

# Macroeconomics

## Lecture 3 — AD-AS, policy

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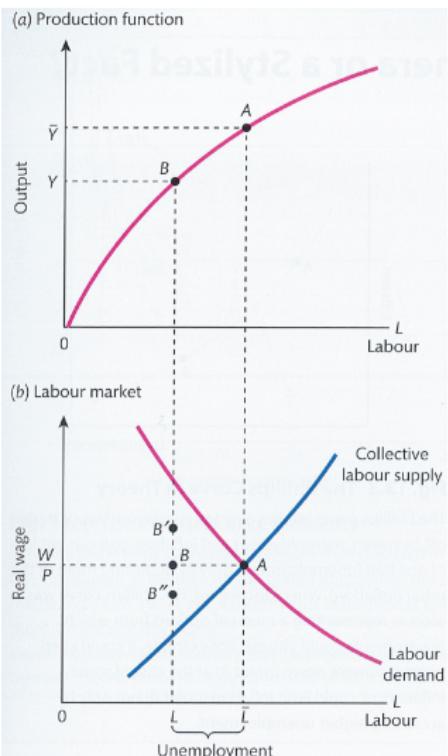
Fall 2022

# Lecture overview

- ▷ So far, very short run  $\Rightarrow$  prices fixed  $\Rightarrow$  no modelling of *inflation dynamics*
- ▷ This lecture:
  - ▷ **Long run:** flexible prices  $\Rightarrow$  **Monetary Neutrality**
  - ▷ **Medium run:** prices adjust in response to excess demand and supply of goods, but not all markets clear fully.
- ⇒ **Phillips curve** and **AS** curve, the two closely related

# Supply-determined output in the long run

- ▷ What determines output in the **long run (on the trend)**?
- ▷ Simplistic production theory:
  - ▷ Only labor ( $L$ ) used for production
  - ▷  $L$ 's **marginal product = real wage**  $\Rightarrow$  equilibrium  $\bar{L}$ , output  $\bar{Y}$
- ▷ What about demand?
  - ▷ In the medium run, **demand adjusts to supply via real wage**



Source. Burda and Wyplosz (2017), Figure 13.2.

# Money and inflation in long run

Start with the **Cambridge equation** (Quantity Theory of money):

$$M = kPY$$

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

assuming *money velocity*  $k$  constant, logarithms of both sides and a total differential:

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

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

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

## Monetary policy, interest in the long run

The long-run inflation is the inflation target in the Taylor rule:

$\bar{\pi} = \mu - g$ . Target depends on:

1. Money growth rate  $\mu$ , a policy variable
2. Trend growth rate  $g$  determined (mostly) by technology and demographics

$\pi = \bar{\pi}$ ,  $Y = \bar{Y}$  in the long run, so from the TR equation:

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

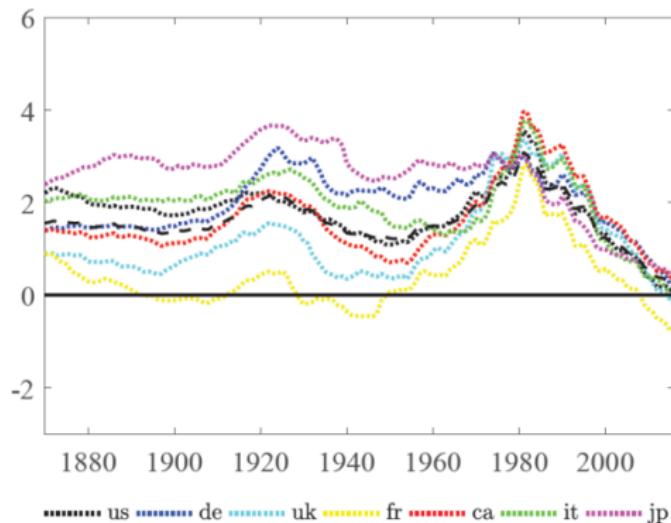
Nominal interest at its long-run target — the **natural interest rate**. Real interest rate:

$$\bar{r} = \bar{i} - \bar{\pi} = \bar{i} - \mu + g$$

Technology and demographics affect the real interest rate: it is high in an economy with faster trend growth.

# Real natural interest estimates in developed economies

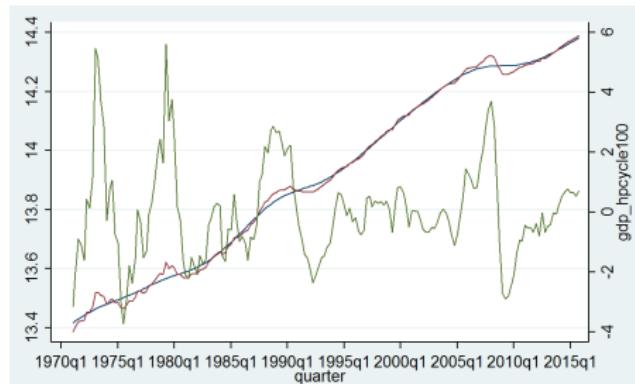
- ▷  $\bar{r}$  has a common tendency between countries; very low or negative levels in the 2010s



**Note.** Estimates from a Bayesian factor model with country-specific and global trend for the real natural rate of interest,  $r_i^*$ . **Source.** Del Negro, Giannone, Giannoni and Tambalotti (2019), 'Global trends in interest rates', Figure 3.

## Recap: short vs. long run

- ▷ Keynesian short run: supply adjusts to demand
- ▷ Long run: technology, demographics determine output
  - ▷ Keynesian demand mechanisms not relevant



**Note.** Decomposition of real GDP in the United Kingdom (in logarithm), 1970Q1 - 2018Q4, using the hp-filter for the trend (blue line) and cycle (green line) decomposition. **Source.** OECD, author's calculations.

**Next:** How do prices and wages move in response to temporary disequilibria on goods and labour markets?

# Outline

## 1 Phillips curve

- General Equilibrium with Flexible Prices
- The Phillips Curve
- Theoretical Phillips Curve — markups

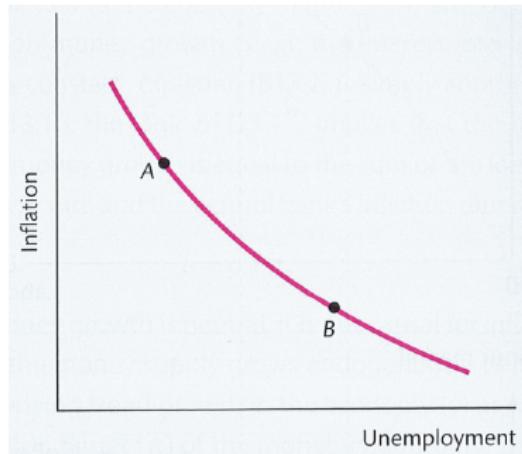
## 2 AS-AD model

## Phillips Curve and Okun's law: role for theory

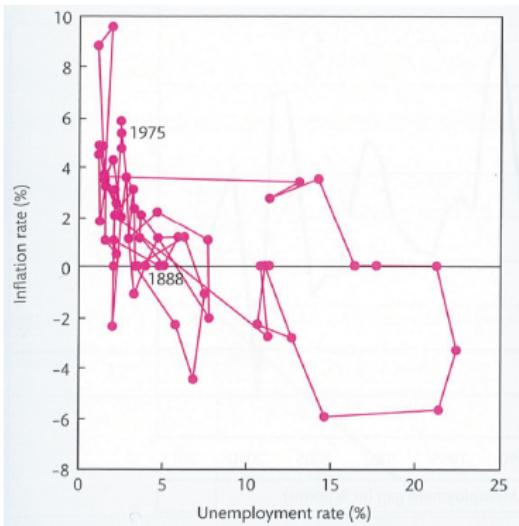
- ▷ Keynesian theory: no relation between aggregate output and inflation — the *missing equation* problem
  - ▷ two empirical findings used to fill the theory gap:
    1. A. W. Phillips (1958): negative correlation between wage inflation and unemployment rate
    2. A. Okun (1962): negative correlation between unemployment rate and GDP changes
- ⇒ inflation-output relationship

# The Phillips Curve

PC in theory



PC in the data (UK 1921-1973)



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

## The Phillips Curve: policy trade-off

- ▷ Phillips curve as an intuitive and practical idea for policy-makers: cannot achieve all good macro indicators at once:
  - ▷ Either lower inflation and higher unemployment, ...
  - ▷ ... or higher inflation, but lower unemployment.
- ▷ Slope of Phillips curve referred to as **sacrifice ratio**

*"I would rather prefer 5% inflation, then 5% unemployment (...)"*

Helmut Schmidt, 1978

## Okun's Law

- ▶ Missing element: Aggregate relationship between output and inflation



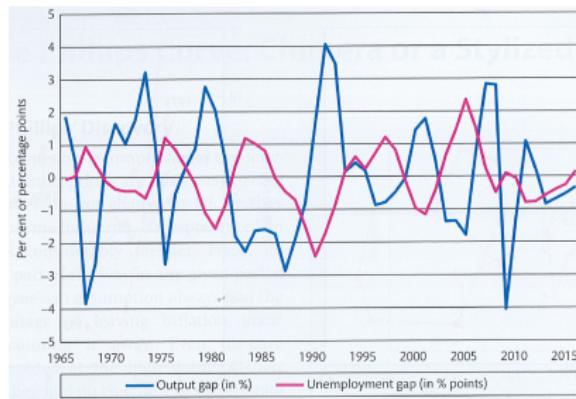
1. (1) **Phillips curve** (PC) not sufficient
  2. (2) **Okun's Law** (OL), Arthur Okun (1928-1980):
    - ▷ negative relationship between output and unemployment.

# Okun's Law: Data

- ▷ **output gap** and **unemployment gap** are negatively correlated,  
 $\text{corr}(Y_{\text{gap}}, U_{\text{gap}}) < 0$ ,  $Y_{\text{gap}} \equiv (Y - \bar{Y})/\bar{Y}$  and  $U_{\text{gap}} \equiv U - \bar{U}$
- ▷ equilibrium level of unemployment,  $\bar{U}$
- ▷ potential level of output,  $\bar{Y}$
- ▷ Modelling:

$$U_{\text{gap}} = -h Y_{\text{gap}}$$

Figure. The output gap and unemployment in Germany, 1970-2016



Source. Burda and Wyplosz (2017), Figure 13.5.

# Outline

## 1 Phillips curve

- General Equilibrium with Flexible Prices
- The Phillips Curve
- Theoretical Phillips Curve — markups

## 2 AS-AD model

# Prices and Costs

How are goods' prices (inflation) connected to wages and to output? Consider profit-maximizing firms:

- ▷ Firms have some **monopoly power** ⇒ set prices
- ▷ Cannot set prices too high because demand is **price-elastic**

## Mark-up pricing:

- ▷ Prices cannot be below **marginal costs**
- ▷ Monopoly power ⇒ price = marginal costs + **mark-up**
- ▷ Size of mark-up depends on **demand elasticity**
- ▷ Competitive markets: high elasticity, mark-up → 0

## Marginal cost vs. average cost, share of labor cost

If  $TC(Y)$  are total costs, **marginal costs** are  $\frac{dTC(Y)}{Y}$ .

**Marginal costs** can be approximated by **average costs** or **unit costs**  $\frac{TC(Y)}{Y}$ :

$$\text{unit costs} = \frac{TC(Y)}{Y} = \underbrace{\frac{W \cdot L}{Y}}_{\text{unit labour costs}} + \underbrace{\frac{\text{total non-labor costs}}{Y}}_{\text{unit non-labor costs}}$$

Share of labor costs is firms output —  $S^L$  — is ratio of labor costs to *value* of output:

$$S^L = \frac{W \cdot L}{P \cdot Y}$$

Share of labour costs ranges from 50% to 70% in firms' output in developed countries and is stable over time — one of Kaldor's stylized facts.

## Building theoretical Phillips curve: battle of markups

### Prices as mark-up on labour costs

Firms with market power aim to set price as a markup over unit labor cost (or setting labor cost share):

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

where  $\theta > 0$  the markup.

### Wages as a mark-up on prices

Workers (unions) bargain with firms for higher wages. **Sticky wages:** negotiated wage fixed for some periods  $\Rightarrow$  firms exposed to change of  $\frac{W}{P}$  in the future under a fixed  $W \Rightarrow P^e$  used in wage setting. Bargaining determines firms' labor cost share under expected future prices  $P^e$ . In the negotiation, firms have reference price  $\bar{P}$  and workers have reference (minimum) wage  $\bar{W}$ .

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

where  $\bar{S}_L$  is reference labor cost share  $\bar{S}^L = \frac{\bar{W}L}{\bar{P}Y}$  and  $\gamma$  is the markup.

## Microfoundations: price setting

$$\max_P P \cdot Y - W \cdot L, \text{ with}$$

$Y = Y^d(P)$  consumers' goods demand,  
 $L = L^d(Y)$  firm's labor demand.

## Microfoundations: wage setting

$\max_W (W - \bar{W})^\beta (\bar{P} \cdot Y - W \cdot L)^{1-\beta}$ , where  $\beta$  is workers' negotiation power.

## Building theoretical Phillips curve: battle of markups

- ▷ Prices depend on wage, wage depends on **expected** prices
- ⇒ combining wage setting and price setting equations,  
dependence of current wages on future wage obtained

$$P = (1 + \theta)(1 + \gamma)\bar{S}_L P^e$$

- ▷ anchor: expected price level  $P^e$

## From markups to output and unemployment

$$P = (1 + \theta)(1 + \gamma)\bar{S}_L P^e$$

The product  $(1 + \theta)(1 + \gamma)$  most likely *procyclical*.

- ▷ Price markup  $\theta$ : when GDP rises, competition increases ( $\theta \downarrow$ ), but demand elasticity decreases ( $\theta \uparrow$ )

⇒ total effect mixed

- ▷ Wage markup  $\gamma$ : when GDP rises, higher workers' bargaining power ( $\beta$ ), firms hire and incentivise over-time work ( $\gamma \uparrow$ )

⇒  $\gamma$  procyclical

## From price to inflation: deriving AS and Phillips curve

Taking logs and total differential of the equation:

$$P = (1 + \theta)(1 + \gamma)\bar{S}_L P^e$$

$$\ln P = \theta + \gamma + \ln \bar{S}_L + \ln P^e \text{ (as } \ln(1 + x) \xrightarrow{x \rightarrow 0} x\text{)}$$

total differential:  $\frac{dP}{P} = d\theta + d\gamma + \underbrace{\frac{d\bar{S}^L}{\bar{S}^L}}_{=0} + \frac{dP^e}{P^e}$

$$\pi = d\theta + d\gamma + \pi^e$$

$$\theta + \gamma \text{ **procyclical**} \rightarrow d\theta + d\gamma = a \cdot Y^{gap} \Rightarrow$$

$$\pi = a \cdot Y_{gap} + \pi^e$$

Finally, using **Okun's law** to replace  $Y^{gap}$  with  $U^{gap}$ :

$$\pi = -b \cdot U_{gap} + \pi^e$$

## AS, Phillips Curve — final form

Two elements are added to obtain full **Phillips curve** and **Aggregate Supply** relationships:

### 1. Underlying rate of inflation $\tilde{\pi}$

- ▷ generalization of expected inflation rate  $\pi^e$  in wage setting
- ▷ wages sticky  $\Rightarrow$  not only current expectations, but past expectations influence wage setting
- ▷ explicit rules might exist for adjusting  $W$  to  $\pi \Rightarrow$  past inflation rates enter  $\tilde{\pi}$

### 2. Supply shocks $s$

- ▷ Shocks to non-wage marginal costs
- ▷ Taken into account by firms when setting prices

## Results:

$$\pi = -bU_{gap} + \tilde{\pi} + s \quad (\text{Phillips Curve})$$

$$\pi = aY_{gap} + \tilde{\pi} + s \quad (\text{AS})$$

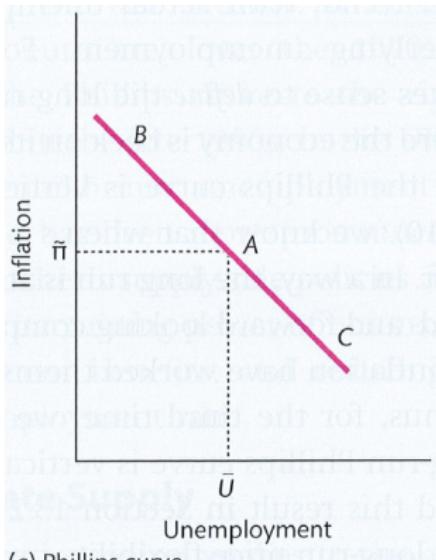
# AS and Phillips curve: symmetry

$$\pi = -bU_{gap} + \tilde{\pi} + s$$

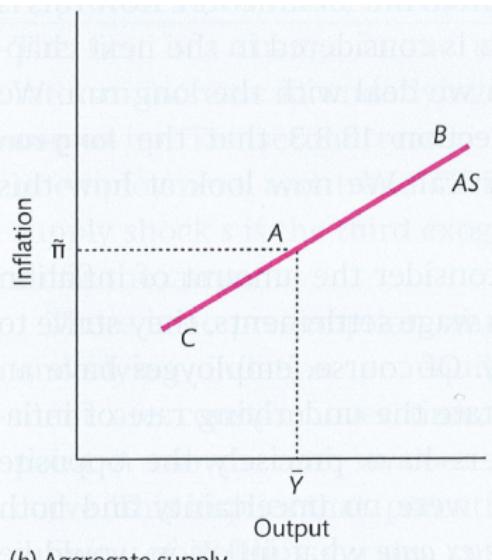
(Phillips Curve)

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

(AS)



(a) Phillips curve



(b) Aggregate supply

Note. The new Phillips curve. Source. Burda and Wyplosz (2017), Figure 13.12.

# Non-labour costs and supply shocks

Firms have small supply shocks all the time, but which ones are macroeconomic?

**Energy prices**, especially fossil fuels, have a big role:

- ▷ First oil shocks: 1973/74, 1979/81
- ▷ Second sequence of shocks: 1999/2001, 2005/12
- ▷ Favourable oil shocks: 1986 and 2015
- ▷ Current: war & sanctions ⇒ Russian oil shut off: 2022



Brent Europe crude oil price. **Source.** St. Louis Fed.

# Underlying inflation, long-run Phillips curve

## ▷ Rational expectations

- ▷ Forecast errors occur, but must average to zero over longer horizons
- ▷ Differences in  $\pi$  and  $\tilde{\pi}$  must be temporary
- ▷ Long-run link equivalence of actual and underlying inflation:  
if  $s = 0$  and  $U = \bar{U}$ , then  $\pi = \tilde{\pi}$

▷ Implies a **vertical Phillips Curve in the long run**

▷ The level of **long run inflation?**

→  $\bar{\pi}$ , **inflation target of the central bank.**

# Long-run Aggregate Supply (LAS)

- ▷ Recall that **trend output**  $\bar{Y}$  determined by technology, demographics
  - ▷ No relation of  $\bar{Y}$  level to  $\pi \Rightarrow$  **vertical LAS**
- ▷ Another way to obtain — long-run Phillips curve & Okun's law

## Implications:

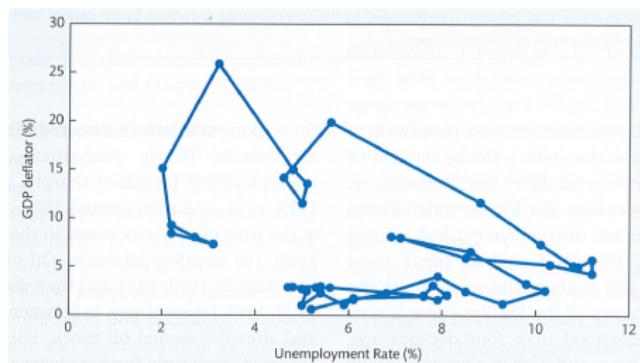
- ▷ **Short run:** Actual inflation deviates from underlying inflation  $\tilde{\pi}$  in tandem with the business cycle
- ▷ **Long-run:** output returns to its growth path, independent of price level.

Horizontal movement due to trend output  $\bar{Y}$  growing at rate  $g$

## Shifts in Phillips curve and AS — unstable relationships

- ▷  $\tilde{\pi}$ ,  $\bar{U}$ ,  $\bar{Y}$ ,  $s$  are taken as exogenous and can shift the curves  
→ a set of Phillips curves, not a stable negative relationship
- ▷ A. W. Phillips was **lucky** to find one stable curve
- ▷ At least two strong reasons for shifts since 1970s:
  - ▷ Supply shocks (oil prices)
  - ▷ Shifts in the equilibrium unemployment rate

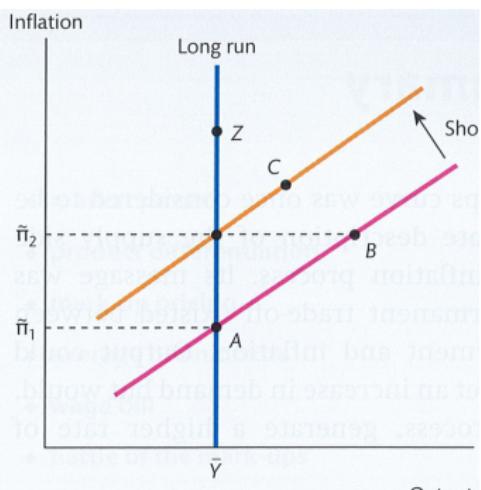
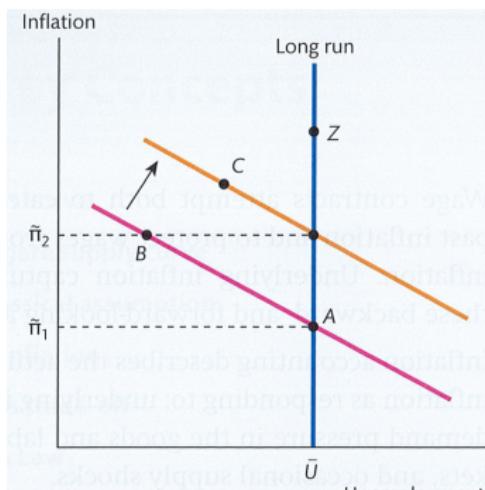
Figure. United Kingdom, 1970-2015



Source. Burda and Wyplosz (2017), Figure 13.10.

## Phillips curve and AS: summary

- ▷ Instead of a simple  $U, \pi$  relationship found originally, theoretical Phillips curve is more flexible:
  1. Short-run Phillips curve depends on expectations and supply shocks
  2. Long-run Phillips curve is vertical — no inflation-unemployment link
- ▷ Via **Okun's law**, short-run and long-run **AS** are obtained



Source. Burda and Wyplosz (2017), Figure 13.13.

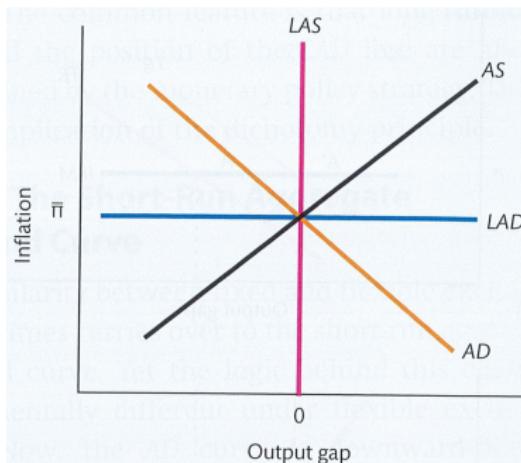
## AD-AS model

- ▷ Medium-term movements of output and inflation shaped by both supply and demand
- ▷ **AS** is obtained above
- ▷ **AD** follows immediately from the IS-TR model with full version of TR:

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

## Long-run AD: Natural rate of interest

- ▷ In the long run, central bank assumed to set interest such that  $\pi = \bar{\pi}$  for whatever  $Y$  (which is  $\bar{Y}$  anyways)
  - ▷ horizontal **LAD**
  - ▷ will become more relevant in open economy analysis



Source. Burda & Wyplosz (2017), Figure 14.12.

# Short run AD

AD & IS-TR:

Assume an increase in  $\pi$ :

- ▷ TR: Central bank raises interest rate
- ▷ Investment decreases, *IS* shifts to the left
- ▷ Equilibrium  $Y$  lower for higher  $\pi$ : downward sloping short run **AD**

## Shifts in AD

- ▷ IS: any shift in desired demand
- ▷ *TR*:  $\bar{Y}, \bar{\pi}$

## Policy example: monetary policy

**Higher inflation target**,  $\bar{\pi}' > \bar{\pi}$

## Policy example: government spending

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