Macroeconomics
Lecture 3 — AD-AS

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Lecture overview

- So far, very short run $\Rightarrow$ prices fixed $\Rightarrow$ no modelling of inflation
- This lecture:
  - **Medium run**: prices adjust in response to excess demand and supply of goods, but they remain **sticky**

  $\Rightarrow$ **Aggregate Demand (AD)** relationship between inflation and GDP, derived from IS-TR or IS-TR-IFM

  $\Rightarrow$ **Phillips curve** or **Aggregate Supply (AS)** derived from firms' price setting

  - **Long run**: flexible prices, GDP is on trend, **monetary neutrality**

Short vs. long run

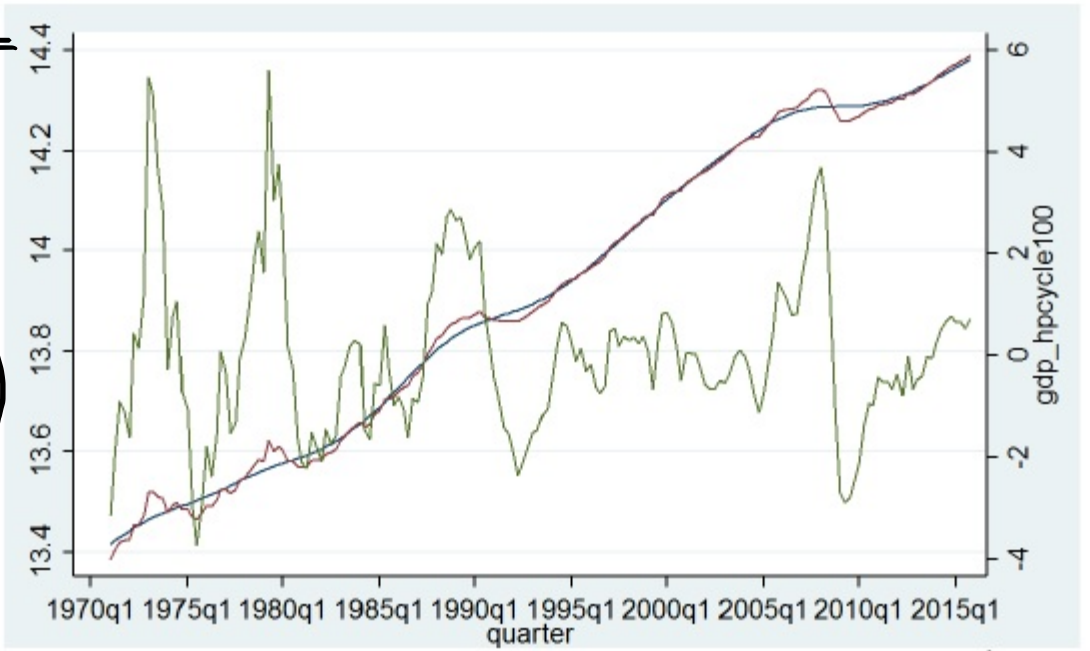
- Keynesian short run: prices are fixed; supply adjusts to demand $\Rightarrow$ demand determines GDP
- Long run: prices adjust to all demand shocks $\Rightarrow$ GDP is on **trend** determined by technology, demographics

$$\ln Y_t - \ln \bar{Y}_t =$$

$$= \ln\left(\frac{Y_t}{\bar{Y}_t}\right)$$

$$= \ln\left(1 + \frac{Y_t - \bar{Y}_t}{\bar{Y}_t}\right)$$

$$\approx \frac{Y_t - \bar{Y}_t}{\bar{Y}_t}$$



Note. Decomposition of real GDP in the United Kingdom (in logarithm), 1970Q1 - 2018Q4. Blue line (left axis) is the trend estimated by Hodrick-Prescott (HP) filter. Green line (right axis) is the cycle, i.e. difference of actual GDP and estimated trend. Source: OECD.

Outline

1 Aggregate Demand

2 Medium run aggregate supply

3 The long run

4 AD-AS analysis of shocks

Aggregate Demand

A macroeconomic relationship between **inflation** (or price level*) and **GDP** describing the Keynesian IS-TR or IS-TR-IFM equilibrium. We will plot it in (Y, π) space.

Aggregate Demand $\neq$ sum of agents' demands for goods !!

AD is a **negative** relationship between Y and π in the 3 settings that we have seen: closed economy, fixed exchange rate economy, flexible exchange rate economy. The **reason** for the negative relationship is **different** in the 3 cases

*: AD in (Y, P) space is derived from the IS-LM model

Aggregate Demand in a closed economy

A closed-economy AD is obtained from IS-TR model with **TR that reacts to inflation**:

$$i = \bar{i} + a(\pi - \bar{\pi}) + b\left(\frac{Y - \bar{Y}}{\bar{Y}}\right)$$

$a > 0$

When solving the IS-TR model, one can eliminate i and obtain Y as a function of π – try this at home

We will construct the AD curve graphically, as we did for IS

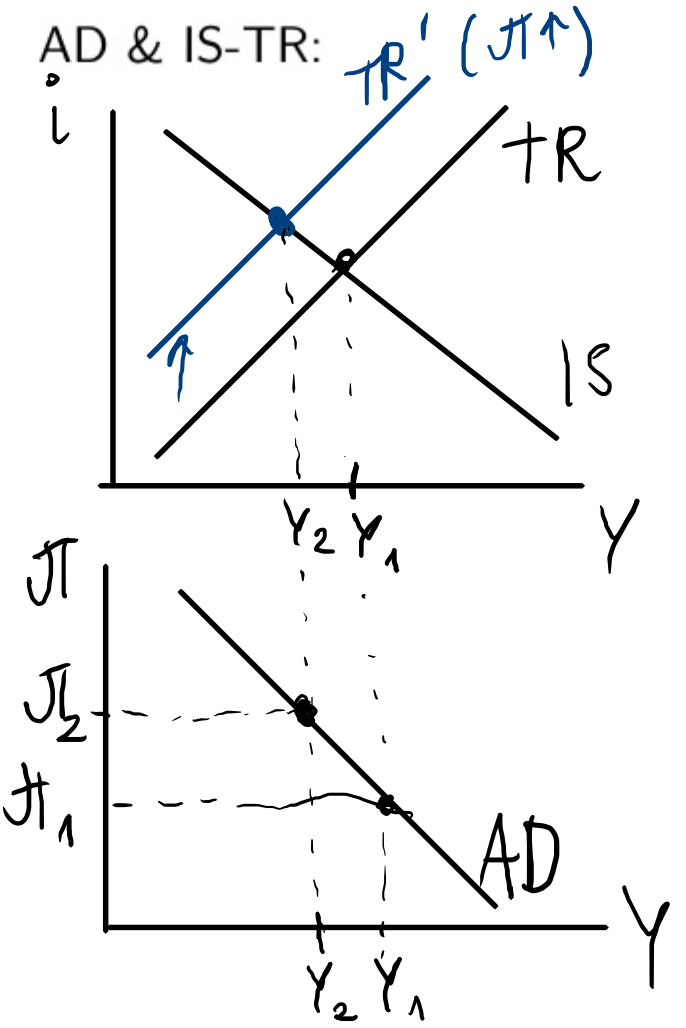
AD curve construction

Assume an increase in π:

- Central bank reacts by raising interest rates for whatever Y: **shift** of TR
- $i \uparrow \Rightarrow I \downarrow$ movement **along IS** to the left
- In the (Y, π) space, Y lower for higher π: downward sloping **AD**

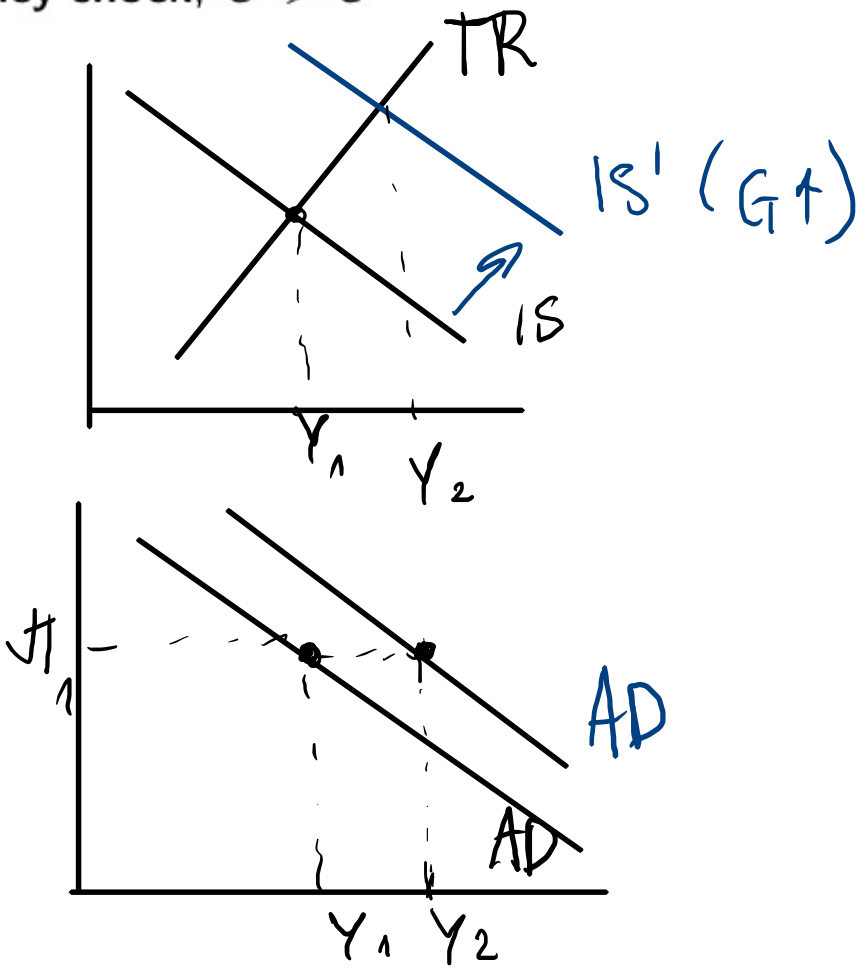
Shifts in AD

- Can come from IS: any shift in desired demand
- Can also come from TR: $\bar{i}, \bar{\pi}$



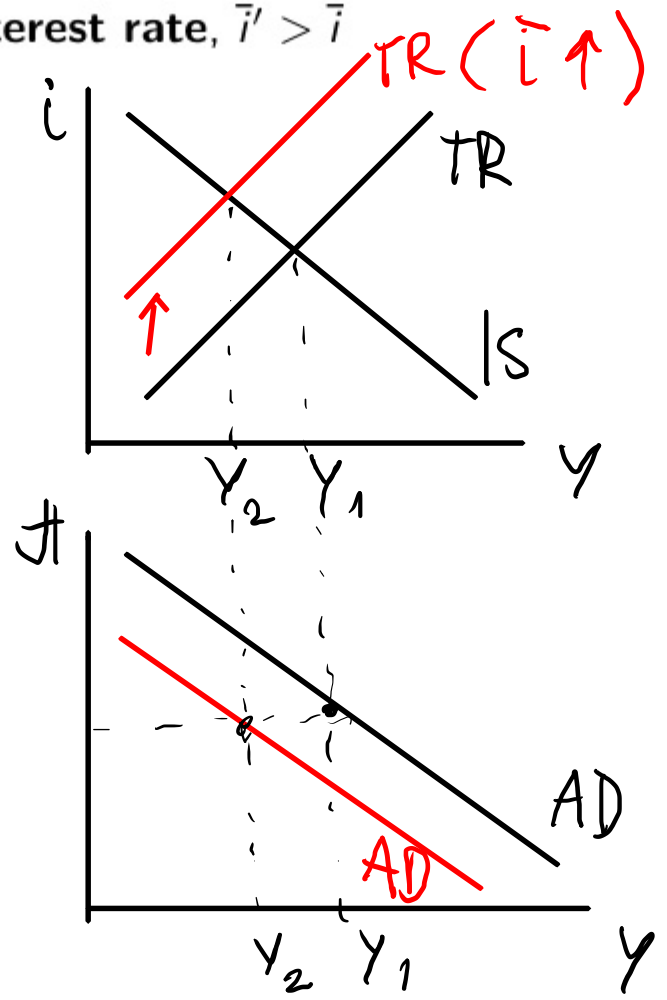
Shocks shifting AD: government spending

Positive fiscal policy shock, $\bar{G}' > \bar{G}$



Shocks shifting AD: monetary policy

Higher natural interest rate, $\bar{i}' > \bar{i}$



Open economy AD: Inflation & real exchange rate

Real exchange rate formula: $\sigma = \frac{SP}{P^*}$

What is a formula for a **change** of σ?

To study changes, take logarithm of both sides and apply the total differential:

$$\ln \sigma = \ln S + \ln P - \ln P^*$$

$$\frac{d\sigma}{\sigma} = \frac{dS}{S} + \frac{dP}{P} - \frac{dP^*}{P^*}$$

$$\frac{d\sigma}{\sigma} = \frac{dS}{S} + \pi - \pi^*$$

$d(\ln \sigma) = \frac{d \ln \sigma}{d\sigma} \cdot d\sigma = \frac{1}{\sigma} \cdot d\sigma = \frac{d\sigma}{\sigma}$

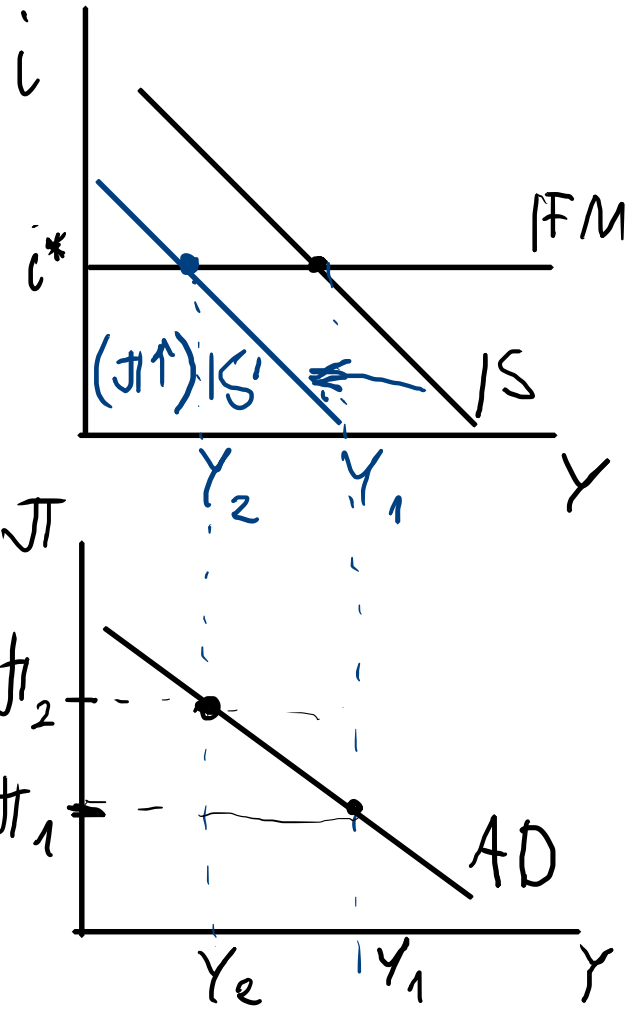
AD construction: fixed exchange rate regime

- Assuming $\pi \uparrow$
- $\frac{d\sigma}{\sigma} = \frac{dS}{S} + \pi - \pi^* = \pi - \pi^*$ $\Rightarrow \sigma \uparrow$ ($\frac{dS}{S} = 0$ for fixed e.r.)
- IS-(TR)-IFM: IS shifts to the left, intersection with IFM has lower Y

$\Rightarrow$ inflation higher, output lower: downward sloping **AD**

Shifts in AD

- Demand shocks (IS)
- Devaluations, revaluations ($\bar{S}$)
- IFM (i^*)



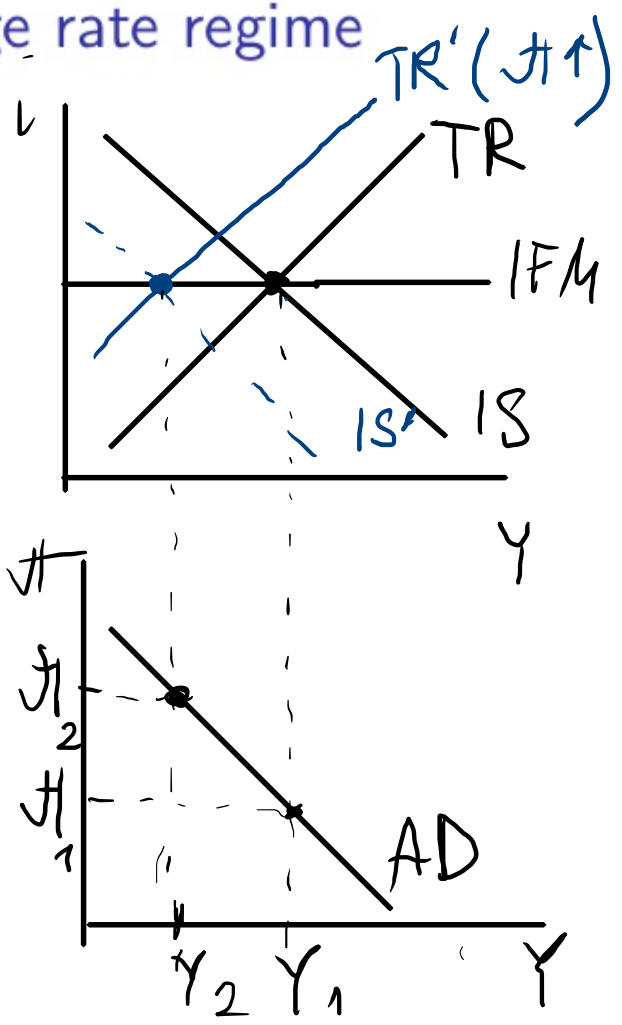
AD construction: flexible exchange rate regime

- Assuming $\pi \uparrow$
- TR shifts up (as in closed economy) $\Rightarrow$ TR-IFM intersection with lower Y
- IS moves left to the TR-IFM intersection because $\frac{d\sigma}{\sigma} = \frac{dS}{S} + \pi - \pi^* \Rightarrow \sigma \uparrow$

$\Rightarrow$ inflation higher, output lower: downward sloping **AD**

Shifts in AD

- TR shocks $(\bar{i}, \bar{\pi})$
- IFM (i^*) – opposite effect to fixed exchange rate case
- **NOT** the demand shocks (IS shifters other than σ)



Supply side in the medium run: theory

Main idea: firms that have some **market power** $\Rightarrow$ can set prices

Important factors for price setting:

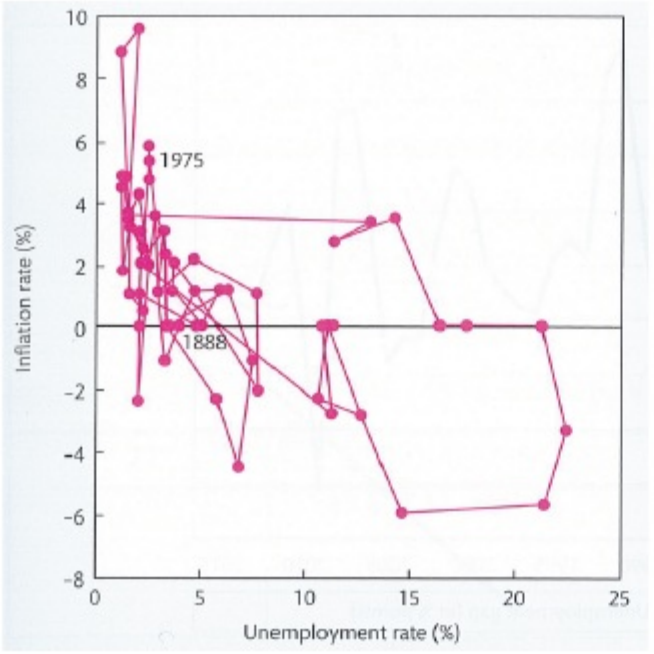
1. **Marginal cost** (we consider **labor cost** only)

2. **Expected aggregate price level in the future**: prices are not perfectly flexible in medium run $\Rightarrow$ price chosen today may remain for a while, must be adequate for future conditions

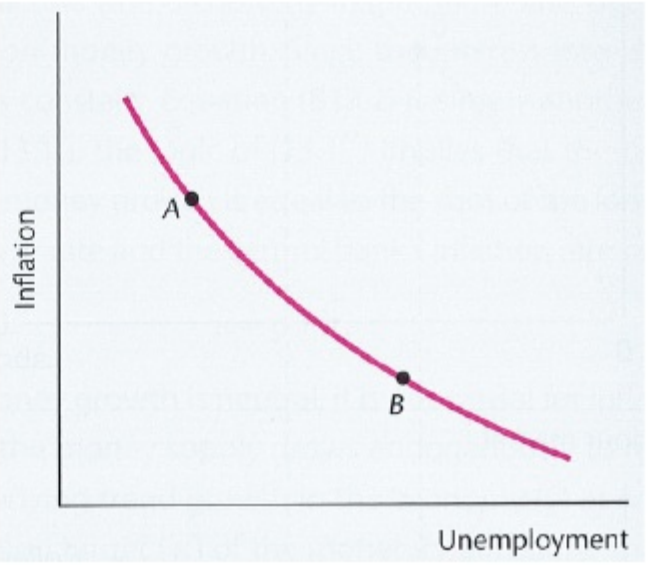
Both **Phillips Curve (PC)** and **Aggregate Supply (AS)** relate positively **current inflation** to **expected inflation**. In addition, PC relates negatively inflation to **unemployment**, while AS relates positively inflation to **output**

The Phillips Curve

A regularity in the UK data...



...transformed into a theory



Source. Burda and Wyplosz (2017), Figure 13.3, Figure 13.4.

Supply side of inflation: price setting

- Firms produce goods with labor and have market power on both goods market and labor market

$\Rightarrow$ Prices depend marginal cost (wage) and **demand elasticity**

- Prices are **sticky**: price set today can remain in the future

$\Rightarrow$ The price choice takes into account which prices other firms may charge in the future $\Rightarrow$ **expected inflation matters**

How are prices linked to unemployment (u)? In an expansion ($Y > \bar{Y}$), u is low, and incomes relatively high $\Rightarrow$ demand elasticity of consumers is lower $\Rightarrow$ firms can charge higher prices

Suppy side of inflation: labor market

Labor market strengthens the link of current prices to future inflation and to unemployment:

- Consider **wage bargaining** between firms and workers/ unions
- Wages stay fixed until next negociation $\Rightarrow$ inflation may erode real income $\Rightarrow$ current wage negotiation must be based on **expected inflation**
- In an expansion ($Y > \bar{Y}$, low u) workers have higher bargaining power (less afraid to lose jobs) and some may work overtime $\Rightarrow$ wages rise

$\Rightarrow$ firms' marginal cost (wage) and price depend:

1. positively on π^e
2. negatively on u

Theoretical Phillips Curve

The factors influencing firms' optimal price also influence current inflation

One gets the theoretical Phillips Curve:

$$\pi = b \cdot u^{gap} + \pi^e + s$$

Where

- $u^{gap} = u - \bar{u}$ and $\bar{u}$ is **natural unemployment** rate: seasonal, job-to-job transitions...
- $b < 0$
- s is a **supply shock**: a variable regrouping all non-wage macroeconomic factors that raise firms' marginal cost

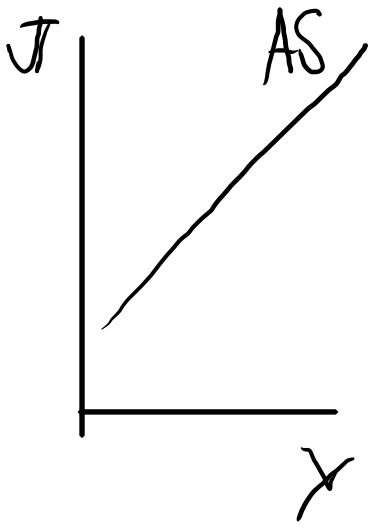
Typical supply shock – energy prices

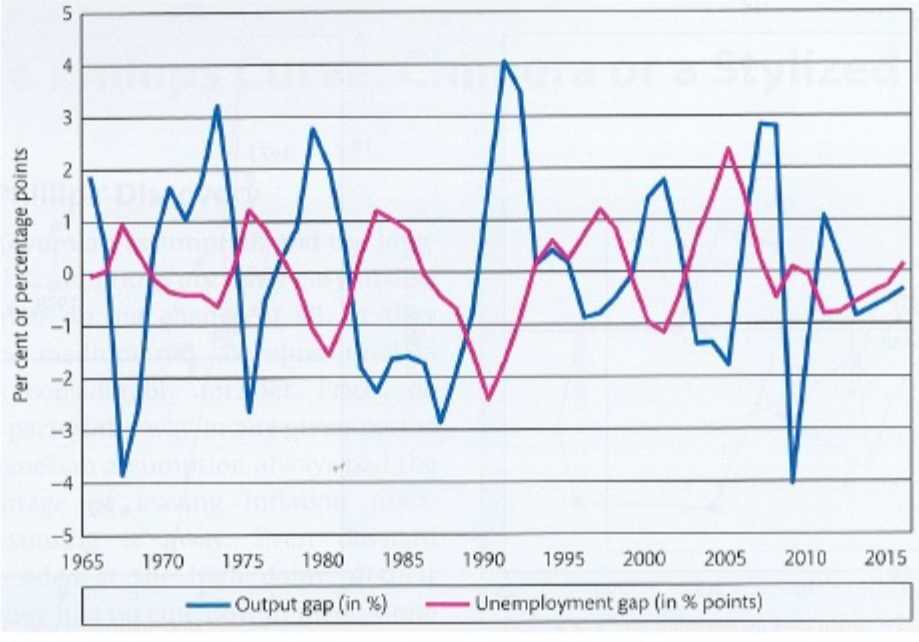
From u to Y – Okun's Law, AS

Data shows strong negative relationship between unemployment gap $u - \bar{u}$ and output gap $(Y - \bar{Y})/\bar{Y}$: **Okun's law**

$\Rightarrow$ Can replace u^{gap} in Phillips Curve with Y^{gap}

- ▷ **AS** relationship $\pi = a \cdot Y^{gap} + \pi^e + s$, with $a > 0$



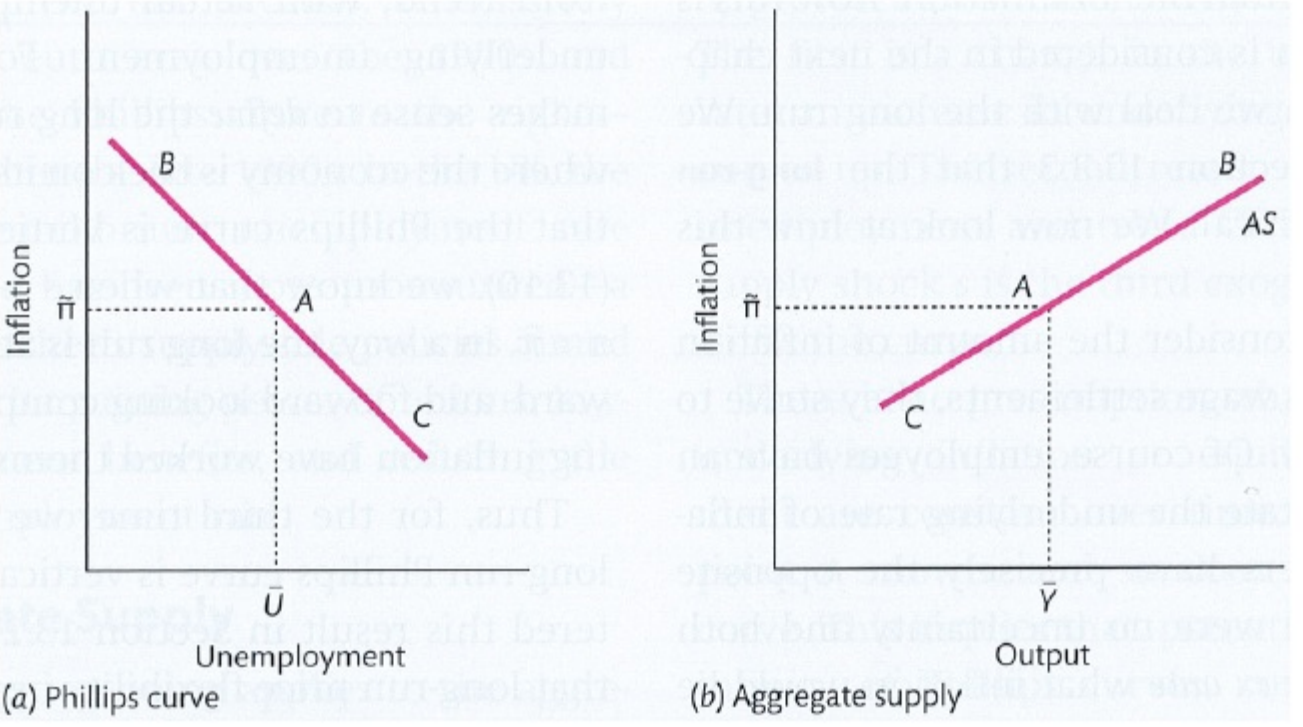


The output and unemployment gap in Germany, 1970-2016. **Source.** Burda and Wyplosz (2017), Figure 13.5.

AS and Phillips curve: symmetry

$$\pi = a \cdot Y^{gap} + \pi^e + s \qquad \text{(AS)}$$

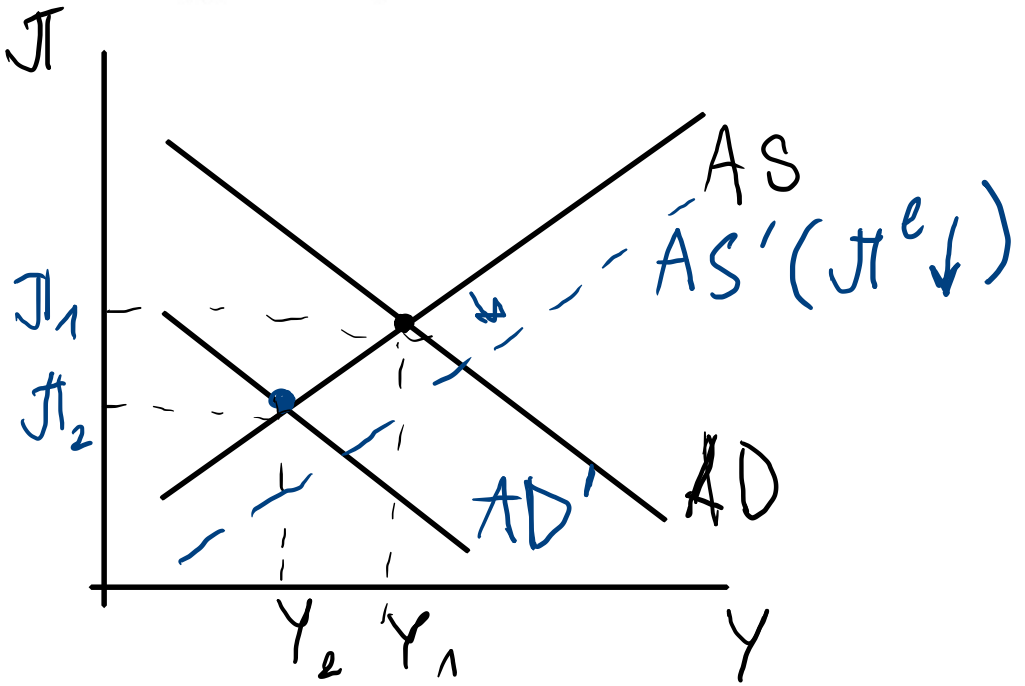
$$\pi = b \cdot u^{gap} + \pi^e + s \qquad \text{(Phillips Curve)}$$



Burda and Wyplosz (2017), Figure 13.12.

Endogenous π^e: shifts in AS

Demand and supply shocks bring **unexpected changes** of inflation. **Rational expectations** are assumed $\Rightarrow$ π^e **changes** following shocks, **AS shifts**



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Money and inflation in the long run

Quantity Theory of Money describes money-output relationship:

$$\underbrace{M}_{\text{money supply}} = \underbrace{k}_{\text{money velocity}} \times \underbrace{P}_{\text{price level}} \times \underbrace{Y}_{\text{GDP}}$$

$$\Leftrightarrow \quad P = \frac{M}{kY}$$

where money velocity k measures how fast money circulates. Assuming k constant, taking logarithms of both sides and a **total differential**:

$$\ln P = \ln M - \ln k - \ln Y$$

total differential:

$$\underbrace{\frac{dP}{P}}_{=\pi} = \underbrace{\frac{dM}{M}}_{\equiv\mu} - \underbrace{\frac{dk}{k}}_{=0} - \underbrace{\frac{dY}{Y}}_{\equiv g}$$

$$\Leftrightarrow \pi = \mu - g$$

Where $\frac{dP}{P} = \pi \approx \frac{P(t+\Delta)-P(t)}{P(t)\Delta}$ when the time step Δ is small

Long run real exchange rate

Absence of **arbitrage** between countries assumed in long run $\Rightarrow$ two versions of **purchasing power parity (PPP)** condition:

1. **Absolute PPP**: $\sigma = 1 \Leftrightarrow S \cdot P = P^*$

2. **Relative PPP**: σ constant:

$$d\sigma = 0 \Rightarrow \frac{d\sigma}{\sigma} = \frac{dS}{S} + \frac{dP}{P} - \frac{dP^*}{P^*} = 0$$

$$\frac{dS}{S} = \pi^* - \pi$$

$\Rightarrow$ if domestic and foreign inflation rates not equal on average, permanent nominal exchange rate appreciation/depreciation

Absolute PPP implies relative PPP; the converse is not true

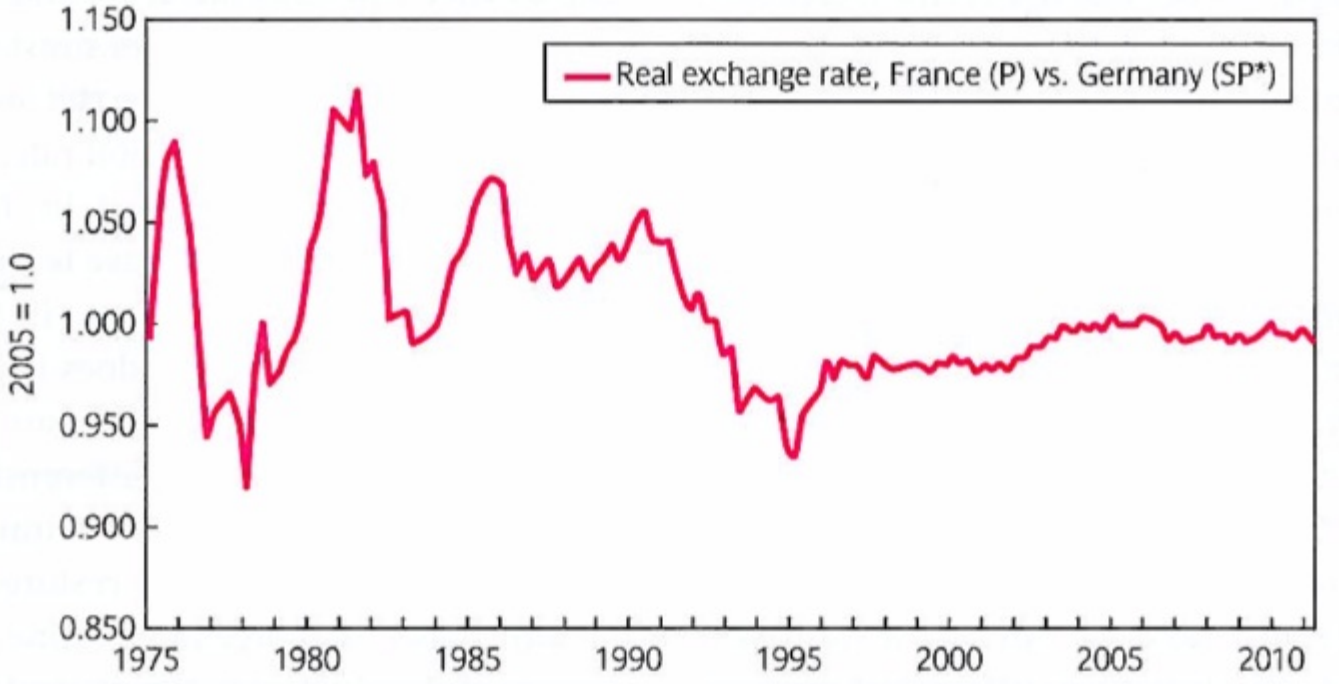
Fixed exchange rates and Purchasing Power Parity

Under the fixed exchange rate regime, purchasing power parity implies equality of inflation rates with the rest of the world:

$$\underbrace{\frac{dS}{S}}_{=0} + \pi - \pi^* = 0 \Leftrightarrow \pi = \pi^*$$

$\Rightarrow$ horizontal line $\pi = \pi^*$ for long-run AD-AS analysis of fixed exchange rate economies

Change of exchange rate regime and real exchange rate: case study



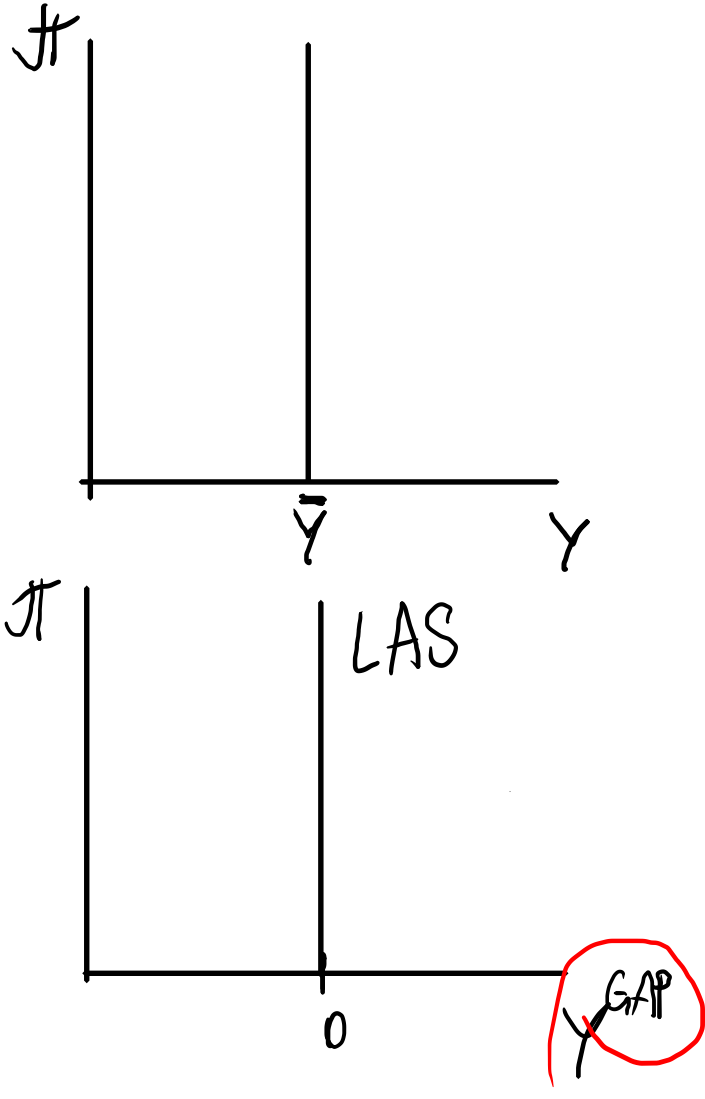
Source. Burda and Wyplosz (2017), Figure 13.9.

Long-run aggregate supply

Rational expectations $\Rightarrow$ all forecast errors are temporary $\Rightarrow$ $\pi = \pi^e$ in the long run.
Supply shocks are also null $\Rightarrow$

$$\pi = a \cdot Y^{gap} + \pi^e + s \Leftrightarrow Y^{gap} = 0$$

or $Y = \bar{Y}$ in the long run.



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How to use AD-AS framework

1. Find out which curve (AD or AS) is affected by a shock – drawing IS-TR (or IS-TR-IFM) in case of demand shocks is helpful

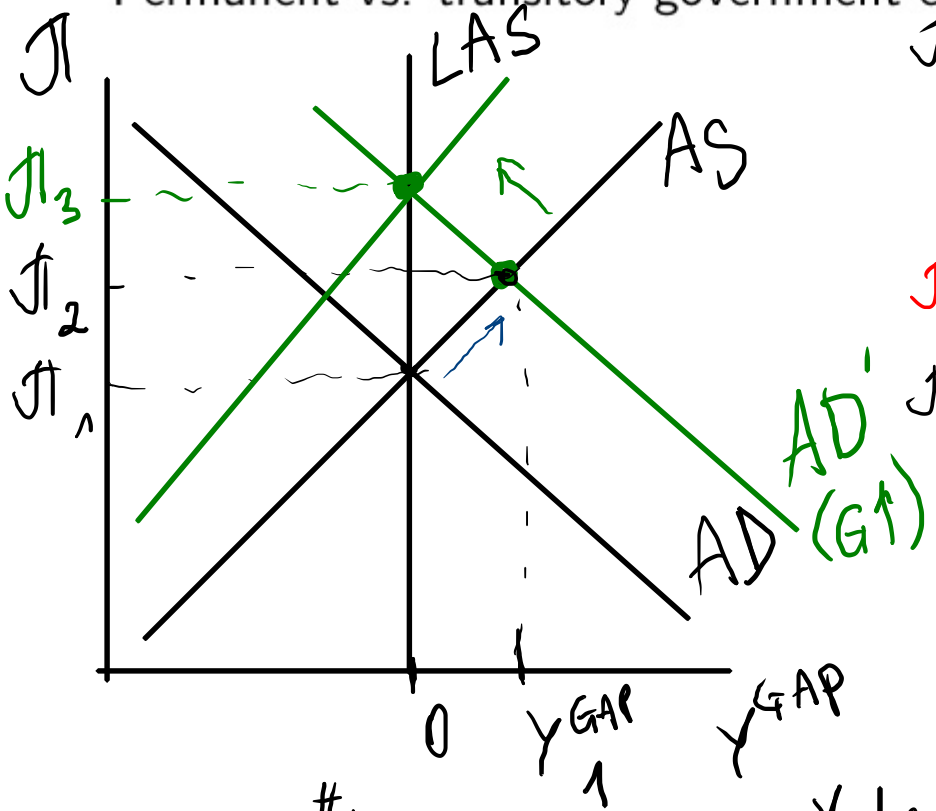
2. Show the new medium-run equilibrium

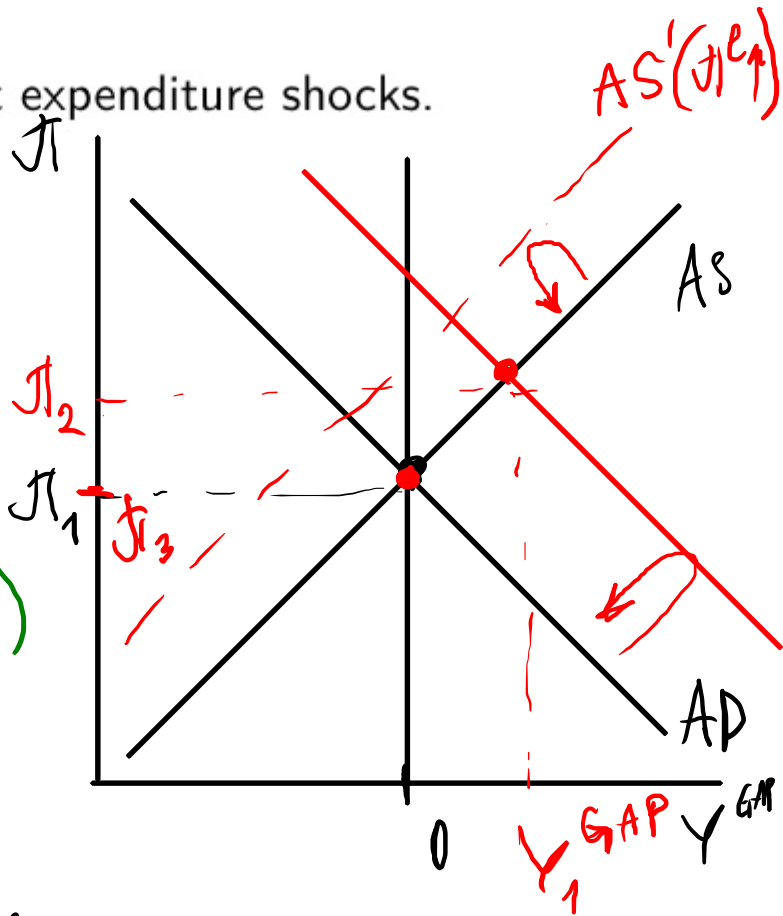
3. Think about how inflation expectations are affected and whether AS needs to shift (again)

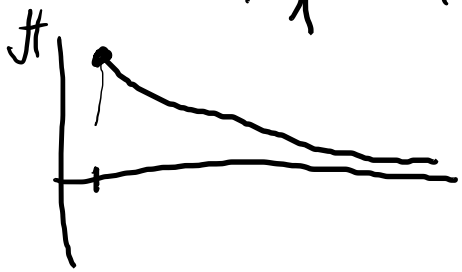
4. After all the shifts, GDP must converge to trend (Y^{gap} must converge to 0)

AD-AS in closed economy

Permanent vs. transitory government expenditure shocks.







AD-AS under flexible exchange rate regime

Similar to closed economy, with additional shifts in AD due to σ.

AD-AS under fixed exchange rate regime

Additional long run condition $\pi = \pi^*$

Summary

- We studied GDP and inflation in the medium run (sticky prices) and long run (flexible prices)
- The AD relationship is negative in the (Y, π) space. The mechanism is not the same in closed and open economies with different exchange rate regimes
- The AS relationship is equivalent to the Phillips curve and follows from firms' price-setting decisions
- The AS curve shifts following unexpected changes in inflation in medium run
- In the long run, the output gap is null