Lecture 8: Intermediate macroeconomics, spring 2016

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Literature*: Mankiw, chapters 14 and 15.*

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Lectures 8-10

- **Inflation and unemployment**
  - **The economy's supply side**
  - **Inflation expectations**
  - **The conduct of monetary policy**
  - **A dynamic model of aggregate supply and aggregate demand**
- **How active should stabilisation policy be?**
  - **Discretion versus rules**
  - **Independent central banks**
- **Recent macroeconomic development**
  - **The Great Moderation**
  - **The Financial Crisis and the Great Recession**
- **Consumption and forward-looking households**
  - **Asset prices**
  - **The controversy about monetary policy in Sweden**
- **Fiscal policy and budget deficits**
  - **Ricardian equivalence**
  - **Deficits and long-run debt**
  - **Sustainability of fiscal policy**
  - **The European debt crisis**

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Topics today

- **The sticky-price model of aggregate supply**
- **Inflation-unemployment trade-offs and the expectations-augmented Phillips curve**
- **Adaptive versus rational expectations**
- **A dynamic model of aggregate demand and supply**
- **The Taylor rule**
- **Supply versus demand shocks**
- **Output versus inflation variability**

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Aggregate supply

Y = Actual output

$\bar{Y}$ = Natural (equilibrium) level of output

P = Actual price level

EP = Expected price level

$\alpha > 0$ is a parameter showing how much output responds to unexpected changes in the price level

$$Y = \bar{Y} + \alpha(P - EP)$$

Interpretation

The deviation of output from its natural (equilibrium) level is proportional to the deviation of the actual price level from the expected price level (the expectational error).

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Sticky-price model

Two types of firms

- **Flexible-price firms**
- **Rigid-price firms**

Flexible-price firms

$$p = P + a(Y - \bar{Y})$$

Rigid-price firms

$$p = EP + a(EY - E\bar{Y})$$

Assume $EY = E\bar{Y}$**. Then** $p = EP$**.**

s **= share of firms with rigid prices**

$1 - s$ **= share of firms with flexible prices**

Aggregate price level

$$P = sEP + (1 - s)[P + a(Y - \bar{Y})]$$

Solve for P**:**

$$P = EP + [(1 - s)\, a/s]\,(Y - \bar{Y})$$

Alternatively, one can solve for $Y - \bar{Y}$**:**

$$Y - \bar{Y} = \overbrace{\frac{s}{a(1-s)}}^{\alpha}\,(P - EP)$$

Thus:

$$Y - \bar{Y} = \alpha\,(P - EP)$$

Figure 14-1: The Short-Run Aggregate Supply Curve

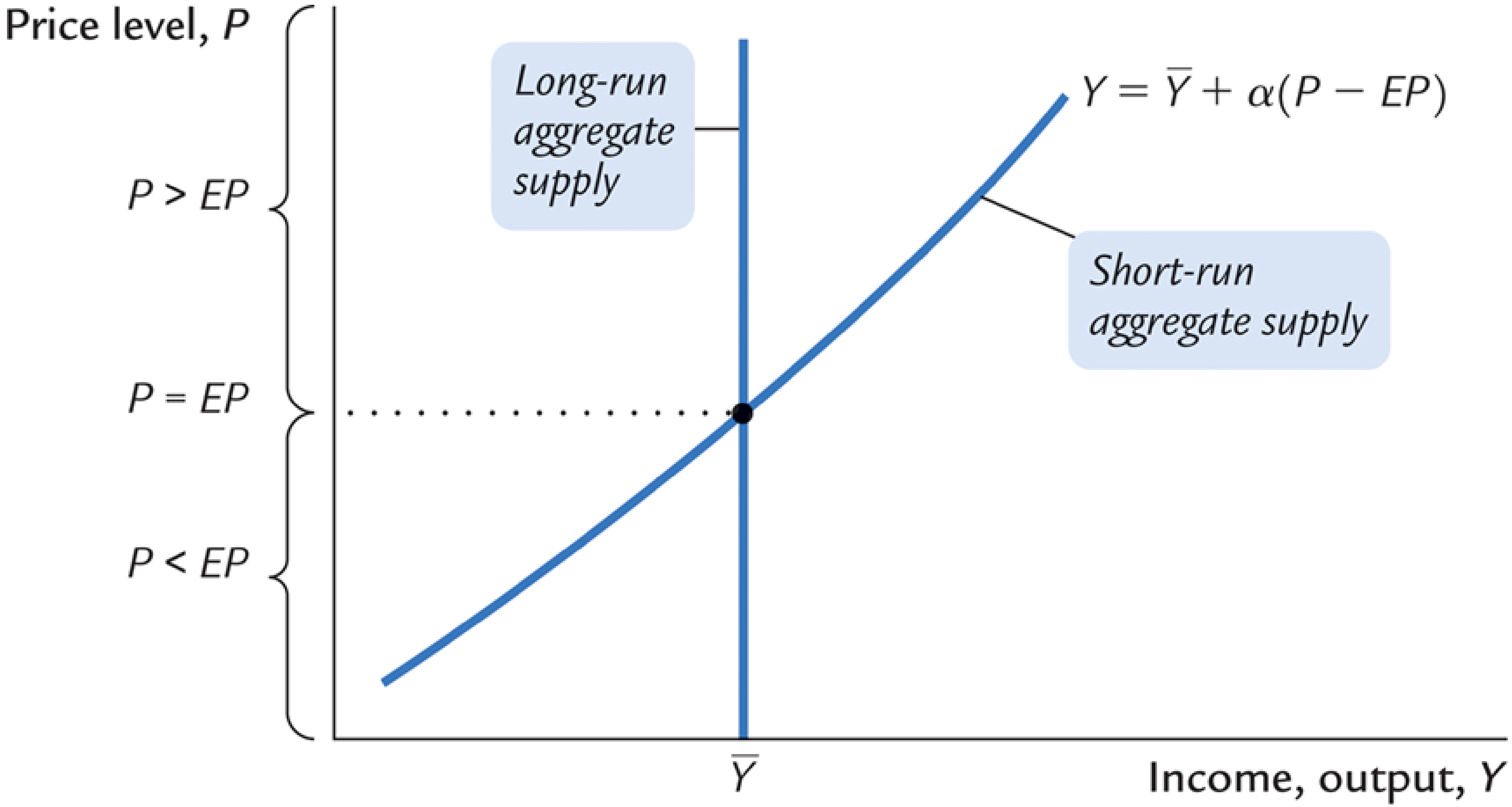
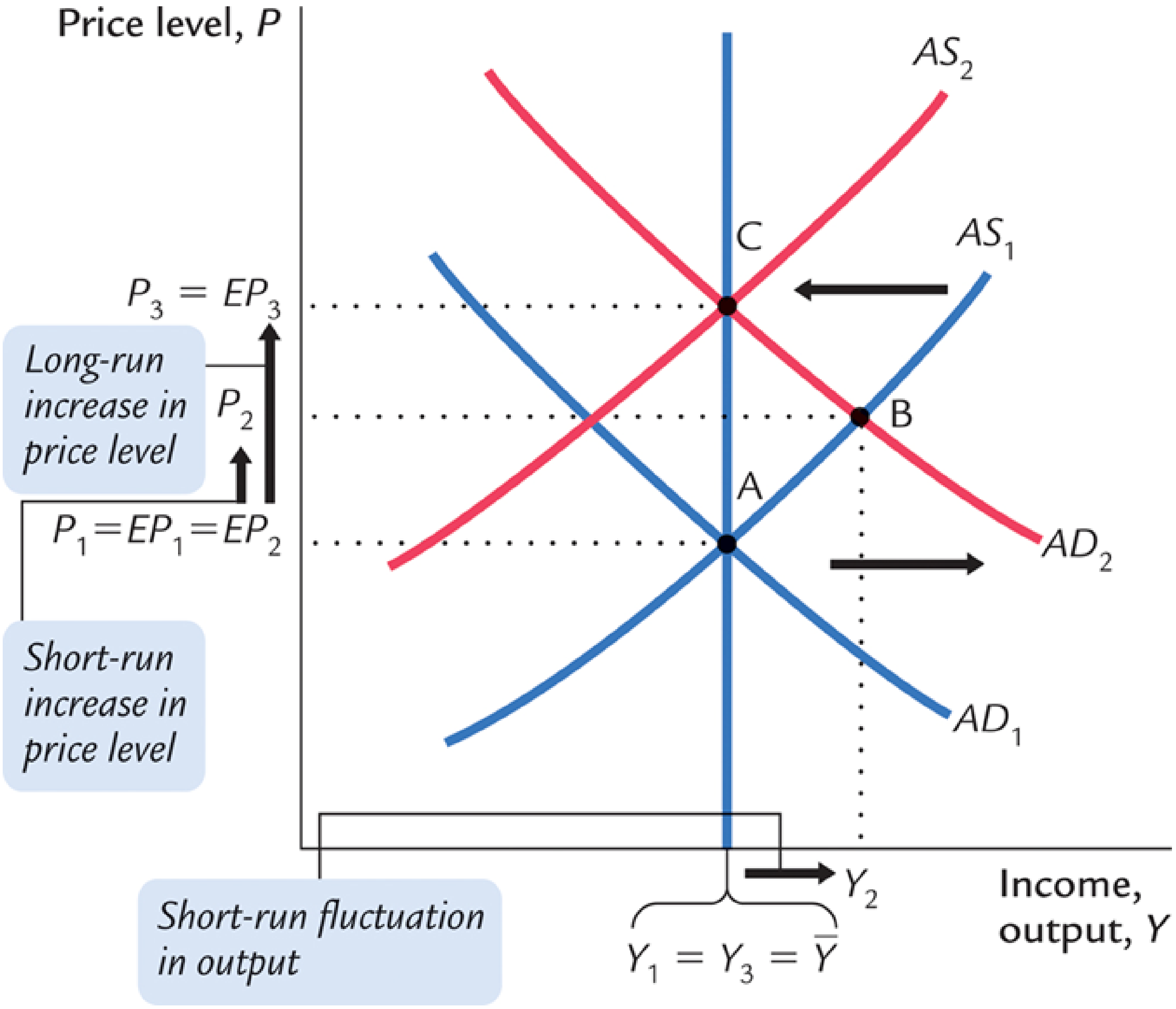


Figure 14-2: How shifts in aggregate demand lead to short-run fluctuations



The expectations-augmented Phillips curve

π = actual inflation

$E\pi$ = expected inflation

$u - u_n$ = cyclical unemployment, i.e. the deviation of actual unemployment from the natural (equlibrium) rate

v = supply shock

β = parameter showing how inflation reacts to cyclical unemployment

$$\pi = E\pi - \beta(u - u_n) + v$$

Inflation = Expected inflation – β × Cyclical unemployment + Supply shock

$u - u_n$ and $v = 0 \Rightarrow \pi = E\pi$

Inflation is equal to expected inflation if unemployment is at the natural (equilibrium) rate and there is no supply shock.

The Phillips curve and the surprise supply function

- **The expectations-augmented Phillips curve and the surprise supply function can be seen as two sides of the same coin.**

$$Y - \bar{Y} = \alpha(P - EP)$$

$$P - EP = \frac{1}{\alpha}(Y - \bar{Y}) \Rightarrow$$

$$P = EP + \frac{1}{\alpha}(Y - \bar{Y})$$

P_{-1} is the price level the preceding period.
Add supply shock *v*!

$$P - P_{-1} = EP - P_{-1} + \frac{1}{\alpha}(Y - \bar{Y})$$

$$\pi = E\pi + \frac{1}{\alpha}(Y - \bar{Y}) + \nu$$

- **According to Okun's law the output gap is related to the deviation of unemployment from its equilibrium (natural rate).**

$$u - u_n = -\gamma(Y - \bar{Y})$$

$$(Y - \bar{Y}) = -\frac{1}{\gamma}(u - u_n)$$

- **Hence:**

$$\boldsymbol{\pi = E\pi - \overbrace{\frac{1}{\alpha} \times \frac{1}{\gamma}}^{\beta}(u - u_n) + \nu}$$

$$\boldsymbol{\pi = E\pi - \beta(u - u_n) + \nu}$$

The Phillips curve and adaptive expectations

- $$\pi = E\pi - \beta(u - u_n) + \nu$$
- **Adaptive expectations:** $\pi = \pi_{-1}$
- **Expected inflation = inflation in the previous year**

$$\pi = \pi_{-1} - \beta(u - u_n) + \nu$$

$$\pi - \pi_{-1} = -\beta(u - u_n) + \nu$$

- **The rate of change of inflation is proportional to the deviation from equilibrium unemployment.**
- **Actual unemployment = equilibrium unemployment implies a constant rate of inflation if ν = 0 (no supply shock), since $u = u_n \Rightarrow \pi = \pi_{-1}$.**

$u < u_n \Rightarrow \pi > \pi_{-1}$, that is inflation is increasing if actual unemployment is lower than equilibrium unemployment and no supply shock. This is the reason why the equilibrium rate of unemployment is sometimes labelled the NAIRU (Non-accelerating inflation rate of unemployment).

Alternative hypothesis on expectations

- **Rational inflation expectations that are formed on the basis of all available information.**
- **Since it takes time for monetary policy to influence inflation, central banks find it important to influence inflation expectations.**
- **If a central bank can reduce expected inflation through announcements only, it is able to reduce inflation painlessly.**
- **But this requires high credibility.**

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Figure 14-4: The short-run tradeoff between inflation and unemployment

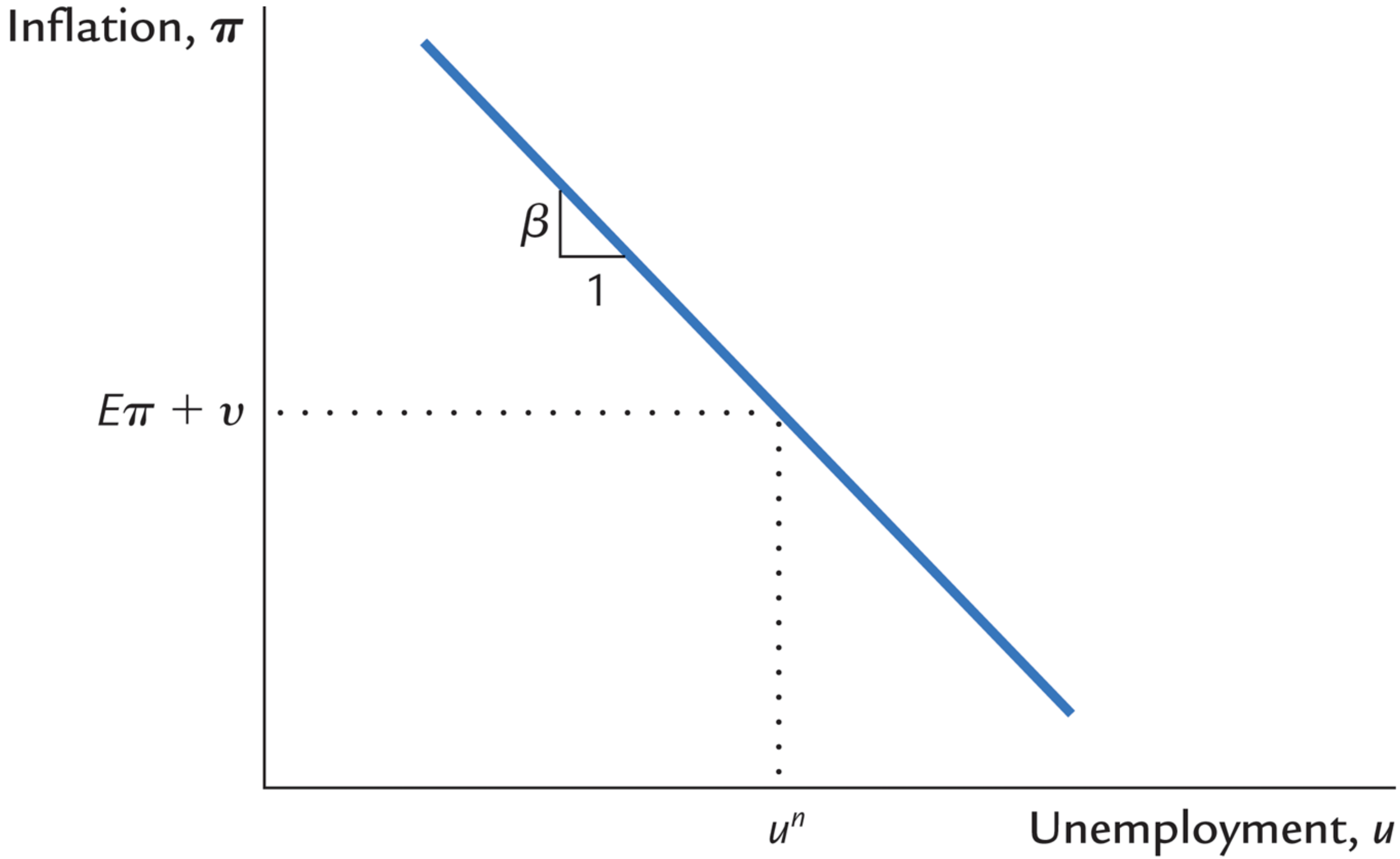
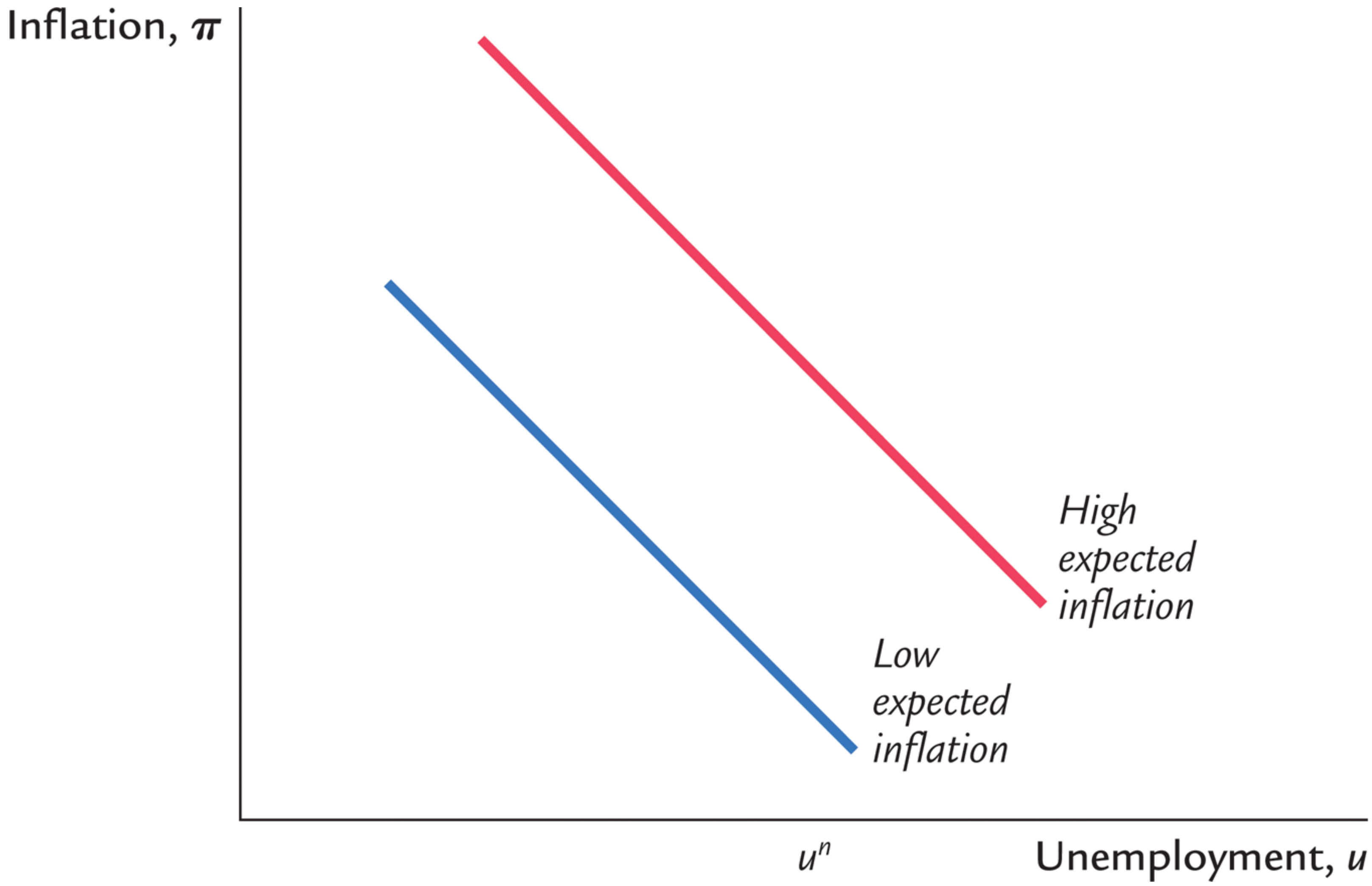
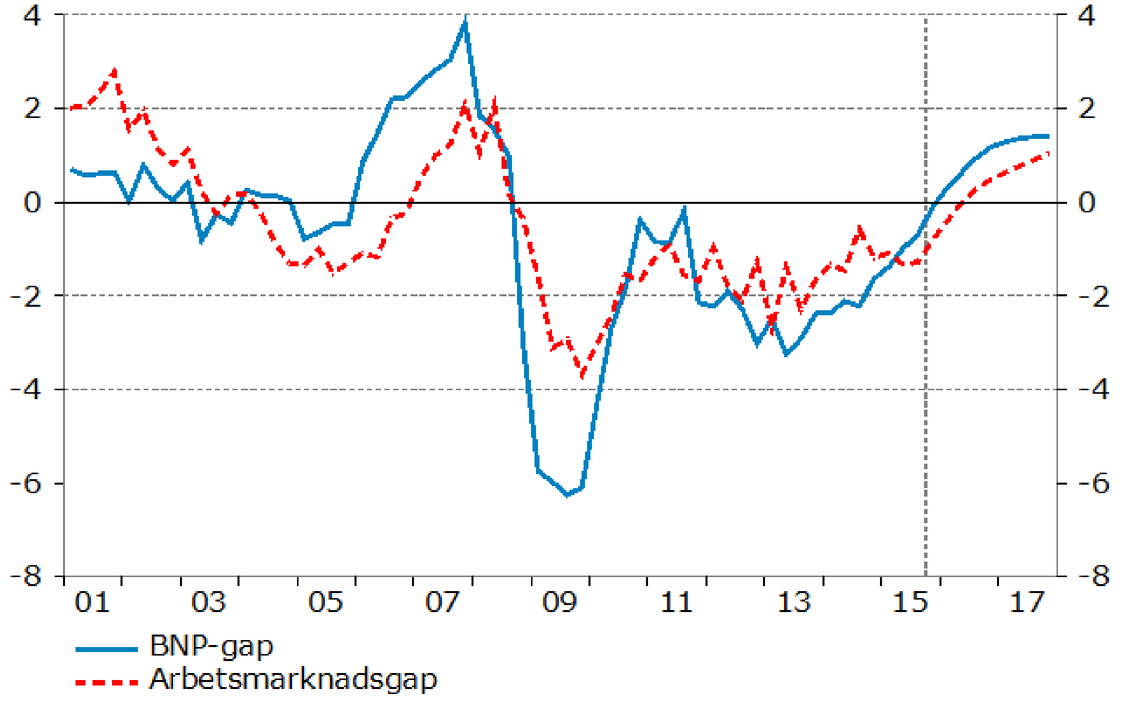


Figure 14-5: Shifts in the short-run tradeoff



Högkonjunktur 2016 med positiva BNP- och arbetsmarknadsgap

Procent av potentiell BNP respektive potentiellt arbetade timmar, säsongsrensade kvartalsvärden

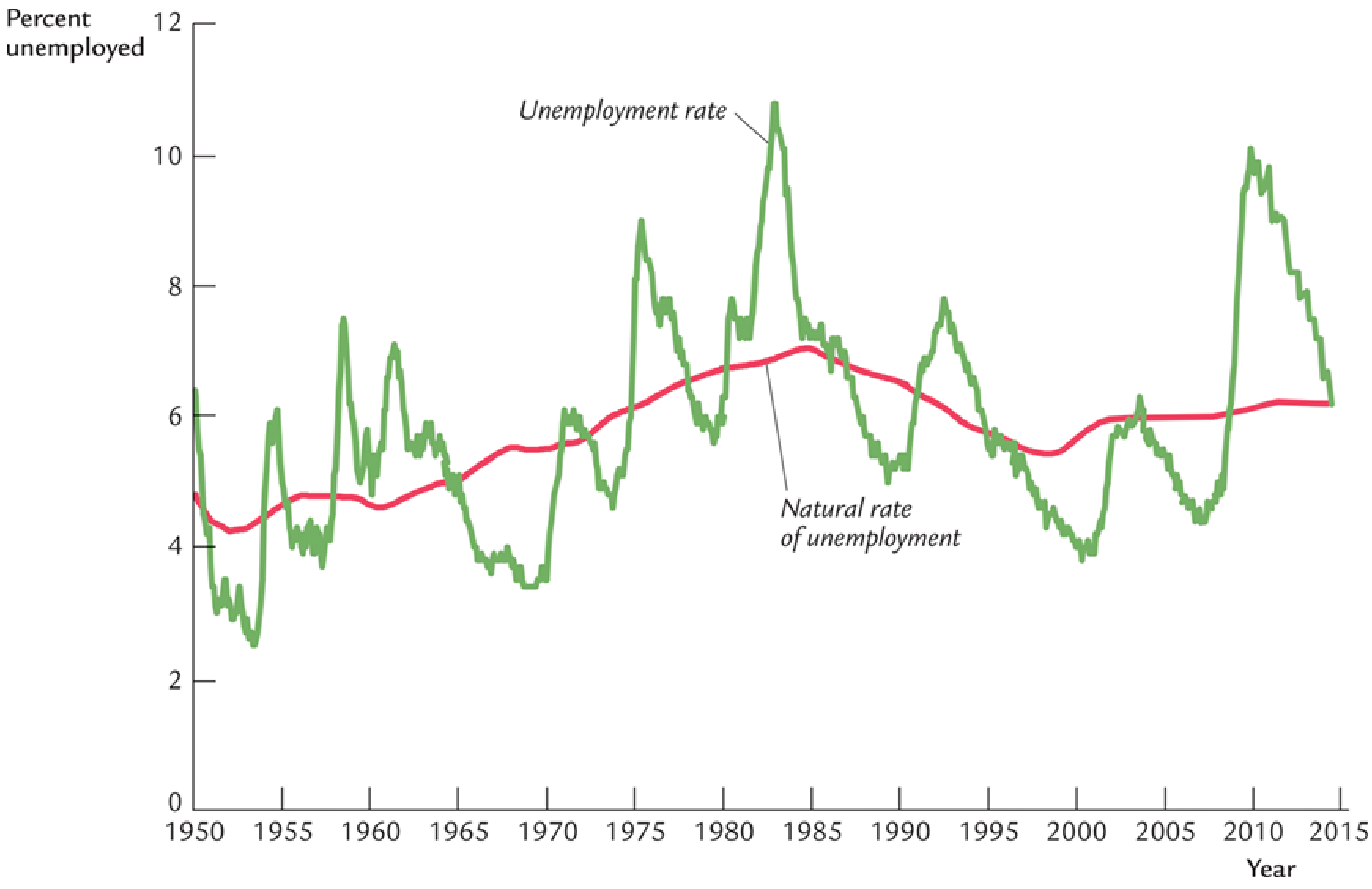


Source: Konjunkturinstitutet.

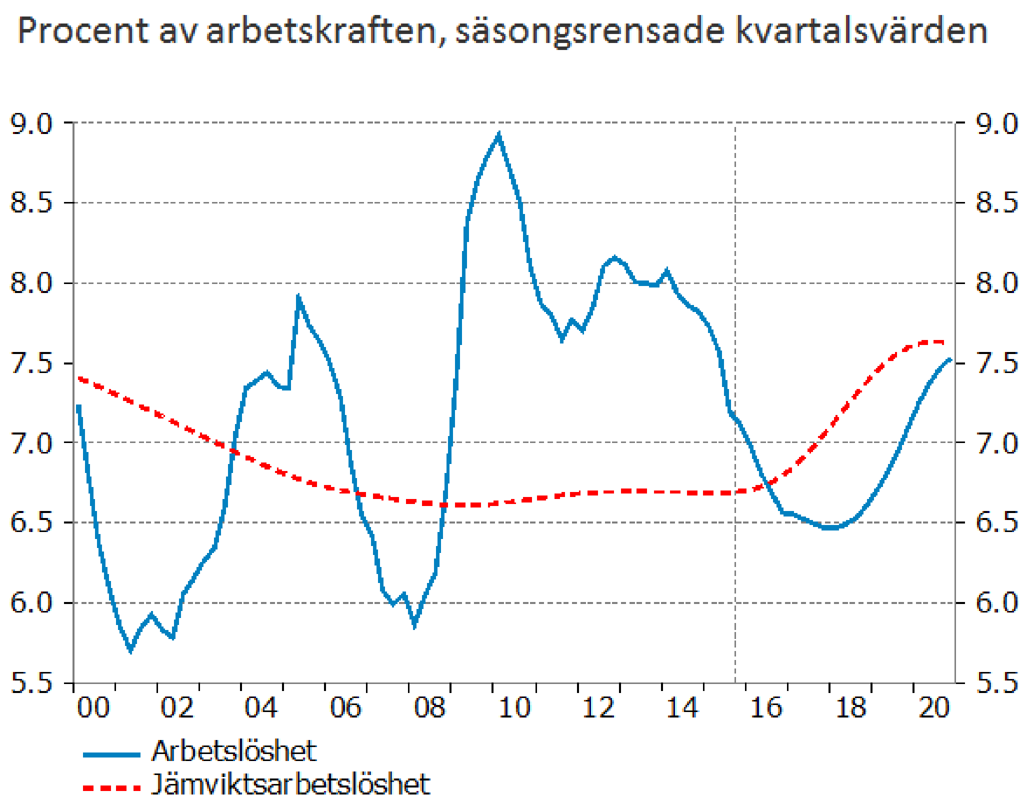
Does the actual unemployment rate affect the natural (equilibrium) rate

- **Rises in the actual rate of unemployment seem to give rise to rises in the natural (equilibrium) rate as well**
- **Hysteresis**
  - **Loss of human capital**
  - **Statistical discrimination**
  - **Discouraged-worker effects**
  - **Wage setting only take insiders, not outsiders, into account**
- **Will recent high unemployment have permanent effects?**

Figure 7-1: The unemployment rate and the natural rate of unemployment in the United States



Actual and Equilibrium Unemployment Rates in Sweden



Source: Konjunkturinstitutet.

A dynamic model of aggregate demand and aggregate supply

- **Economic fluctuations are dynamic**

  - continuous shocks

  - effects over time

- **Incorporation of monetary policy response**

- **The central bank sets the interest rate**

- **The interest rate should be interpreted as the short-run interest rate**

- **Simplified version of Dynamic Stochastic General Equilibrium (DSGE) models**

Aggregate demand

Y = Output

$\bar{Y}$ = Natural (equilibrium) level of output

r = Real interest rate

ρ = Natural (equilibrium) rate of interest

ε = Random demand shock

α = Sensitivity of output demand to the real rate of interest

Time indices for all variables

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t \qquad \alpha > 0,\ \varepsilon_t \gtreqless 0$$

- **Higher natural level of output increases demand: people feel richer**
- **Demand depends negatively on the real interest rate**
  - **investment**
  - **saving**
  - **net exports (via change of the exchange rate)**
- **ε represents various types of shocks**
  - **investment (“animal spirits”)**
  - **boom in house prices**
  - **fiscal policy**
- **ρ is the real rate of interest at which aggregate demand equals the natural level of output**

<u>Definition of real interest rate</u>

i **= Nominal interest rate**

E **= Expectations operator**

π **= Inflation rate**

$E_t \pi_{t+1}$ **= Expectation of inflation during period *t* + 1 held in time period *t***

$$r_t = i_t - E_t \pi_{t+1}$$

- r_t **is thus the ex ante real rate of interest**
- i_t **= nominal rate of return between period *t* and period *t* + 1**
- π_{t+1} **= rate of price change between period *t* and period *t* +1**

<u>Inflation</u>

Φ **= Sensitivity of inflation to the output gap**

v **= Supply shock**

$$\pi_t = E_{t-1}\pi_t + \phi(Y_t - \overline{Y}_t) + \nu_t \qquad \phi > 0$$

- **Phillips-curve equation**

- **Supply shock captures**
  - **oil price changes**
  - **wage changes**
  - **VAT change**
  - **productivity change**

Expected inflation

$$E_t\pi_{t+1} = \pi_t$$

$$E_{t-1}\pi_t = \pi_{t-1}$$

- **Expectations are thus assumed to be adaptive**
- **Major simplification of the model**

<u>Central bank behaviour (Taylor rule)</u>

π^* = **The central bank's inflation target**

θ_π = **Response of the nominal interest rate to deviation of inflation from target**

θ_y = **Response of the nominal interest rate to output gap (deviation of output from its natural level)**

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \bar{Y}_t)$$

$$\theta_\pi > 0, \qquad \theta_y > 0$$

- $\pi_t = \pi_t^*$ **and** $Y_t = \bar{Y}_t \Rightarrow i_t = \pi_t + \rho$

- **Since** $E_t\pi_{t+1} = \pi_t$ **, this implies that**

  $$r_t = i_t - E_t\pi_{t+1} = \pi_t + \rho - E_t\pi_{t+1} = \pi_t + \rho - \pi_t = \rho$$

- **Hence, if inflation is at target and there is no output gap, the central bank sets the nominal interest rate such that the natural real interest rate obtains.**

- **If** $\pi_t > \pi_t^*$ **and** $Y_t > \bar{Y}_t$**, we have** $r_t > \rho$

- **If** $\pi_t < \pi_t^*$ **and** $Y_t < \bar{Y}_t$**, we have** $r_t < \rho$

The Taylor rule (cont.)

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \bar{Y}_t)$$

$$\frac{di_t}{d\pi_t} = 1 + \theta_\pi$$

$$r_t = i_t - E_t\pi_{t+1} = i_t - \pi_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \bar{Y}_t) -$$
$$- \pi_t = \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \bar{Y}_t)$$

$$\frac{dr_t}{d\pi_t} = \theta_\pi > 0$$

- **A rise in inflation induces the central bank to raise the nominal interest rate *more* than inflation**
- **Hence, a rise in inflation causes the real interest rate to rise**
- **This is crucial**

Where is the money supply?

- **The nominal interest rate is the central bank's policy parameter**
- **There is a money market in the background (cf Krugman-Obstfeld-Melitz)**
  - **Equality between money supply and money demand determines the nominal interest rate**
  - **The central bank adjusts money supply so that the desired interest rate is reached**
  - **This is not shown in the model but is happening in the background**

The Taylor rule: numerical examples

$\rho = 2$ percent

$\pi^* = 2$ percent

$\theta_\pi = \theta_Y = 0.5$

Assume $Y_t - \bar{Y}_t = 0$, so that output is at its equilibrium level and $\pi_t = \pi_t^* = 2$ percent. The nominal interest rate set is:

$$i_t = 2 + 2 + 0.5 \times (2 - 2) + 0.5 \times 0 = 4$$

Then $r_t = i_t - \pi_t = 4 - 2 = 2$

Assume $Y_t - \bar{Y}_t = 2$, so that output is above its equilibrium level and $\pi_t = 4$. The nominal interest rate set is:

$$i_t = 4 + 2 + 0.5 \times (4 - 2) + 0.5 \times 2 = 8$$

Then $r_t = i_t - \pi_t = 8 - 4 = 4$

To dampen inflation, the nominal interest rate is raised more than inflation so that the real interest rate goes up.

The Taylor rule in a recession

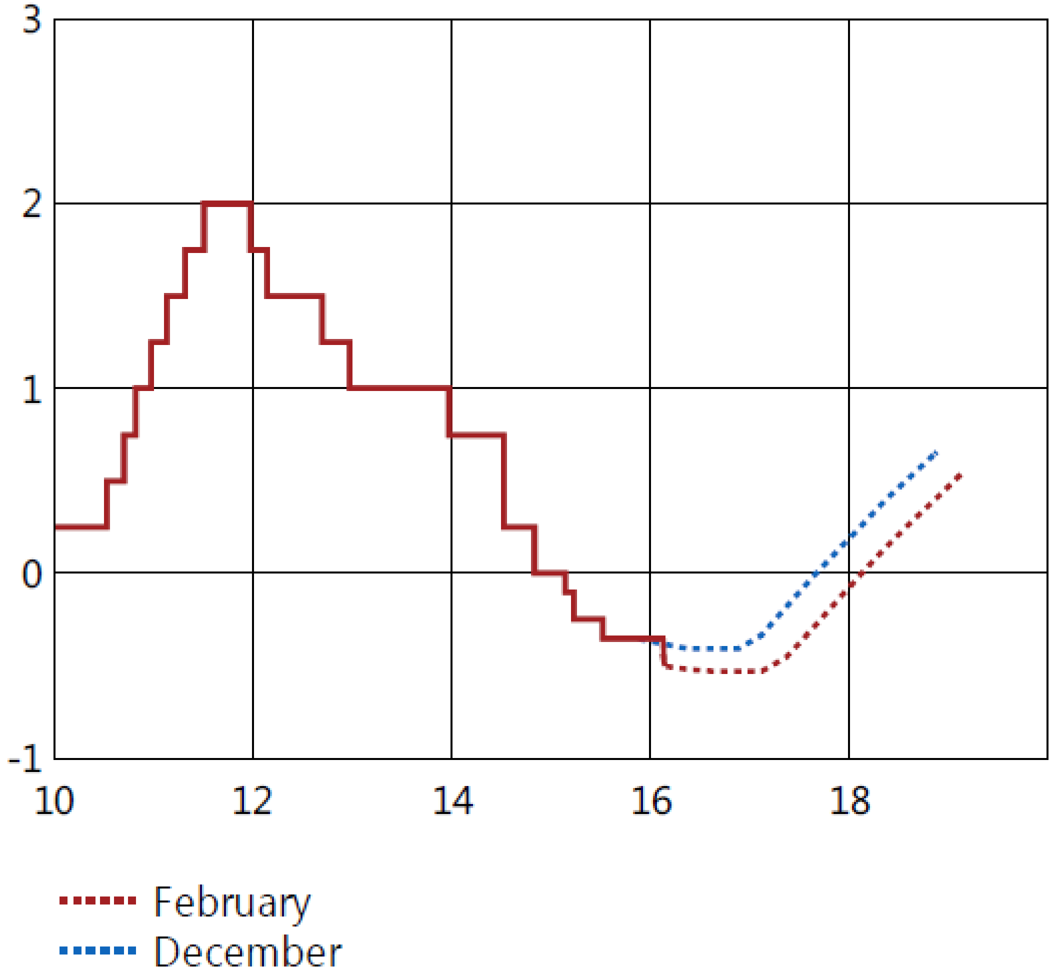
Suppose $Y_t - \bar{Y}_t = -6$ percent and that $\pi_t = 0$ percent. The nominal interest rate according to the formula should be

$$i_t = 0 + 2 + 0.5 \times (0 - 2) + 0.5 \times (-6) = -2$$

A negative nominal interest rate would be required.

Figure 1:10. Repo rate

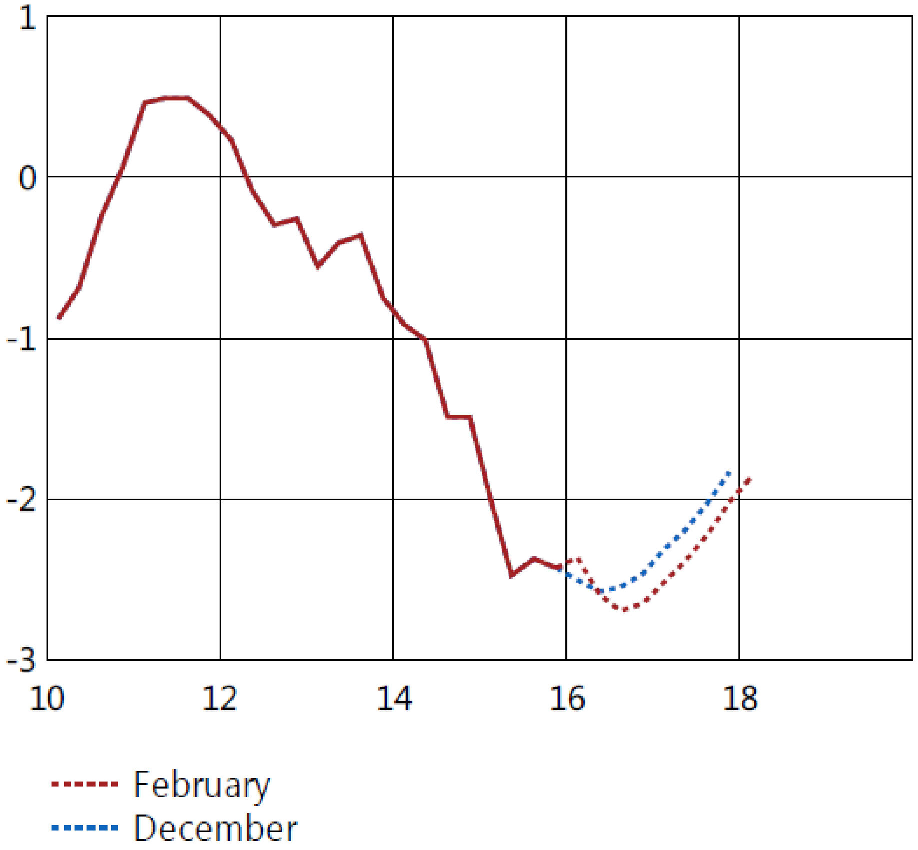
Per cent



Note. Outcomes are daily data and the forecasts refer to quarterly averages.

Source: The Riksbank

Figure 1:12. Real repo rate
Per cent, quarterly averages



Note. The real repo rate is a mean value of the Riksbank's repo rate forecast four quarters ahead minus the inflation forecast (CPIF) for the corresponding period.

Sources: Statistics Sweden and the Riksbank

Negative interest rates were required in the recession

- **Traditional view: zero interest rate bound**

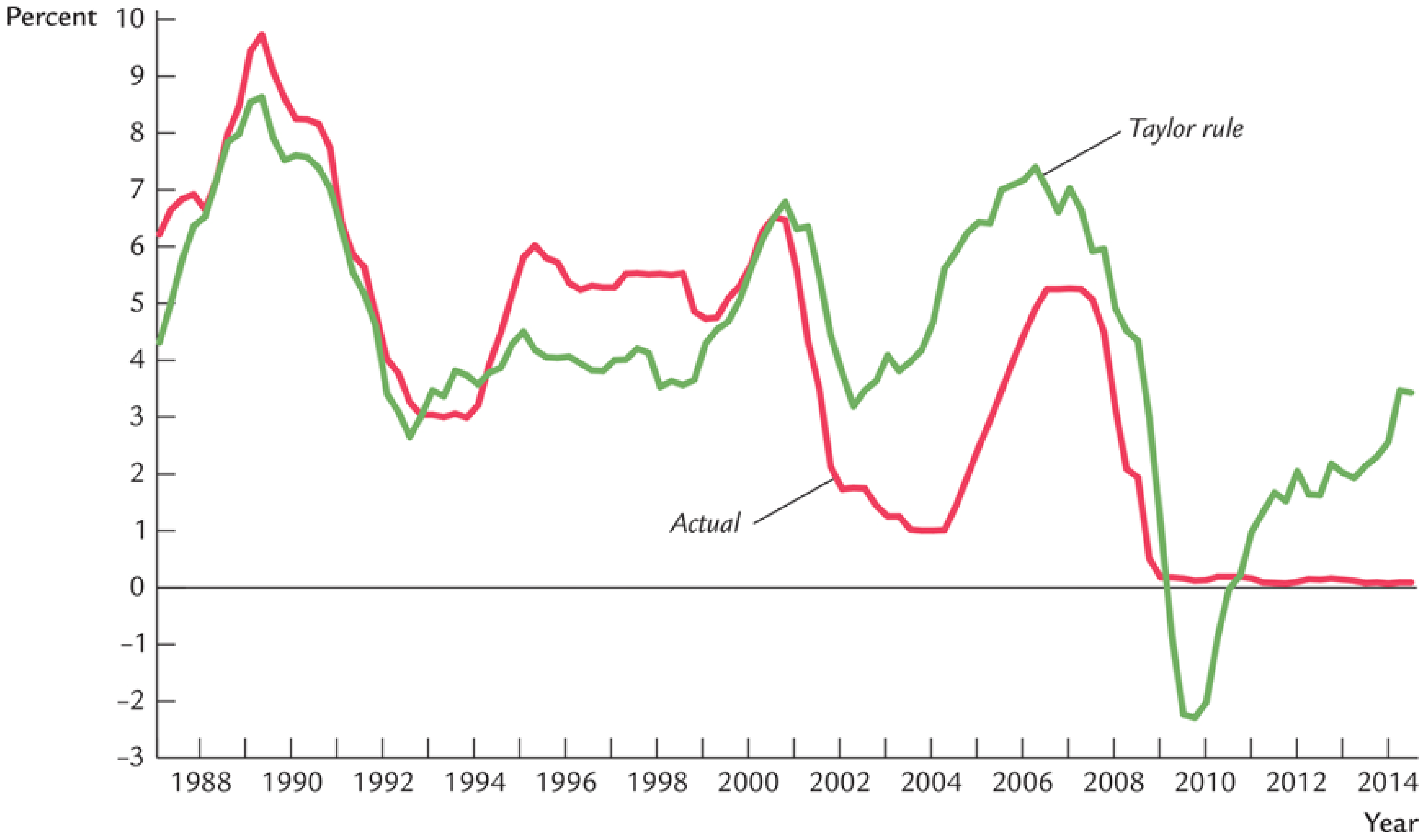
- **This view is being questioned**

- **negative interest rate for bank deposits in central bank**
- **in principle the central bank could pay banks to borrow in the central bank (ECB now) agents might still hold bank deposits with negative interest rate (instead of having money in the mattress and pay for protection)**

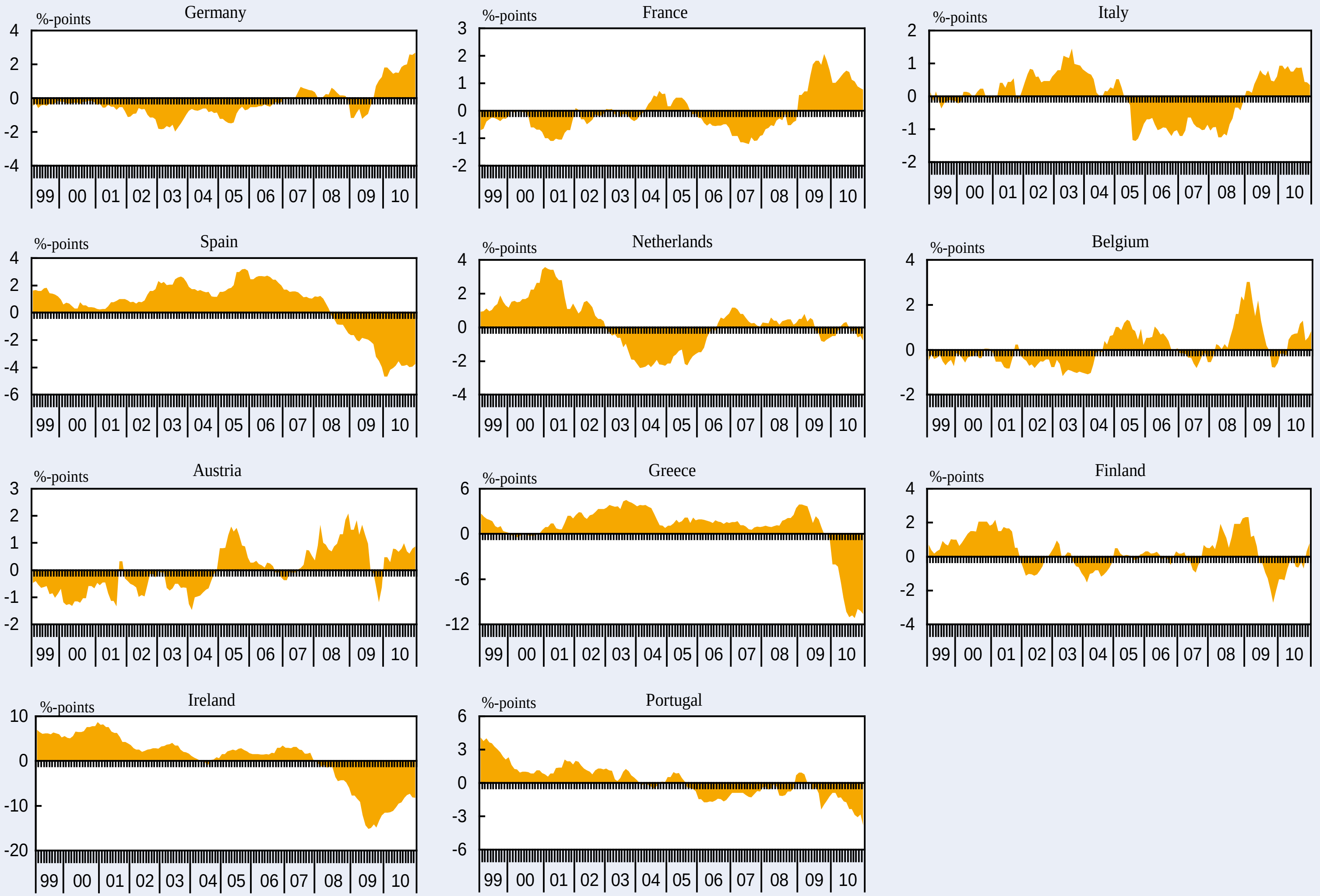
- **But central banks are unwilling to enter unchartered territory**

- **quantitative easing: purchases of long-term government and commercial bonds**
- **lending to banks against collateral of lower quality**
- **provision of liquidity through operations with longer maturity**

Figure 15-1: The Federal funds rate: actual and suggested



Deviations of country-specific optimal policy rates from the ECB rate



Source: European Central Bank; Consensus Economics Inc.; EEAG calculations and estimates.

The complete model

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t$$ **Aggregate demand**

$$r_t = i_t - E_t\pi_{t+1}$$ **Real rate of interest**

$$\pi_t = E_{t-1}\pi_t + \phi(Y_t - \bar{Y}_t) + \nu_t$$ **Phillips curve**

$$E_t\pi_{t+1} = \pi_t$$ **Adaptive expectations**

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \bar{Y}_t)$$ **Taylor rule**

Table 15-1: The equations, variables, and parameters in the dynamic *AD-AS* model

Equations	
$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \epsilon_t$	The demand for goods and services
$r_t = i_t - E_t\pi_{t+1}$	The Fisher equation
$\pi_t = E_{t-1}\pi_t + \phi(Y_t - \bar{Y}_t) + \upsilon_t$	The Phillips curve
$E_t\pi_{t+1} = \pi_t$	Adaptive expectations
$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t)$	The monetary-policy rule
Endogenous Variables	
Y_t	Output
π_t	Inflation
r_t	Real interest rate
i_t	Nominal interest rate
$E_t\pi_{t+1}$	Expected inflation
Exogenous Variables	
$\bar{Y}_t$	Natural level of output
π_t^*	Central bank's target for inflation
ϵ_t	Shock to the demand for goods and services
υ_t	Shock to the Phillips curve (supply shock)
Predetermined Variable	
π_{t-1}	Previous period's inflation
Parameters	
α	The responsiveness of the demand for goods and services to the real interest rate
ρ	The natural rate of interest
ϕ	The responsiveness of inflation to output in the Phillips curve
θ_π	The responsiveness of the nominal interest rate to inflation in the monetary-policy rule
θ_Y	The responsiveness of the nominal interest rate to output in the monetary-policy rule

Long-run equilibrium

No shocks: $\varepsilon_t = \nu_t = 0$

Stable inflation: $\pi_t = \pi_{t-1}$

$$E_t \pi_{t+1} = \pi_t = \pi_{t-1} \qquad (1)$$

$$\pi_t = E_{t-1}\pi_t + \phi(Y_t - \bar{Y}_t) + \nu_t$$

$$\pi_t = \pi_t + \phi(Y_t - \bar{Y}_t)$$

$$0 = \phi(Y_t - \bar{Y}_t)$$

$$Y_t = \bar{Y}_t \qquad (2)$$

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t$$

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho)$$

$$\bar{Y}_t = \bar{Y}_t - \alpha(r_t - \rho)$$

$$0 = -\alpha(r_t - \rho)$$

$$r_t = \rho \qquad (3)$$

$$r_t = i_t - E_t\pi_{t+1}$$

$$r_t = i_t - \pi_t$$

$$i_t = r_t + \pi_t$$

$$i_t = \rho + \pi_t \qquad (4)$$

Long-run equilibrium (cont.)

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \overline{Y}_t)$$

$$\rho + \pi_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*)$$

$$0 = \theta_\pi(\pi_t - \pi_t^*)$$

$$\pi_t = \pi_t^* \qquad (5)$$

Long-run equilibrium (cont.)

$Y_t = \bar{Y}_t$:	**Output at the natural level**
$r_t = \rho$:	**Real interest rate at the natural level**
$\pi_t = \pi_t^*$:	**Inflation at the target level**
$E_t\pi_{t+1} = \pi_t^*$:	**Expected inflation equals the inflation target**
$i_t = \rho + \pi_t^*$:	**The nominal interest rate equals the natural interest rate + the inflation target**

Features

- **Classical dichotomy: Separation of real from monetary variables**
- **Monetary variables do not influence real variables**
- **The inflation target π_t^* influences only inflation π_t, expected inflation $E_t\pi_{t+1}$ and the nominal interest rate i_t .**
- **Output Y_t and the real interest rate r_t do not depend on the inflation target π_t^*.**

<u>The Dynamic Aggregate Supply curve (DAS curve)</u>

$$\pi_t = E_{t-1}\pi_t + \phi(Y_t - \bar{Y}_t) + \nu_t$$

$$\pi_t = \pi_{t-1} + \phi(Y_t - \bar{Y}_t) + \nu_t$$

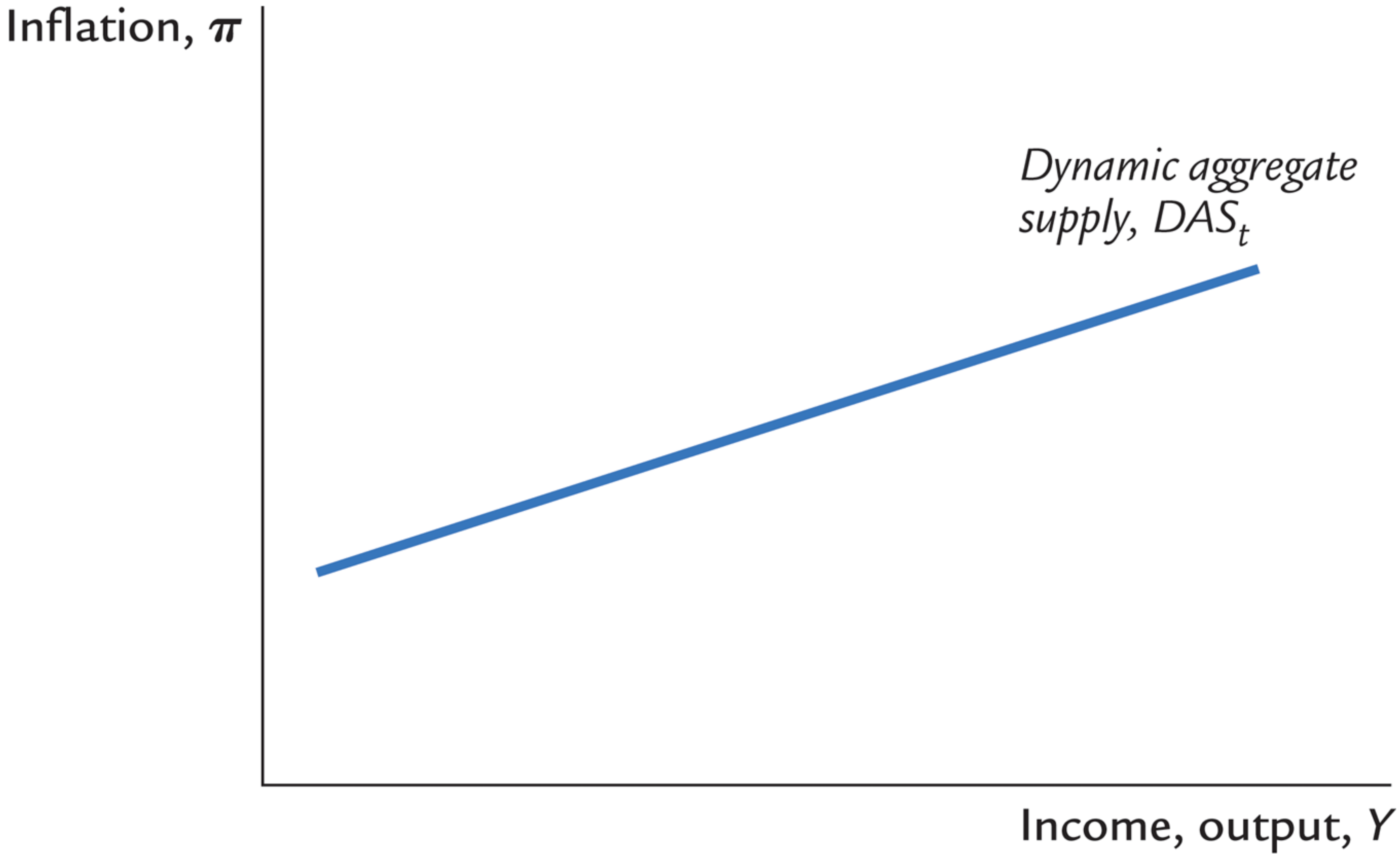
Draw a curve in the π_t , Y_t-plane!

$$\frac{d\pi_t}{dY_t} = \phi > 0$$

Hence, the dynamic supply curve is positively sloped.

A change in v_t shifts the curve.

Figure 15-2: The dynamic aggregate supply curve



The Dynamic Aggregate Demand curve (DAD curve)

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t$$

Use $r_t = i_t - E_t\pi_{t+1}$

$$Y_t = \bar{Y}_t - \alpha(i_t - E_t\pi_{t+1} - \rho) + \varepsilon_t$$

Use the Taylor equation to substitute for i_t

$$Y_t = \bar{Y}_t - \alpha[\pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t) - E_t\pi_{t+1} - \rho] + \varepsilon_t$$

Substitute π_t for $E_t\pi_{t+1}$

$$Y_t = \bar{Y}_t - \alpha[\pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t) - \pi_t - \rho] + \varepsilon_t$$

$$Y_t = \bar{Y}_t - \alpha[\theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t)] + \varepsilon_t$$

$$Y_t = \bar{Y}_t - \alpha\theta_\pi(\pi_t - \pi_t^*) - \alpha\theta_Y Y_t + \alpha\theta_Y\bar{Y}_t + \varepsilon_t$$

$$Y_t + \alpha\theta_Y Y_t = \bar{Y}_t + \alpha\theta_Y\bar{Y}_t - \alpha\theta_\pi(\pi_t - \pi_t^*) + \varepsilon_t$$

$$(1 + \alpha\theta_Y)Y_t = (1 + \alpha\theta_Y)\bar{Y}_t - \alpha\theta_\pi(\pi_t - \pi_t^*) + \varepsilon_t$$

$$Y_t = \bar{Y}_t - \frac{\alpha\theta_\pi(\pi_t - \pi_t^*)}{1+\alpha\theta_Y} + \frac{\varepsilon_t}{1+\alpha\theta_Y}$$

$$\frac{dY_t}{d\pi_t} = -\frac{\alpha\theta_\pi}{1+\alpha\theta_Y}$$

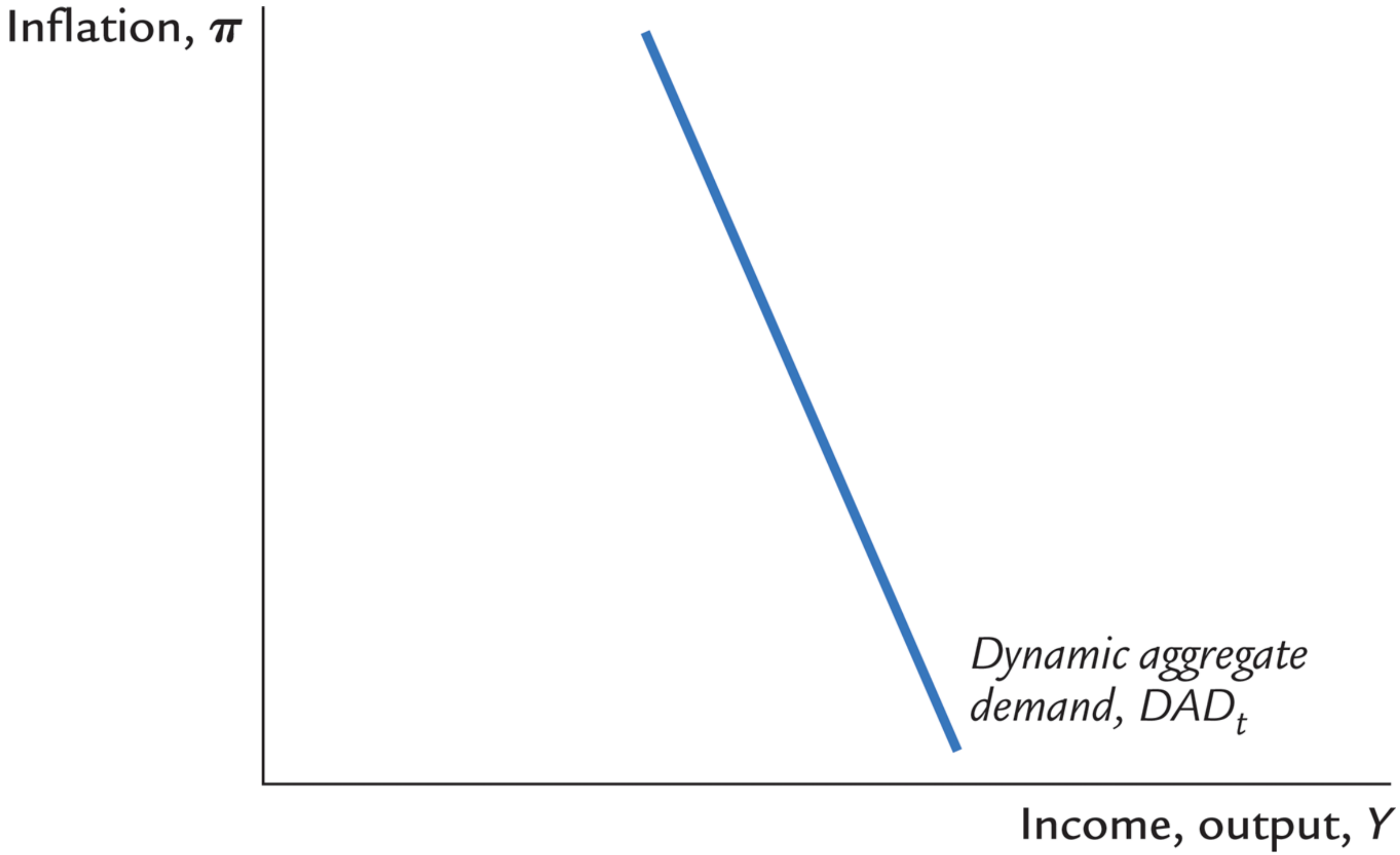
$$\frac{d\pi_t}{dY_t} = -\frac{1+\alpha\theta_Y}{\alpha\theta_\pi}$$

Hence, the dynamic aggregate demand curve is downward-sloping.

- **The curve is drawn for a given monetary policy rule (*not* a given money supply).**
- **When inflation rises, the central bank raises the *real* interest rate, aggregate demand falls.**

- A change in ε_t shifts the curve.
- So does a change in π_t^* .

Figure 15-3: The dynamic aggregate demand curve



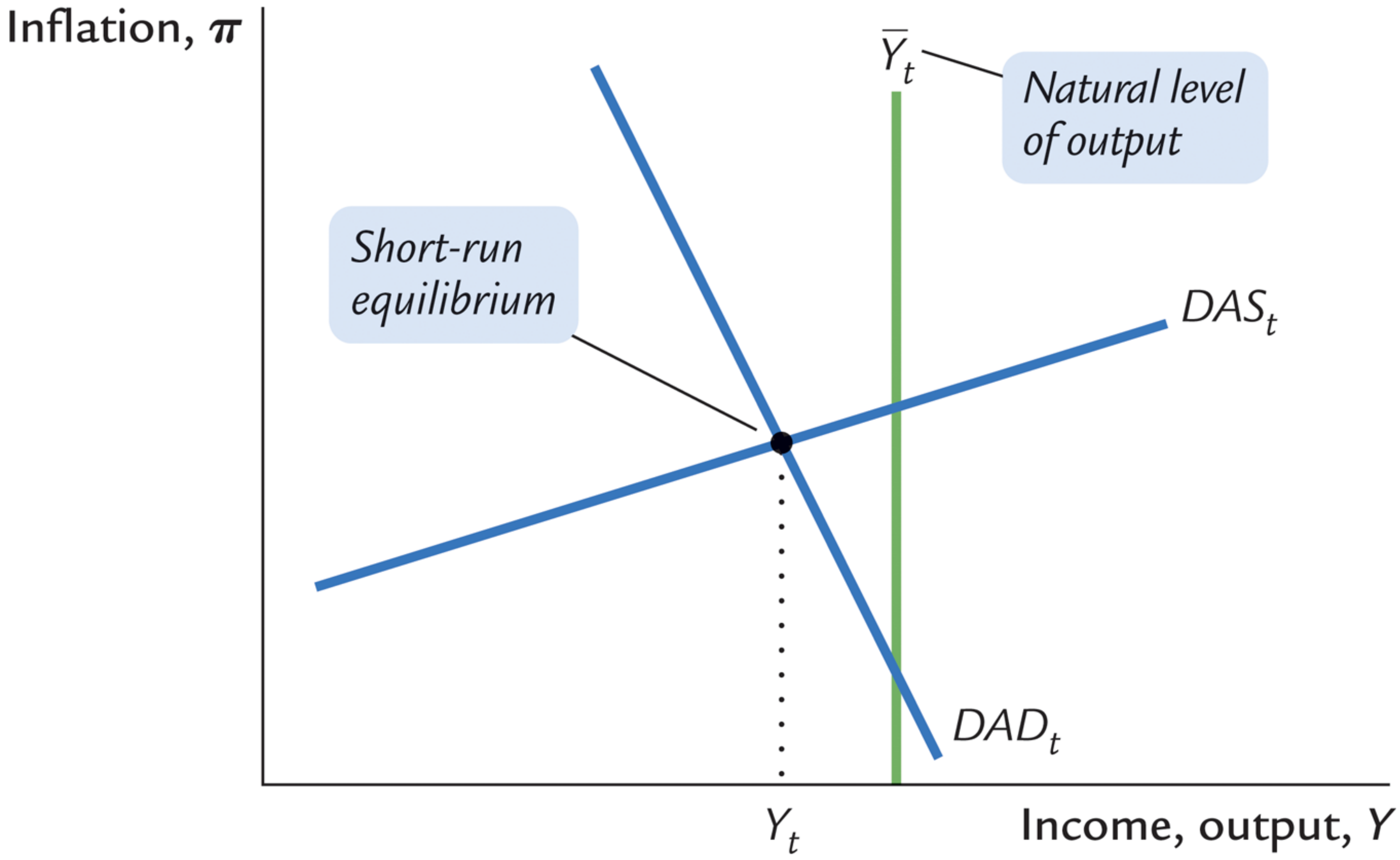
The short-run equilibrium

$$Y_t = \bar{Y}_t - \frac{\alpha\theta_\pi}{1+\alpha\theta_Y}\left(\pi_t - \pi_t^*\right) + \frac{1}{1+\alpha\theta_Y}\,\varepsilon_t \qquad \text{(DAD)}$$

$$\pi_t - \pi_{t-1} + \phi\left(Y_t - \bar{Y}_t\right) + \nu_t \qquad \text{(DAS)}$$

- Together the two curves determine the two endogenous variables Y_t and π_t.
- Exogenous variables: $\bar{Y}_t$, π_t^*, ν_t, ε_t
- Predetermined variable: π_{t-1}
- A change in an exogenous or predetermined variable has an immediate (short-run) impact on π_t and Y_t
- But since π_t affects the equilibrium in the next period etc., a whole dynamic process of change is set in motion (via the Phillips curve).

Figure 15-4: The short-run equilibrium



<u>Figure 15-5: An increase in the natural level of output</u>

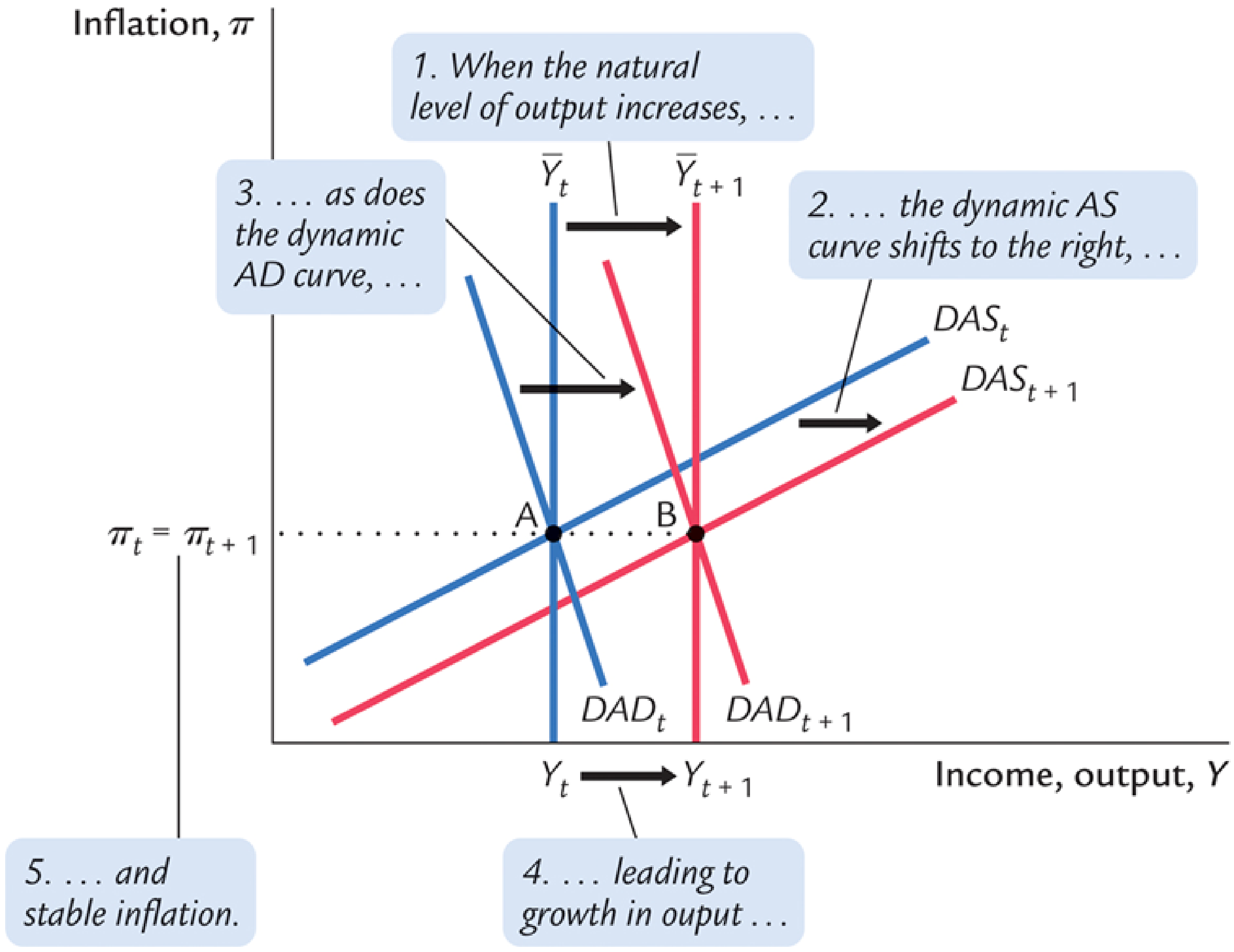
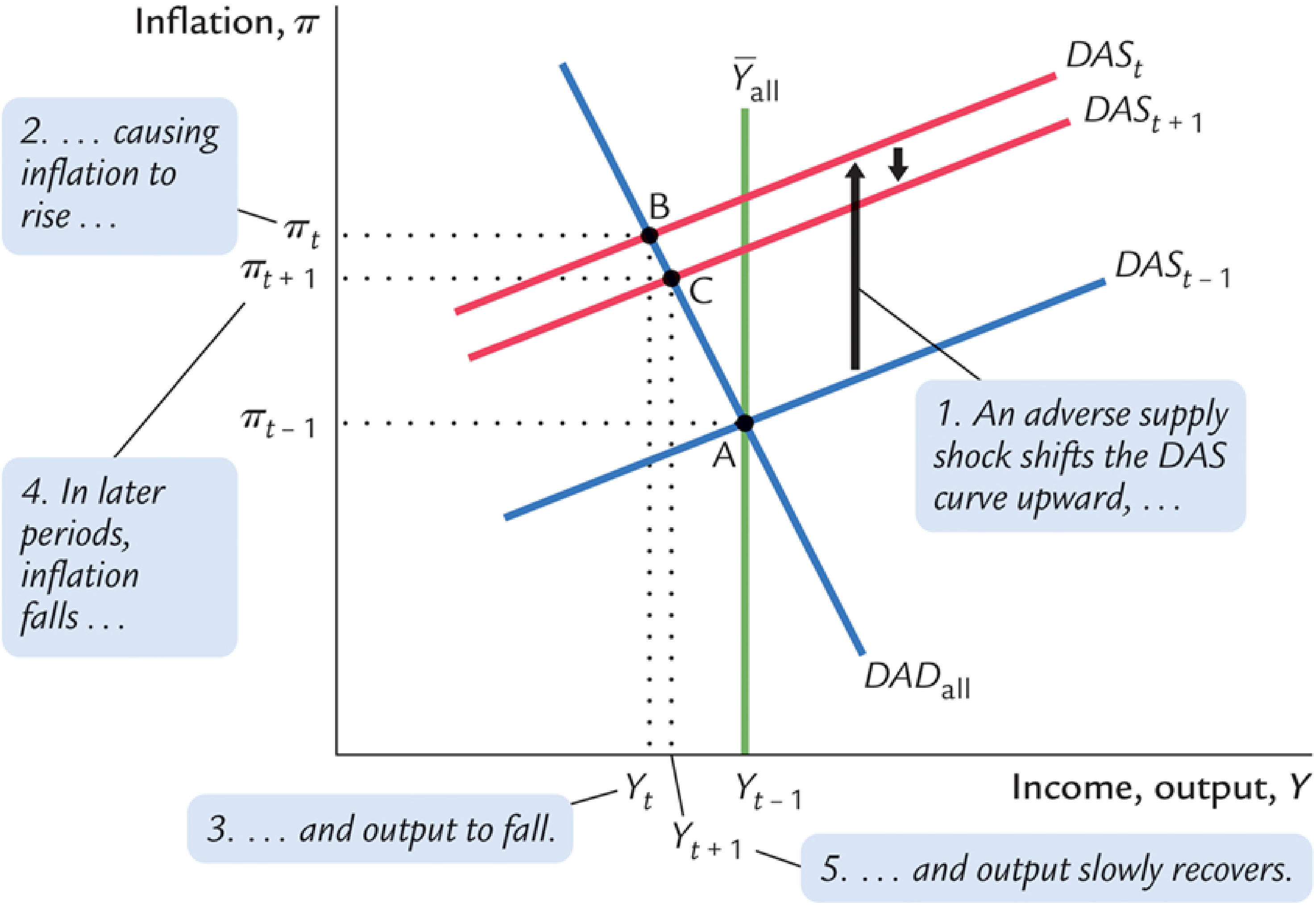


Figure 15-6: A supply shock



Numerical calibration

$\overline{Y}_t = 100$

$\pi_t^* = 2.0$

$\alpha = 1.0$

$\rho = 2.0$

$\phi = 0.25$

$\theta_\pi = 0.5$

$\theta_Y = 0.5$

Figure 15-7: The dynamic response to a supply shock

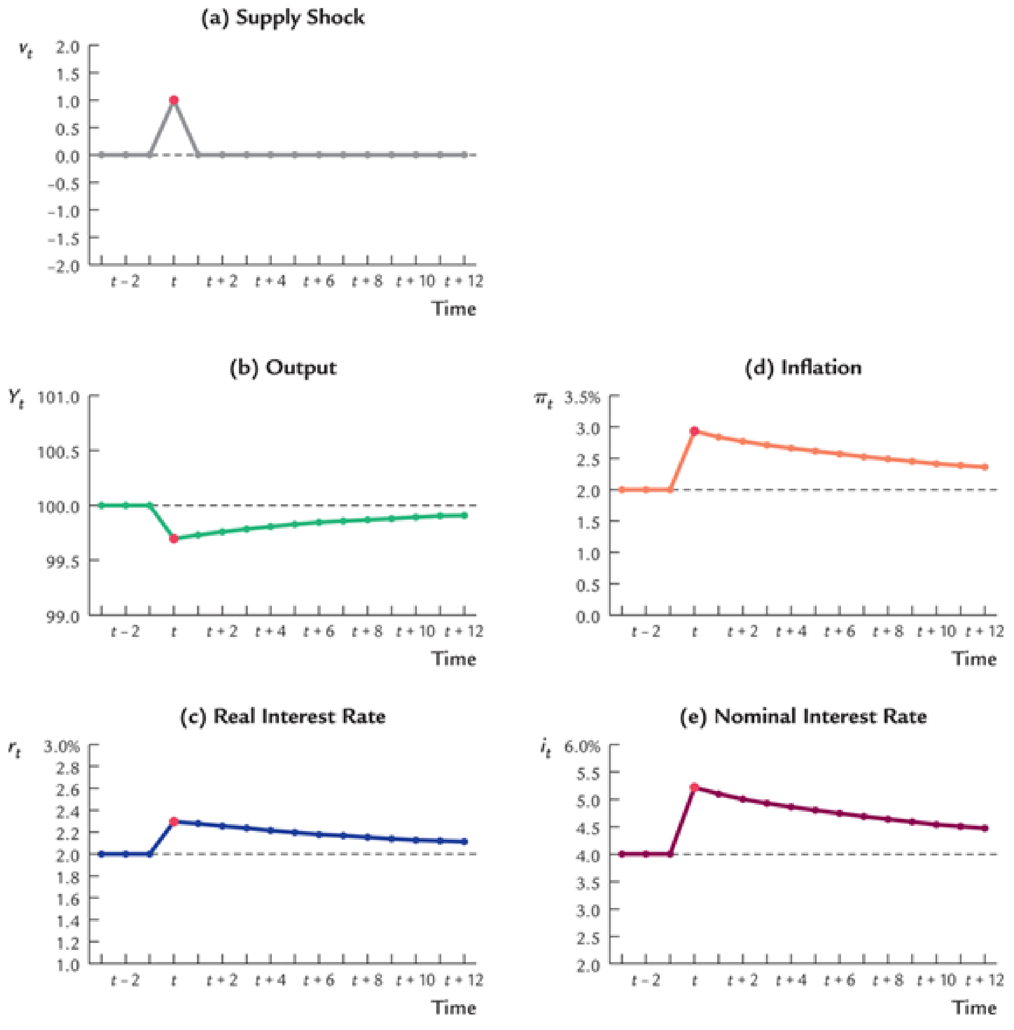


Figure 15-8: A demand shock

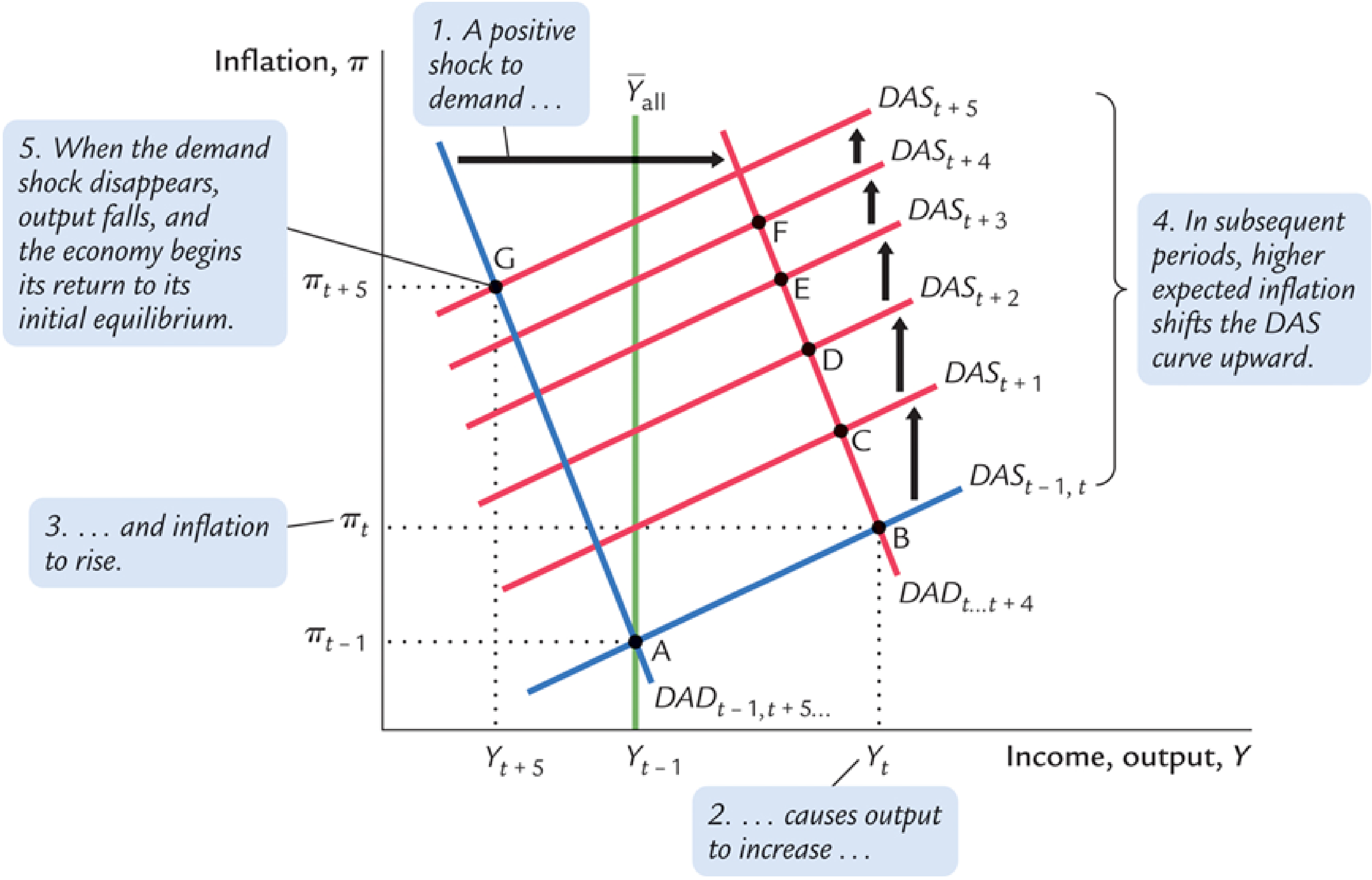
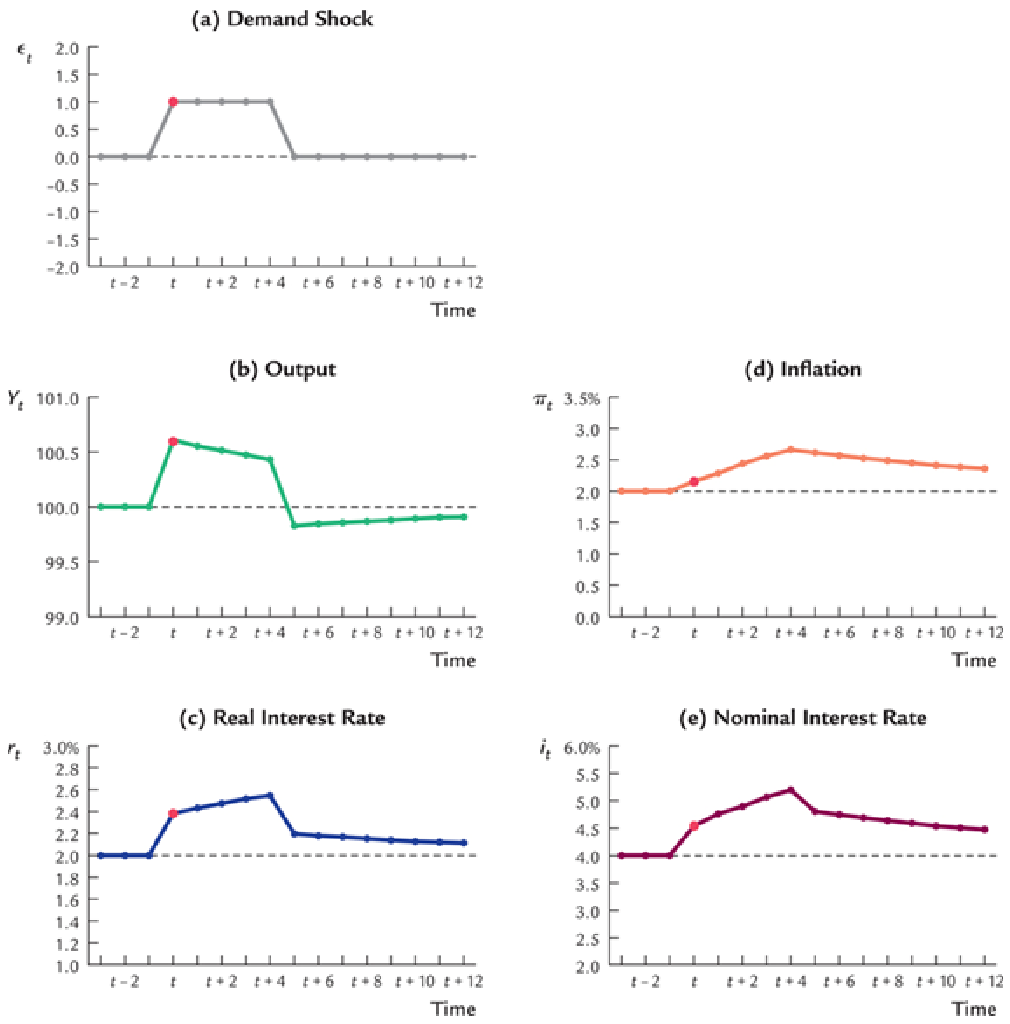


Figure 15-9: The dynamic response to a demand shock



<u>The trade-off between output variability and inflation variability</u>

- **In the case of supply shocks, the central bank faces a trade-off between output variability and inflation variability.**
- **The more the central bank stabilises output, the more variable is inflation and vice versa.**

$$Y_t = \bar{Y}_t - \frac{\alpha\theta_\pi}{1+\alpha\theta_Y}(\pi_t - \pi_t^*) + \frac{1}{1+\alpha\theta_Y}\varepsilon_t$$

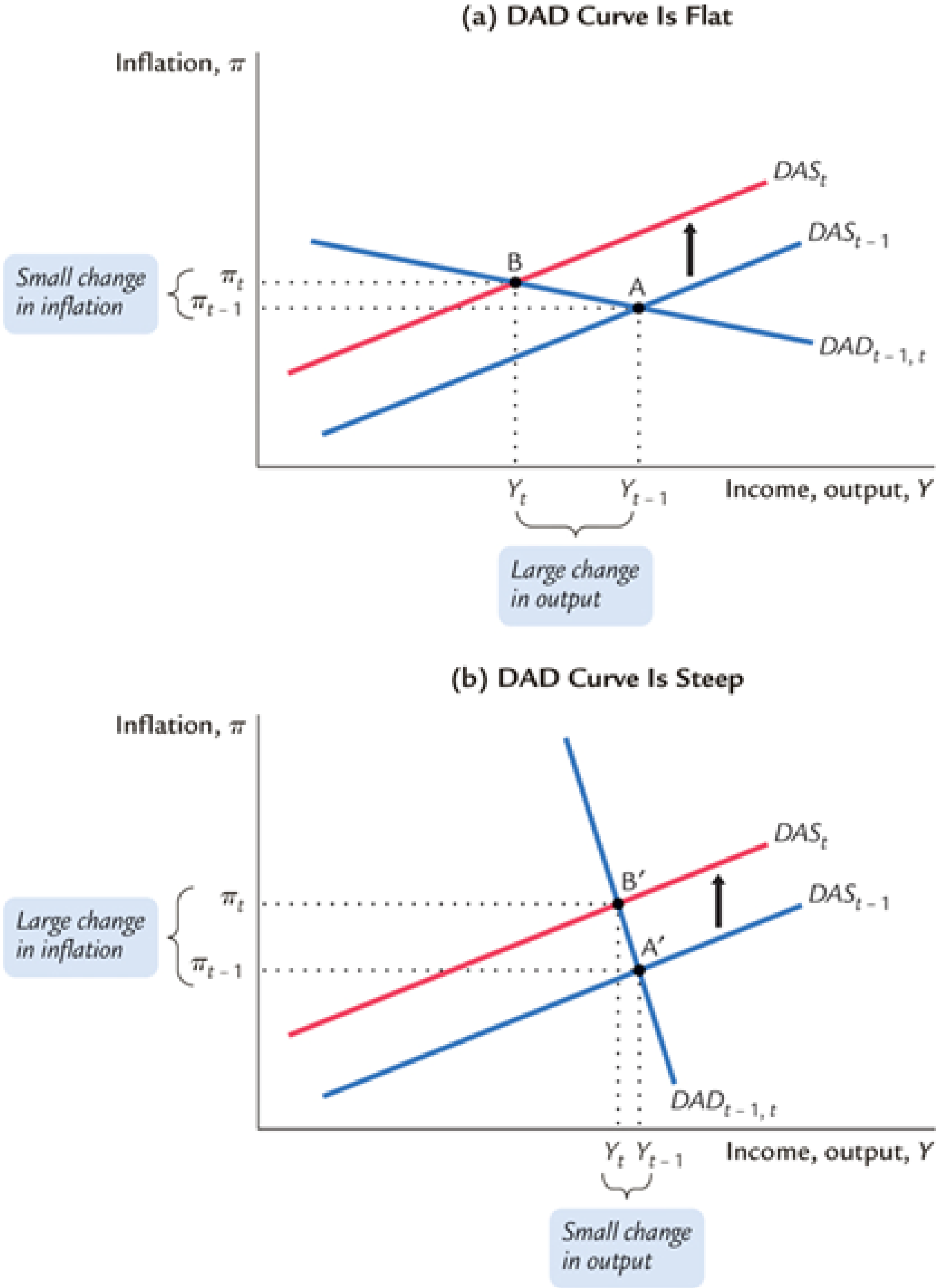
$$\frac{dY_t}{d\pi_t} = -\frac{\alpha\theta_\pi}{1+\alpha\theta_Y}$$

$$\frac{d\pi_t}{dY_t} = -\frac{1+\alpha\theta_Y}{\alpha\theta_\pi}$$

Central bank focusing on stable inflation (high θ_π, low θ_Y): flat DAD curve

Central bank focusing on stable output (high θ_Y, low θ_π): steep DAD curve

Figure 15-12: Two possible responses to a supply shock



The Taylor rule again

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_y(Y_t - \bar{Y}_t)$$

If $\theta_\pi > 0$, r_t rises when π_t rises.

$$Y_t = \bar{Y}_t - [\alpha\theta_\pi/(1+\alpha\theta_Y)](\pi_t - \pi_t^*) + [1/(1+\alpha\theta_Y)]\varepsilon_t$$

$$\frac{dY_t}{d\pi_t} = -\frac{\alpha\theta_\pi}{1+\alpha\theta_Y}$$

$$\frac{d\pi_t}{dY_t} = -\frac{1+\alpha\theta_Y}{\alpha\theta_\pi} < 0$$

$$\theta_\pi < 0 \Rightarrow \frac{d\pi_t}{dY_t} > 0$$

- **If the nominal interest rate rises by less than inflation, the real interest rate falls with inflation.**
- **Then the DAD curve is positively sloped.**
- **A temporary inflationary supply shock will then cause inflation to spiral out of control.**

Figure 15-13: The importance of the Taylor principle