goods market.
- Here, we assume a fixed price level, so there is no distinction between nominal and real interest rates.

The IS curve describes the demand side only.

- "Short-run equilibrium output" refers to the output Y that satisfies the equation $Y = DD(Y, i)$.

Shifting the IS Curve

The IS curve shifts with changes in aggregate demand, such as changes in G (government consumption), T (net taxes), or export demand. Higher demand shifts the IS curve to the right.

- Ensure you understand this: For example, with higher G, the DD curve shifts up for all Y, so equilibrium output is higher for all interest rates.

The IS curve does NOT shift with changes in the interest rate.

- The negative slope of the IS curve already reflects the negative relationship between the interest rate and output (via aggregate demand).

TR Curve

The Taylor rule is a specific monetary policy rule, expressed as follows:

$$i = \bar{i} + a(\pi - \bar{\pi}) + b\frac{Y - \bar{Y}}{\bar{Y}}, \tag{1}$$

where $\bar{i}$ is the "natural interest rate"(or the central bank's estimate of it), π inflation, $\bar{\pi}$ the inflation target, $a > 0$, $b > 0$, and $\bar{Y}$ is potential output (sometimes called trend output or natural output).

This equation reflects a positive relationship between the output gap (or output) and the interest rate, leading to an upward-sloping TR curve.

For now, we (still) assume prices are fixed, so we ignore the second term on the right-hand side of (1).

TR Curve

Is this a good rule?

- The rule aims to stabilize both output and inflation, which is intuitively appealing.
- However, we cannot assess its welfare implications within this framework since it lacks preferences and optimization.

Do central banks follow this rule?

- Roughly speaking, yes. See, for example, Ilbas et al. (2013).
- However, it is difficult to assess when the Zero Lower Bound (ZLB) is binding. In such cases, we need to estimate a "shadow" interest rate, which accounts for non-conventional measures, see Hakkio and Kahn (2014).

IS-TR Model

We combine the two curves or relationships.

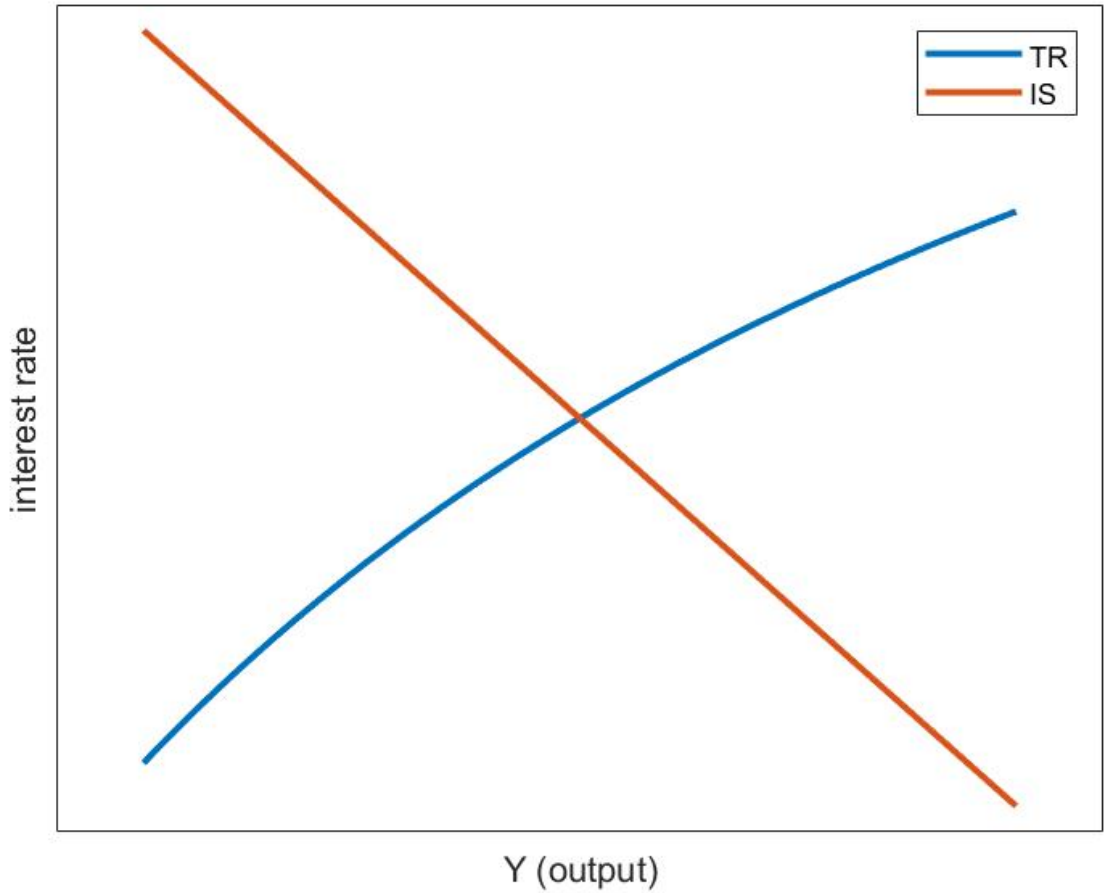
This combination, the intersection of the curves, determines the output and interest rate that are consistent with both the monetary policy rule and the short-run equilibrium in the goods market.

Demand shocks shift the IS curve, while the monetary policy rule acts to stabilize output.

Shocks to the monetary policy rule cause the TR curve to shift.

- For example, changes in the inflation target or changes in the estimated natural interest rate.

IS-TR model



IS-LM Model

The IS curve remains the same as before.

LM (money market equilibrium, or liquidity preference = money supply) curve based on the idea that the money supply is exogenously given, while money demand is endogenously determined.

Money demand is expressed as $M^d(P[+], r + \pi^e[-], Y[+])$, where r is the real interest rate, and π^e is expected inflation.

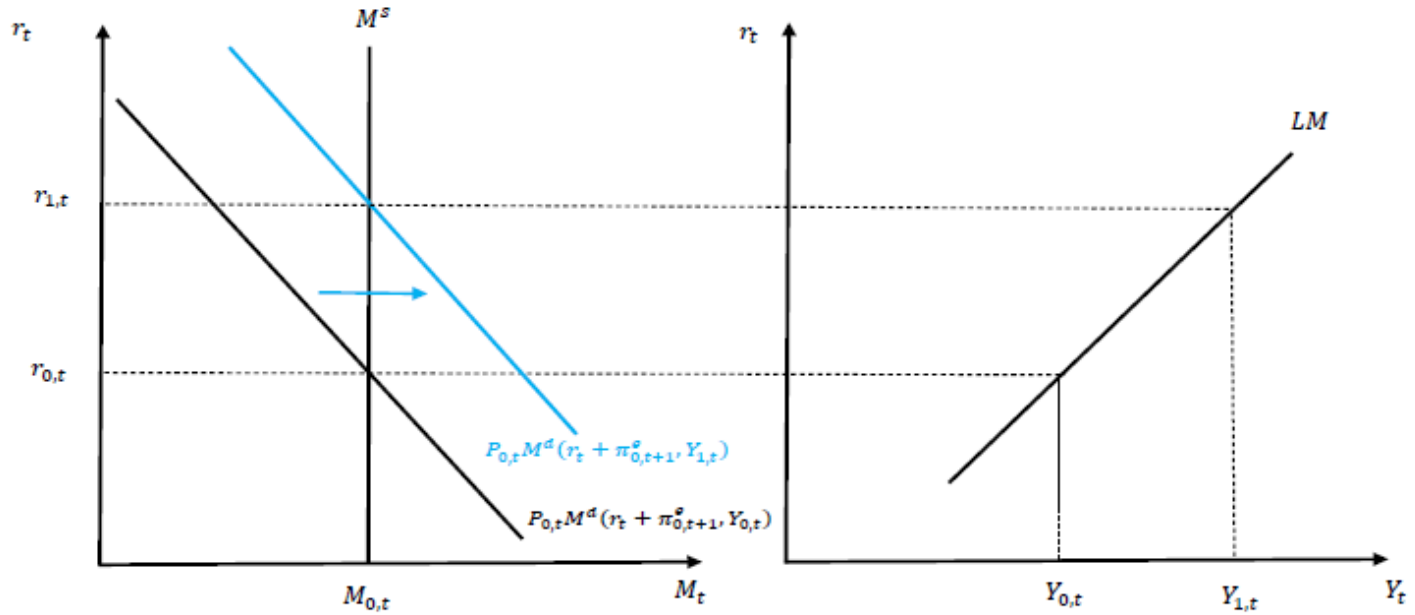
- Money demand increases with the price level and (real) output, as more money is needed for transactions.
- Money demand decreases with the nominal interest rate $i = r + \pi^e$ due to the opportunity cost of holding money.

What happens if output increases?

There is a higher demand for money ($M^d \uparrow$). With a fixed money supply and constant π^e, the interest rate must increase to balance the demand and supply for money.

In other words, there is a positive relationship between output and the interest rate: an upward-sloping LM curve.

Figure 23.1: The LM Curve: Derivation



Derivation of the LM-curve. Garin et al. (2020)

IS-LM Model

The IS and LM curves together determine the equilibrium.

As before, demand shocks (including fiscal policy shocks) shift the IS curve.

In this framework, instead of following the Taylor rule, the central bank keeps the money supply fixed.

Monetary policy shocks, such as increasing (decreasing) the money supply, shift the LM curve to the right (left).

- This is analogous to lowering (increasing) $\bar{i}$ in the IS-TR model.

IS-LM vs. IS-TR

The IS-LM model reflects the somewhat outdated assumption that the central bank controls and targets the money supply.

In this sense, the IS-TR model, where the central bank controls the nominal interest rate, is more realistic.

The TR rule also makes it easier to incorporate inflation (rather than just the price level) into the AD-AS model.

We can think of the money supply as being indirectly controlled via the nominal interest rate.

Consider a positive aggregate demand shock.

In the IS-TR model, the central bank stabilizes the economy by raising the interest rate.

In the IS-LM model, the central bank keeps the money supply fixed, which also requires increasing the interest rate.

- In reality, however, the amount of money varies over the business cycle, partly due to actions by commercial banks.

AD Curve Based on the IS-TR Model

AD: Aggregate demand. A negative relationship between inflation (or the price level) and output.

We now consider changes in the price level or inflation. What happens if inflation increases?

- Inflation is higher relative to output than before.

In the IS-TR model, the TR curve shifts up/to the left (consider the second term on the right-hand side of (1)). $\Rightarrow$ Short-run equilibrium output decreases.

Thus, the AD curve indeed slopes downward.

AD Curve Based on the IS-LM Model

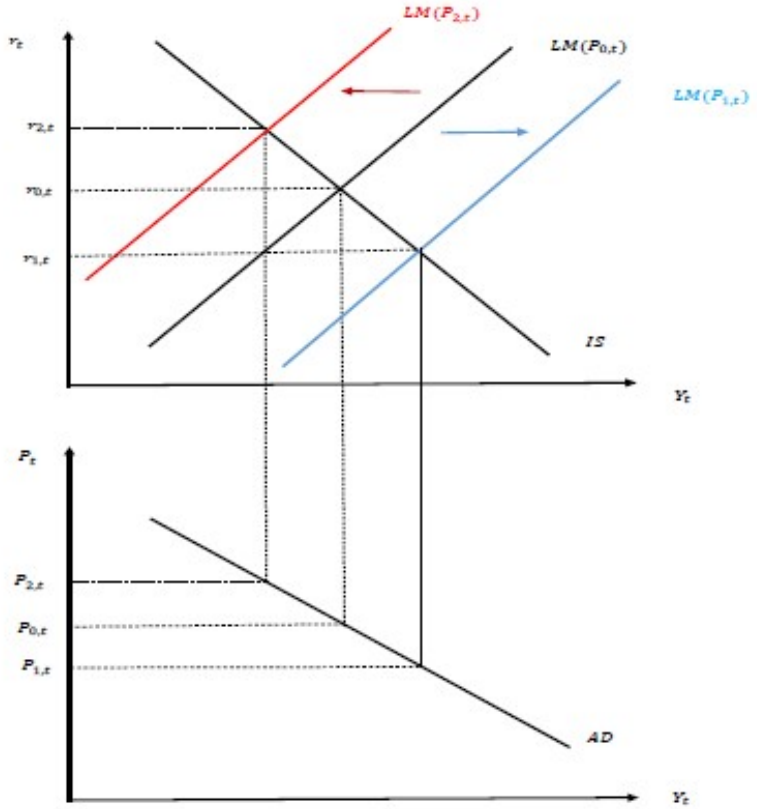
AD and AS curves are often drawn with the price level, rather than inflation, on the vertical axis, making them easier to derive from the IS-LM model.

For a given money supply, output, and interest rate, a higher price level increases the demand for money.$\Rightarrow$ A higher interest rate to balance the demand and supply for money.

As a result, the LM curve (drawn in interest rate-output space) shifts to the left: higher interest rates for all levels of output.

Starting with any LM curve, the intersection of the IS and LM curves occurs at a lower level of output, indicating a negative relationship between the (current) price level and output.

Figure 23.6: The AD Curve: Derivation



Garin et al. (2020)

AS Curve

AS: Aggregate supply. There is a positive relationship between current inflation (or the price level) and output from the supply side.

Deriving the AS curve can be somewhat tricky, and there are ongoing debates on the best approach.

In any case, some form of price rigidities is considered crucial.

To illustrate this, we will first consider three cases: i) flexible price levels, ii) fixed price levels, and iii) partially sticky price levels (based on Garin et al. 2021, Chapter 25).

We will then derive the AS curve based on mark-up pricing and bargaining over nominal wages.

AS with Flexible Prices

Firms, with a predetermined capital stock, pay a real wage w to hire labour.

The labour market is characterised by an upward-sloping labour supply curve and a downward-sloping labour demand curve. Their intersection determines the level of employment, which in turn determines output.

There is no relationship between output and the nominal price level, resulting in a vertical AS curve.

Thus, changes in aggregate demand have no effect on output!

AS with Fixed Prices

Assume now that the price level is fixed.

How is supply determined?

One possibility is to assume that firms supply whatever is demanded without changing prices.

- This implies that firms can be off their optimal labour demand curve.
- They simply hire the amount of labour needed to produce the goods demanded. (What about wages?)

This results in a horizontal AS curve.

- Changes in aggregate demand are fully reflected in output.
- This is similar to the Keynesian cross model we started with.

AS with Partially Fixed Prices

Assume that firms expected a price level $\bar{P}$, and only a fraction of the firms can adjust their prices.

It makes sense to assume that if demand is higher than expected, those firms would increase their product prices.

The current (aggregate) price level could then be determined as $P = \bar{P} + \gamma(Y - Y^f)$, where Y^f is the output associated with flexible prices.

- Admittedly, this is somewhat speculative reasoning...

With $\gamma > 0$, this results in an upward-sloping AS curve (in price level-output space).

AS with Mark-Up Pricing and Wage Bargaining

Finally, let's derive the AS curve based on mark-up pricing and nominal wage rigidity.

This approach is closer to New Keynesian models, though we use a simplified version here (following Burda & Wyplosz, *Macroeconomics: A European Text*).

Main Assumptions

Firms have some market power and follow mark-up pricing.

- Prices are set equal to marginal cost plus a mark-up.
- This is actually the optimal pricing strategy with certain assumptions about demand and production costs.

Labour unions (or workers) bargain with employer unions (firms) over nominal wages.

Wages are adjusted infrequently and in a staggered manner.

- Expectations about the future price level are relevant.

The bargaining power of labour unions varies with the unemployment rate.

Prices and Wages

Assume that labour L is the only factor of production, and $Y = L$. The unit cost is WL/Y, and mark-up pricing implies the unit price:

$$P = (1 + \theta)\frac{WL}{Y},$$

where θ is the mark-up.

Unit costs are determined in wage negotiations as:

$$\frac{WL}{Y} = (1 + \gamma)s_L P^e,$$

where γ (another mark-up) reflects time-varying bargaining power (with an average of $\gamma = 0$), s_L is the average labour share, and P^e is the expected future price level.

Combining to the two equations, we get:

$$P = (1 + \theta)(1 + \gamma)s_L P^e.$$

From Pricing to Inflation

Starting from the previous equation, we can approximate the rate of change of P as:

$$\frac{\Delta P}{P} \approx \frac{\Delta \theta}{(1+\theta)} + \frac{\Delta \gamma}{(1+\gamma)} + \frac{\Delta s_L}{s_L} + \frac{\Delta P^e}{P^e}.$$

Assuming $\Delta s_L = 0$ and using π to denote inflation ($\frac{\Delta P}{P}$), we can rewrite this as:

$$\pi = \Delta(\text{mark-ups}) + \pi^e.$$

From Pricing to Inflation

Arguably, γ increases with the output gap Y_{gap} and decreases with the unemployment gap U_{gap} (unemployment relative to structural unemployment).

On the other hand, no clear relationship between θ and the business cycle.

Thus, we write:

$$\pi = aY_{gap} + \pi^e = -bU_{gap} + \pi^e,$$

where $a, b > 0$.

Underlying Inflation Rate and Supply Shocks

Due to staggered wage negotiations, there is no single expected price level relevant for the entire economy.

Therefore, we replace π^e with $\tilde{\pi}$, the "underlying inflation rate."

Finally, we add supply or "cost-push" shocks s that may affect inflation independently of the output gap or demand:

$$\pi = \tilde{\pi} + aY_{gap} + s.$$

This represents the AS curve (a.k.a. expectations-augmented Phillips curve): a positive relationship between inflation and the output gap.

- The AS curve shifts with changes in underlying inflation and supply shocks (e.g., oil prices).

Higher output generates inflationary pressures via increased labour market tightness.

Inflation Dynamics

Underlying or expected inflation not determined by this (essentially static) model.

However, it makes sense to assume that if realized inflation increases, expected inflation will eventually rise as well.

In other words, we assume that if $\tilde{\pi} > \pi$, $\tilde{\pi}$ decreases, and vice versa.

- This reflects backward-looking or adaptive expectations.

Changes in $\tilde{\pi}$ shift the AS curve.

Admittedly, it is difficult to pinpoint exactly how inflation expectations are determined. Importantly, central banks try to manage them.

- This often makes central bank credibility a crucial issue. For illustration, see Lecture Notes 1.

AS Curve Empirically

What about the empirical evidence regarding the AS relationship?

We would like to empirically identify the parameters β and κ in the equation:

$$\pi = \beta\tilde{\pi} + \kappa Y_{gap} + s.$$

If $\beta \approx 1$ and $\kappa > 1$, this would be consistent with our model, with κ measuring the slope of the Phillips curve.

However, we face several potential identification problems:

- Measuring expected inflation and potential output is challenging.
- Due to supply shocks, we might even observe a negative correlation between inflation and output (see below).
- Monetary policy aims to neutralize the relationship between output/unemployment and inflation, especially when driven by demand shocks. As a result, we may only observe variations stemming from supply shocks. See McLeay and Tenreyro (2018) for a discussion of this issue.

Common view: Yes, a higher output gap is associated with higher inflation (controlling for inflation expectations).

However, the Phillips curve seems to have flattened recently, particularly after the 2008 financial crisis.

See Hazell et al. 2022 for a state-of-the-art analysis.

- The study exploits regional variation across US states.
- According to their results, most of the variation in US inflation has been driven by changes in inflation expectations.
- In other words, κ is relatively close to zero (but still strictly positive).
- The study requires assumptions regarding inflation expectations, meaning β is not directly estimated. Results are sensitive to these assumptions.

AD-AS Model

"God gave economists two eyes: one for supply, and one for demand."— Samuelson

We combine the AD and AS curves, focusing on the output gap and inflation.

- The model is sometimes expressed in terms of the output gap and price level.

Demand shocks shift the AD curve.

- For example, higher G or lower $\bar{i}$ shifts the IS curve to the right, leading to higher output.
- Since this applies to all levels of inflation, the AD curve shifts as well.

Supply shocks and changes in expected inflation shift the AS curve.

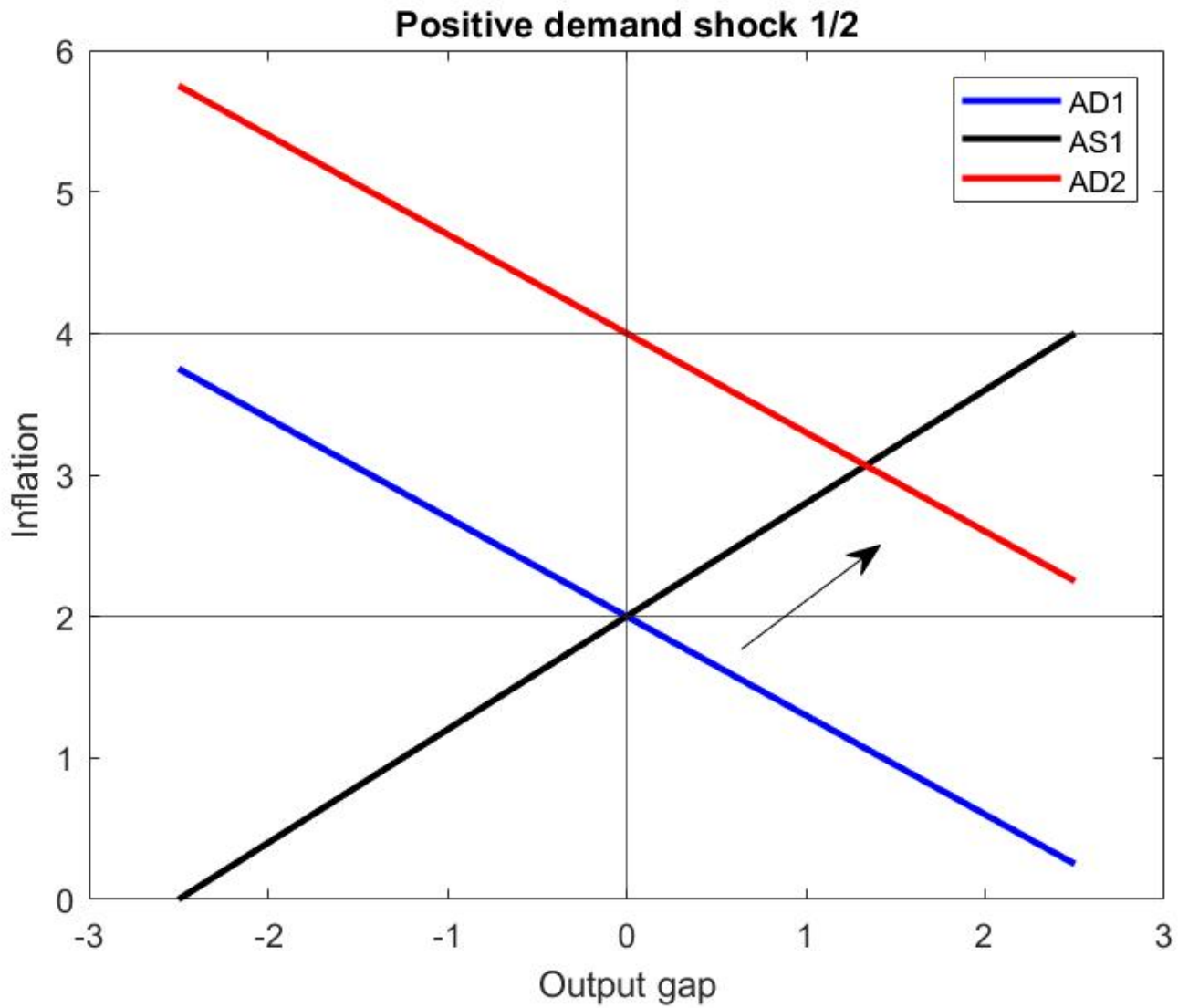
Positive Demand Shock

Start from a situation where the output gap is zero and inflation equals the target inflation.

Assume that private consumption increases, for example, due to lower lending standards by banks or fiscal stimulus.

The AD curve shifts to the right, resulting in higher output and inflation.

As a result, inflation rises above the expected inflation level (as shown by the AS equation).

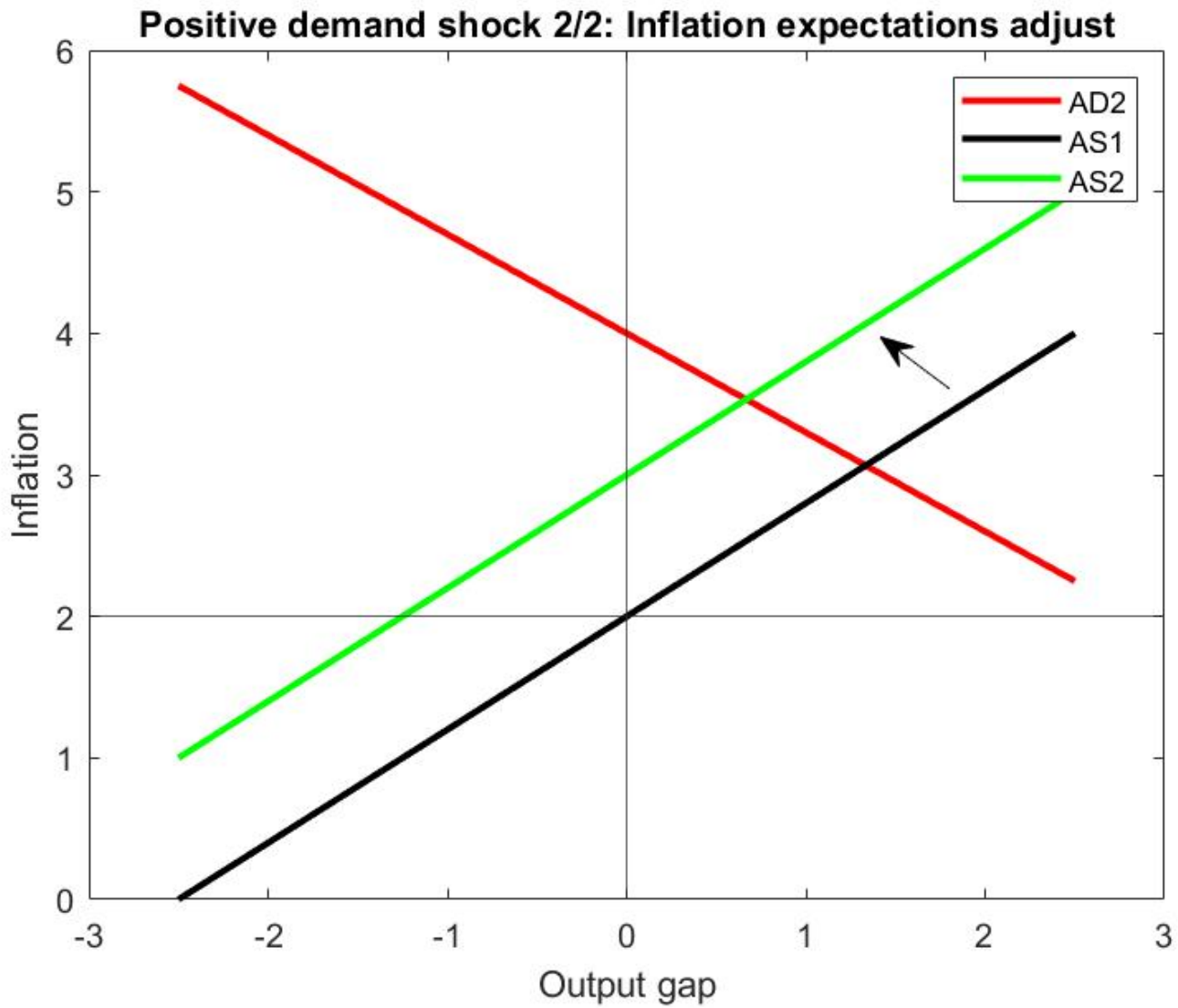

Positive demand shock 1/2
AD1
AS1
AD2
Inflation
Output gap
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3

If inflation and output remain elevated for some time, expected or underlying inflation is likely to increase, causing the AS curve to shift to the left.

What happens next? If the original demand shock persists and we aim to reach the inflation target, either monetary or fiscal policy will need to be tightened.

Tighter fiscal or monetary policy can shift the AD curve back. However, this may lead to output losses if expected or underlying inflation has already risen (see disinflation below).

For sure, the Taylor rule already helps stabilize the economy in response to demand shocks, but not completely.


Positive demand shock 2/2: Inflation expectations adjust
AD2
AS1
AS2
Inflation
Output gap
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3

Stabilization Policies

Assume a negative aggregate demand shock, such as one stemming from a banking crisis.

The AD curve shifts to the left.

Stabilize the economy with expansionary fiscal policy (e.g., increasing G) or monetary policy (e.g., lowering $\bar{i}$ in the Taylor rule).

The AD curve then shifts to the right.

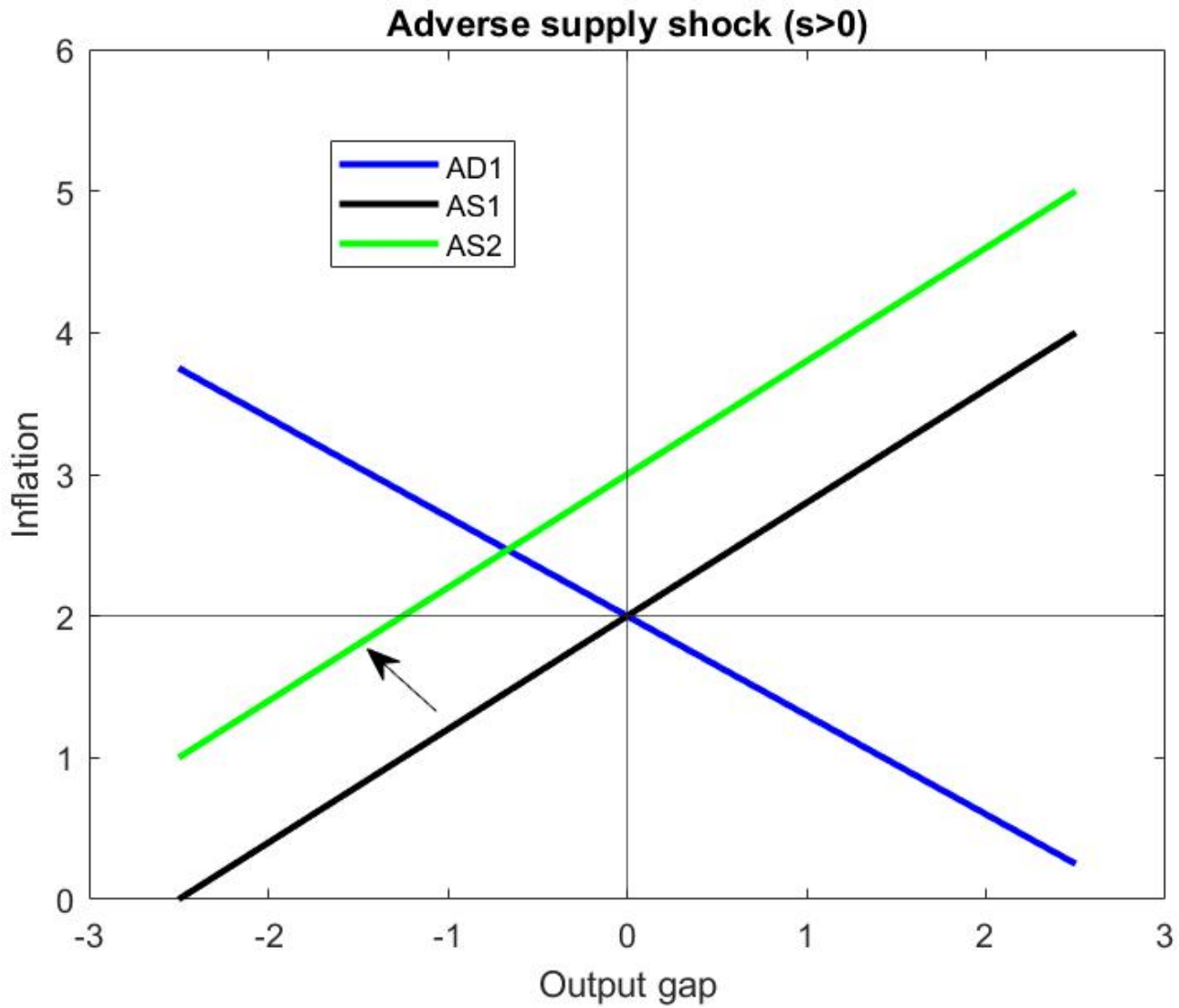
In this case, there is no trade-off between the inflation target and output stabilization (i.e., returning to a zero output gap).

Supply Shocks

Supply shocks (or cost-push shocks) shift the AS curve: $s > 0$ or $s < 0$. There is no obvious fiscal or monetary policy response.

- Expansionary policy (shifts the AD curve to the right): reduces output loss but increases inflation.
- Contractionary policy (shifts the AD curve to the left): lowers inflation but results in a larger output loss.

Note that these shocks create a negative correlation between output and inflation.


Adverse supply shock (s>0)
AD1
AS1
AS2
Inflation
Output gap
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3

Disinflation

Start again from a long-run equilibrium where the output gap is zero, but inflation is relatively high.

Now assume the central bank (CB) wants to achieve a lower inflation target: tighter monetary or fiscal policy to shift the AD curve to the left.

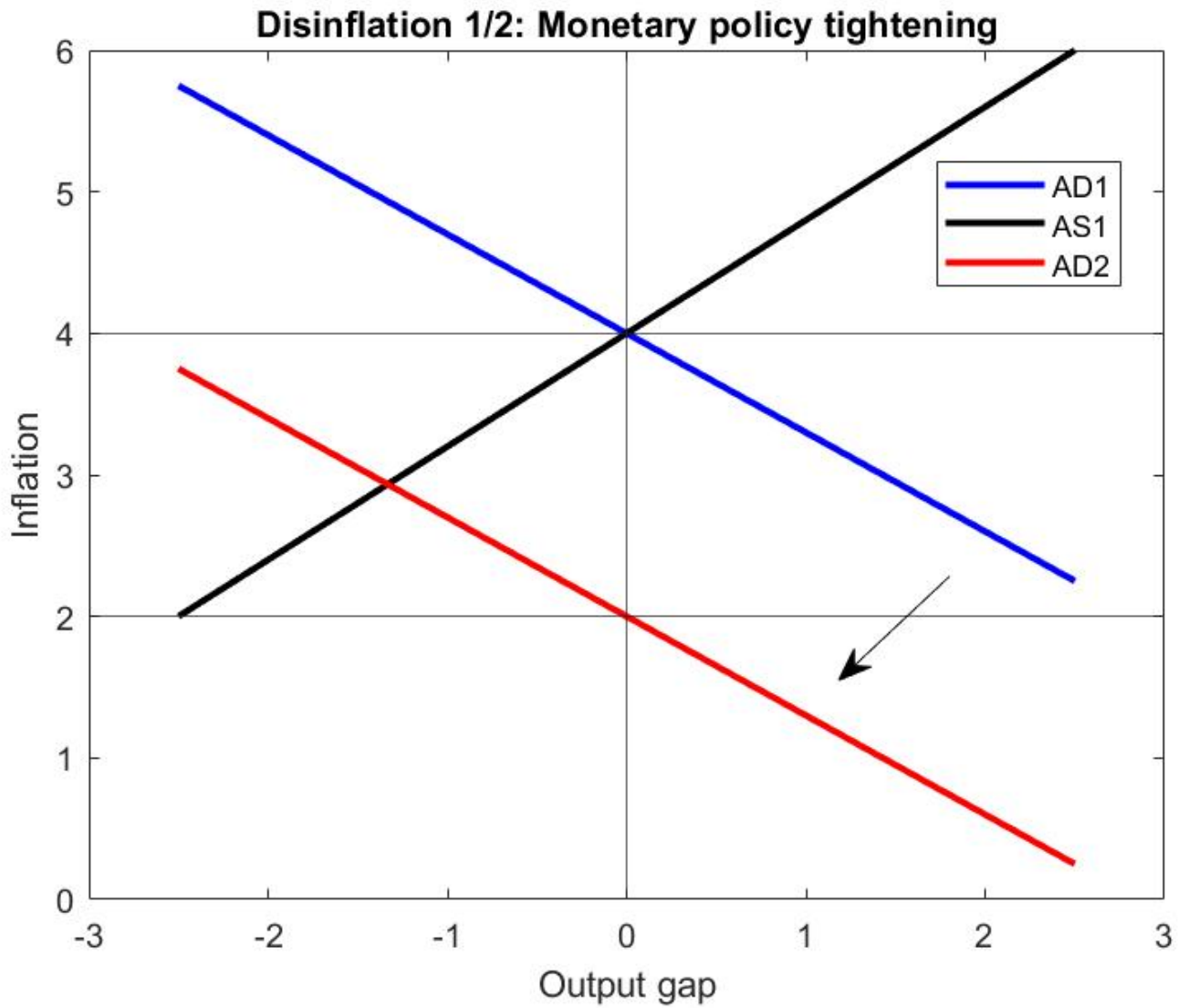
This results in a negative output gap and inflation below expected inflation.

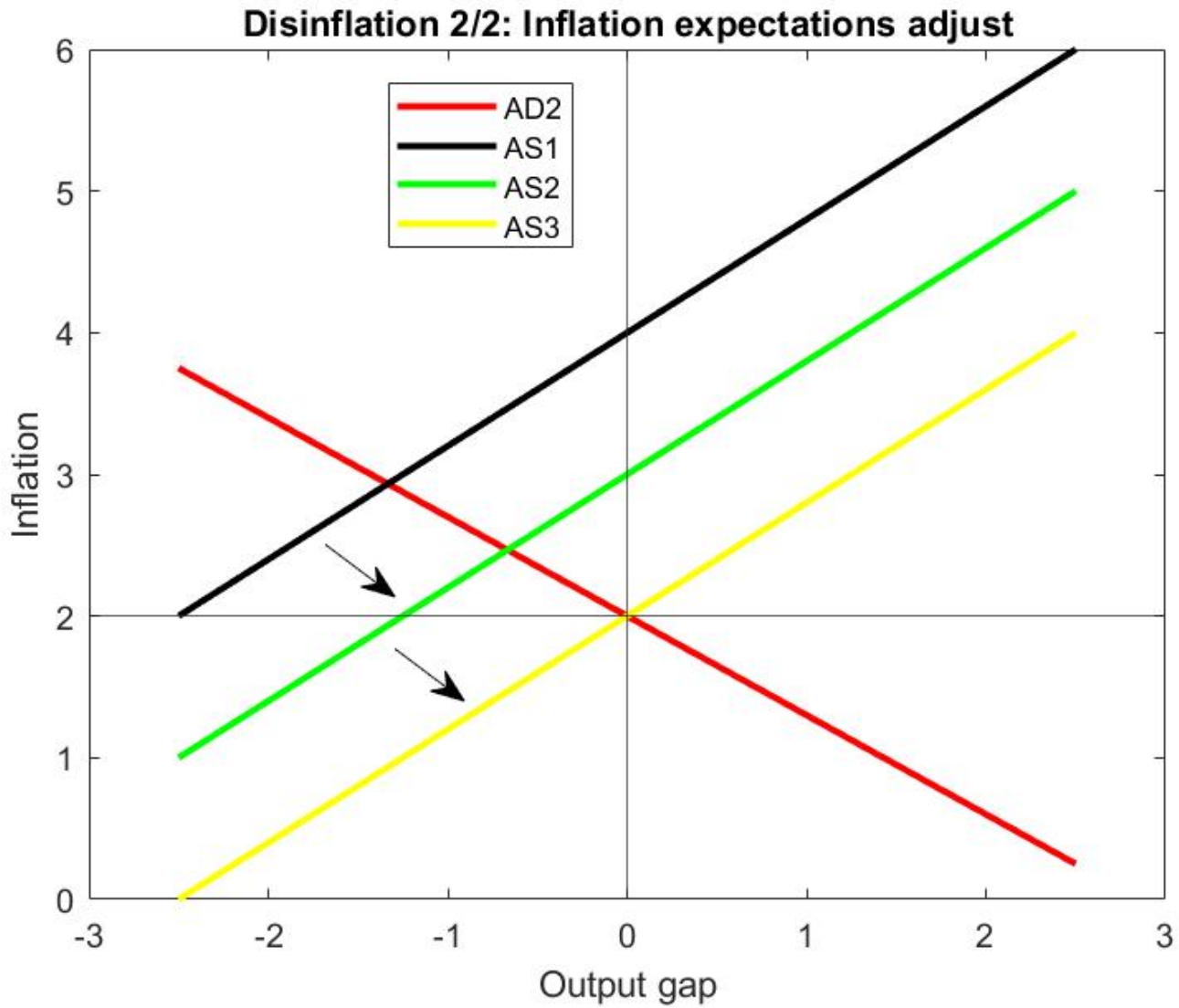
Over time, the AS curve shifts to the right, increasing output.

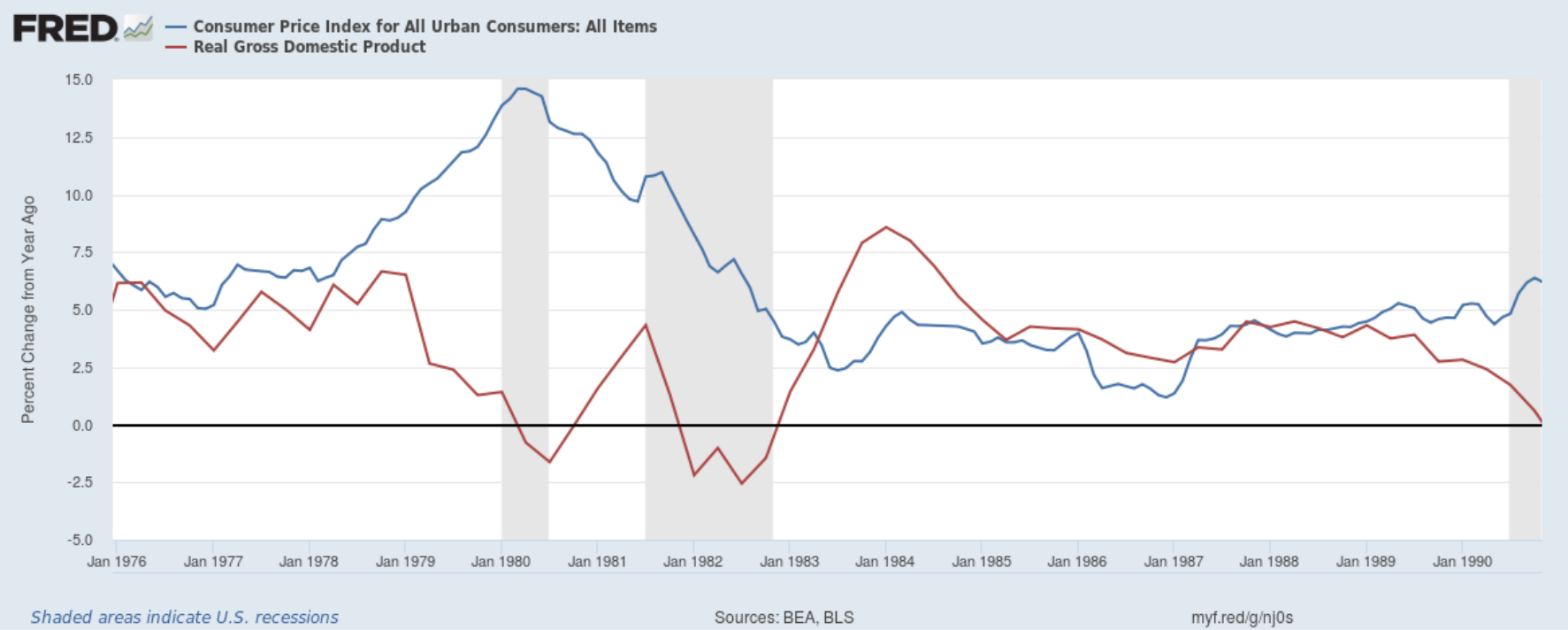
- However, the process may take a long time and result in significant output and employment losses.

Note that the outcome would be very different if expectations were to change quickly.

- Central bank credibility may matter a lot!


Disinflation 1/2: Monetary policy tightening
Inflation
Output gap
AD1
AS1
AD2
0
1
2
3
4
5
6
-3
-2
-1
0
1
2
3


Disinflation 2/2: Inflation expectations adjust
AD2
AS1
AS2
AS3
Inflation
Output gap
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3



The Volcker disinflation in the US.

Recent Inflation Peak in the Euro Area

Euro area inflation peaked at around 10%. It is currently around 2.5%, only slightly above the target.

The surge in inflation was clearly related to various supply shocks (e.g., Russian oil and gas, Ukrainian food exports, French nuclear power issues).

However, supply shocks were not the whole story. Low unemployment and high nominal wage growth also played a role.

The ECB began increasing its policy rates in June 2022.

Arguably, the output losses from disinflation were minimal this time.

- At least, the unemployment rate remained near a record low.

It was likely important that expected medium-term inflation did not increase much.