Lecture 10. From the Short to the Medium Run: The *IS-LM-PC* Model

Reading: Blanchard, Chapters 9, 13-1 and 13-2.

In the previous lecture…

- Goods (and services) Market + Financial Markets + Labor Market

	Keynesian cross	Money market	PS and WS
	↓	↓	↓
• (Y, r)	IS	LM	↓
• (u, π)			PC
			↓
• (Y, π)			PC (relation)

- We introduce price, wage, (un)employment, and production to our framework.

Various versions of the Phillips Curve

	Unemployment: u_t	Unemployment Gap: $u_t - u_n$
Benchmark	$\pi_t - \pi_t^e = (m + z) - \alpha u_t$	$\boldsymbol{\pi_t - \pi_t^e = -\alpha(u_t - u_n)}$
$\pi_t^e = \bar{\pi}$	$\pi_t = (\bar{\pi} + m + z) - \alpha u_t$	$\pi_t = \bar{\pi} - \alpha(u_t - u_n)$
$\pi_t^e = \pi_{t-1}$	$\Delta\pi_t = (m + z) - \alpha u_t$	$\Delta\pi_t = -\alpha(u_t - u_n)$

- $u_n = \frac{m+z}{\alpha}$

Outline

- Derivation
  - The Phillips curve (PC) relation (the labor market)
  - The IS-LM-PC model in the short/medium run

- Applications
  - The Zero Lower Bound and Deflation Spirals
  - Monetary policies
  - Fiscal policies
  - An increase in the oil price
  - Productivity shocks

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Derivation of the Phillips curve relation

- Goal: Write the Phillips curve in terms of and .
- The Phillips curve: $\pi_t - \pi_t^e = -\alpha(u_t - u_n)$

- Production function: $Y = \mathcal{A}N$
- $\Rightarrow \quad Y = \mathcal{A}L(1-u).$
- We define…

  The natural level of employment: $N_n = L(1-u_n)$

  The natural level of output: $Y_n = \mathcal{A}N_n = \mathcal{A}L(1-u_n)$

  or the potential output

Derivation of the Phillips curve relation, continued

- The Phillips curve: $\pi_t - \pi_t^e = -\alpha(u_t - u_n)$

- $u = \frac{U}{L} = \frac{L-N}{L} = 1 - \frac{N}{L} = 1 - \frac{1}{\mathcal{A}}\frac{Y}{L}$
- $\underbrace{u_t - u_n} = \left(1 - \frac{1}{\mathcal{A}}\frac{}{L}\right) - \left(1 - \frac{1}{\mathcal{A}}\frac{}{L}\right) = -\frac{1}{\mathcal{A}L}\underbrace{(Y_t - Y_n)}$

- The PC Relation:

The PC Relation: $\pi_t - \pi_t^e = \frac{\alpha}{\mathcal{A}L}(Y_t - Y_n)$

- Interpretation
- $Y \uparrow$ $\rightarrow$ To produce more, more workers should be hired: N

  $\rightarrow u = \frac{L-N}{L}$ $\rightarrow$ Workers' bargaining power

  $\rightarrow W$ $\rightarrow$ Marginal costs of production

  $\rightarrow$ Firms set prices: P

  $\rightarrow$ Given $P_{t-1} = P(-1)$,

  this leads to a inflation than expected: $\pi - \pi^e$

$\therefore$ The PC is upward sloping in the $(Y, \pi - \pi^e)$ plane.

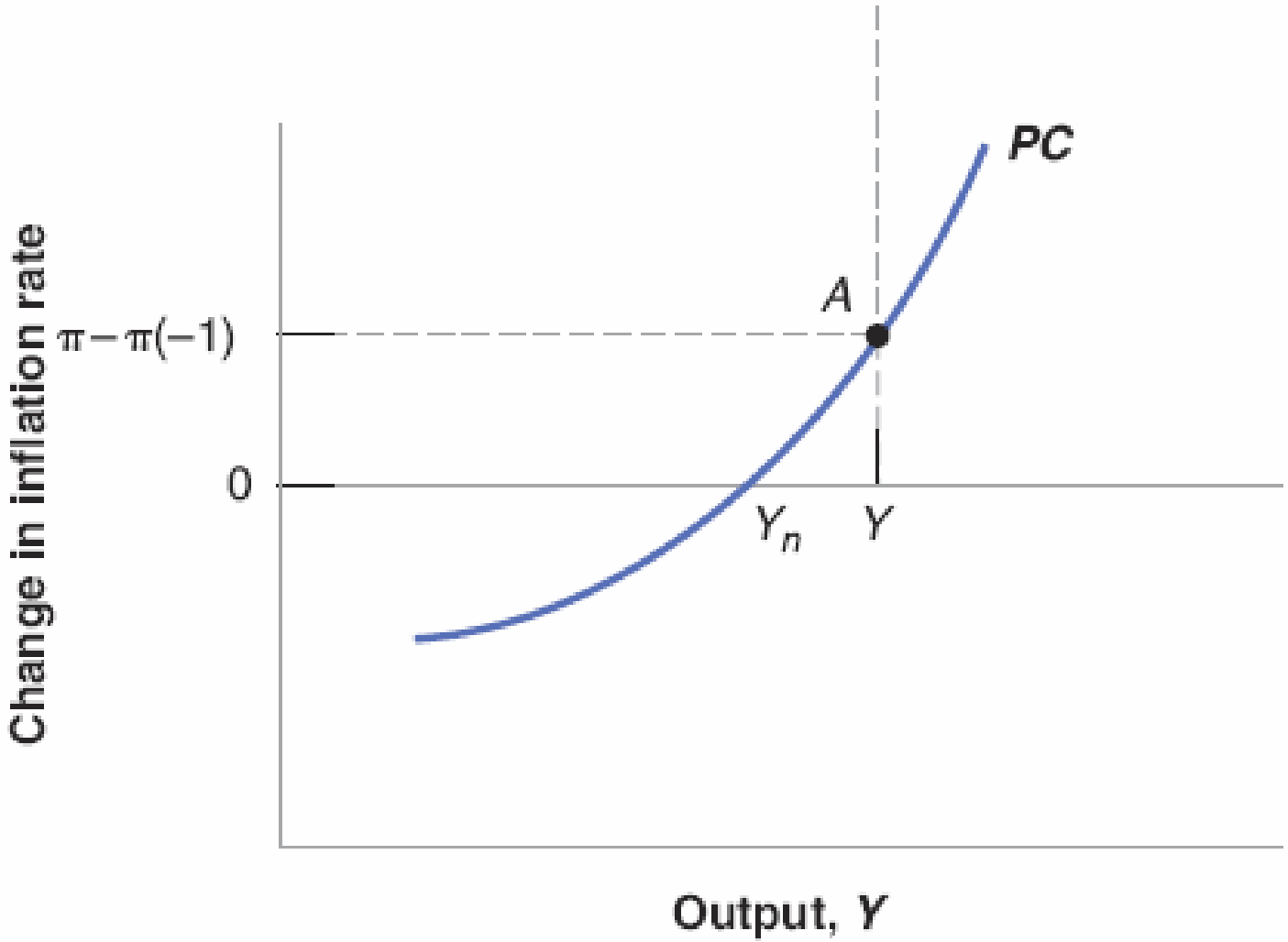
- We know that

$$\text{Output gap} = 0 \quad \Leftrightarrow \quad Y = Y_n \quad \Leftrightarrow \quad N = N_n$$

$$\Leftrightarrow \quad u = u_n \quad (\text{Unemployment gap} = 0)$$

$$\Leftrightarrow \quad P = P^e \quad \Leftrightarrow \quad \pi = \pi^e \quad \big(\text{given } P(-1)\big).$$

- Therefore, the PC passes through $(Y_n, 0)$ in the $(Y, \pi - \pi^e)$ plane.



- Based on the assumption that $\pi^e = \pi(-1)$.
- PC passes through $(Y_n, 0)$. That is, when $Y = Y_n$, $\pi = \pi(-1)$.
- Point A: $Y > Y_n$ (N N_n and u u_n).

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The IS-LM-PC Model

- IS: $Y = C(Y - T) + I(Y, r + x) + G$
- LM: $r = \bar{r}$
- PC: $\Delta\pi = \pi - \pi(-1) = \frac{\alpha}{\mathcal{A}L}(Y - Y_n)$

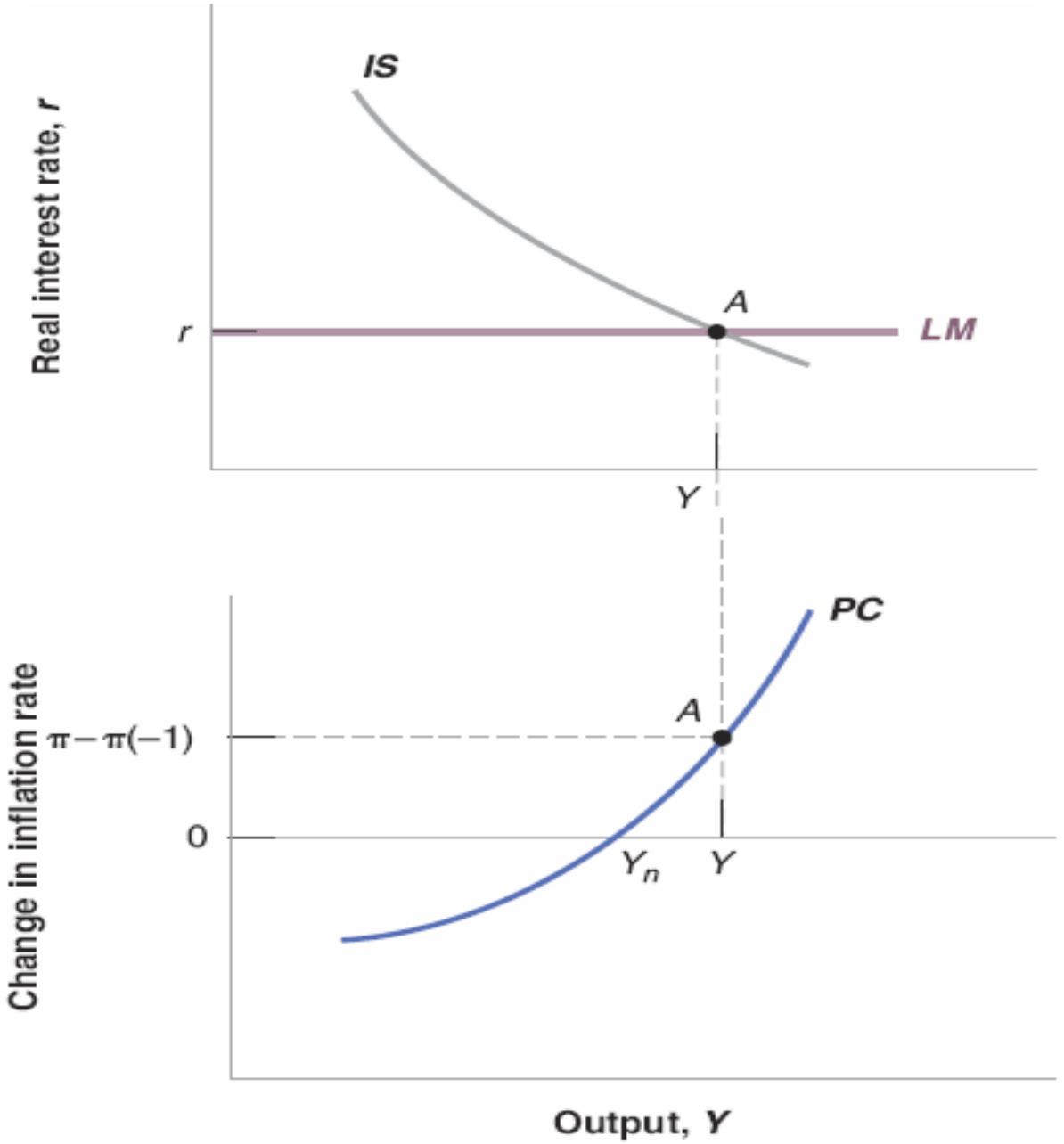
- Figures and analysis in the textbook are based on the accelerationist PC, i.e., $\pi_t^e = \pi_{t-1} = \pi(-1)$.

- The Short Run: the output gap and $\Delta\pi$ need not be 0.
- The Medium Run: $Y = Y_n$, $u = u_n$, and $\pi = \pi^e = \pi(-1)$.

The Short Run

- IS: $Y = C(Y - T) + I(Y, r + x) + G$
- LM: $r = \bar{r}$
- PC: $\Delta\pi = \pi - \pi(-1) = \frac{\alpha}{\mathcal{A}L}(Y - Y_n)$

- The LM relation (or the CB) determines r.
- Given the fiscal policy (G and T) and the risk premium (x), the IS relation pins down Y.
- Then, the PC relation determines π, given $\pi(-1)$.
- In this case, Y_A Y_n, u_A u_n, π $\pi^e = \pi(-1)$.

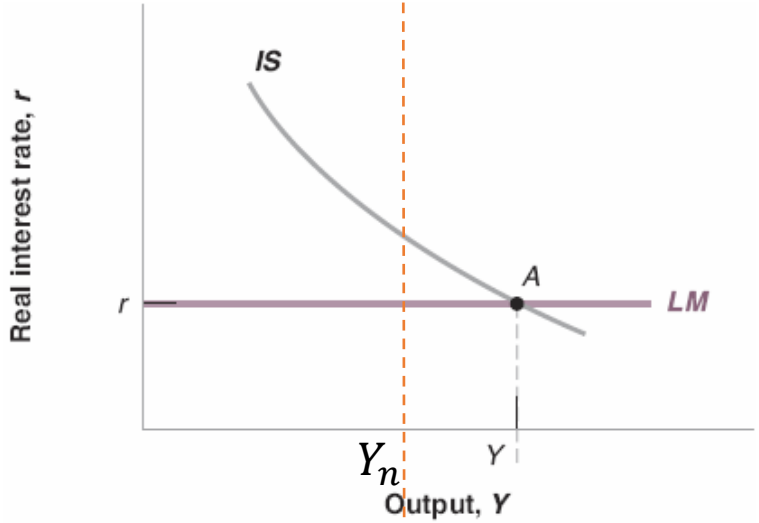


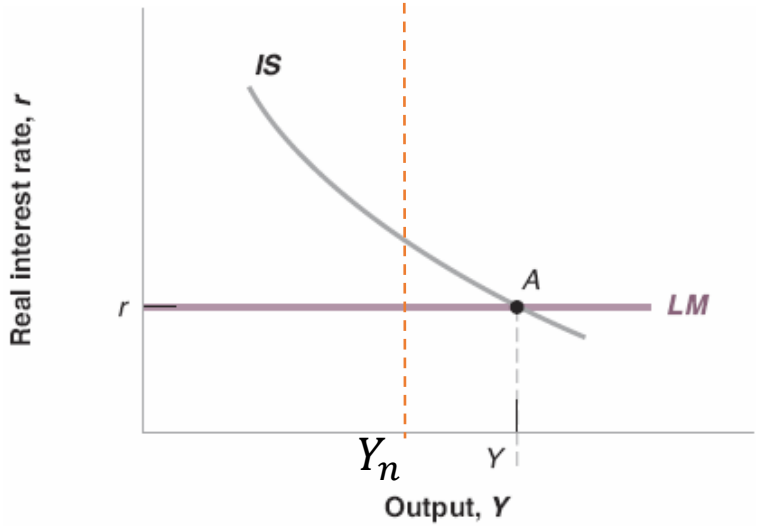
From the short to the medium run

- In theory, there are two possible approaches.

1) Active policy regime:
   The CB adjusts $\bar{r}$ to shift the LM curve until Y becomes Y_n.

2) Active policy regime:
   The government adjusts G and/or T to shift the IS curve until Y becomes Y_n.





From the short to the medium run

- In practice, the CB usually takes the role. Why?

1) The MP has shorter "policy lags" than the FP. It takes some time for the congress to pass a bill for new G and T.
2) The gov't has many other objectives (redistribution, providing public goods, etc.), while the CB can focus on the stabilization policy.

- But when $i \approx 0$ and the CB does not have enough remaining options, FP can be very important for the purpose.
- After the Great Recession and a long-lasting episode of the zero lower bound, people start to pay more attention to the active FP regime.
- In our introductory course, we focus on the active MP regime.

The Medium Run

- The short-run equilibrium: Point A.

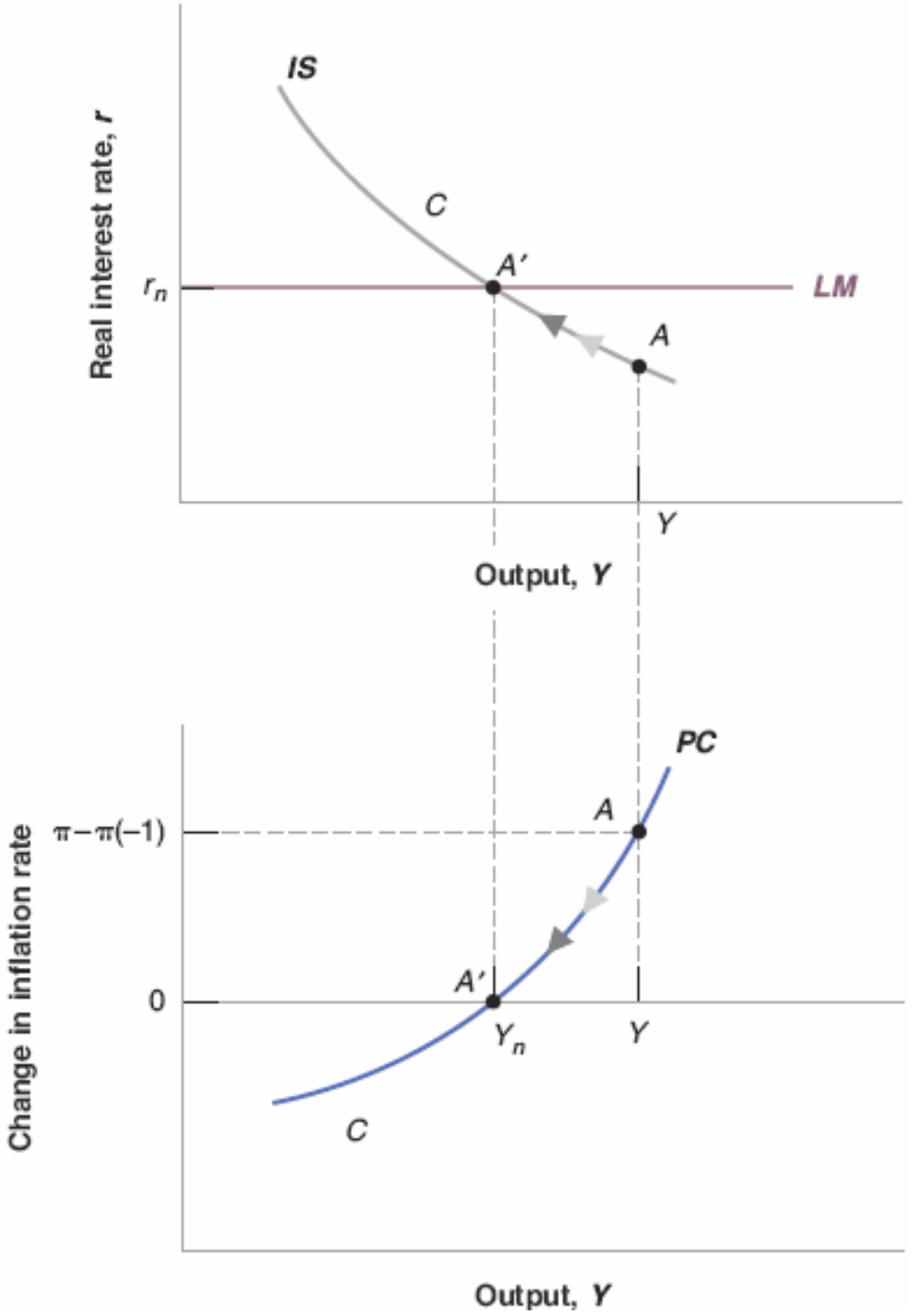
$$Y_A > Y_n, u_A < u_n, \pi_A > \pi(-1).$$

- After realizing that the economy is heated too much, the CB will raise i and r to go to point A'.
- Over time, the economy moves along the IS and PC curves.

- The medium-run equilibrium: Point A'.

$$Y_A, \quad Y_n, \quad u_A, \quad u_n, \quad \pi_A, \quad \pi(-1).$$

- r_n:



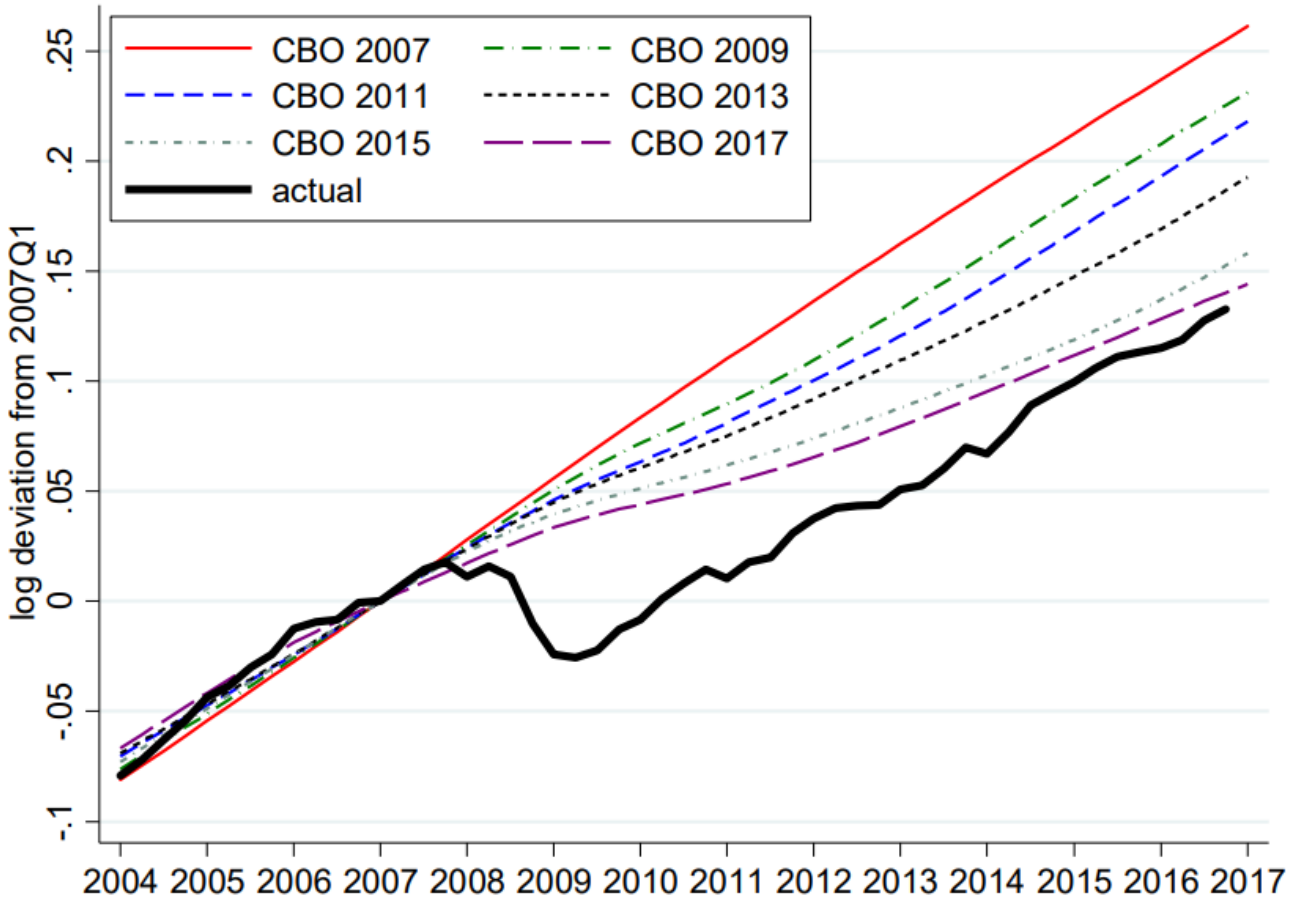
Then, why doesn't the CB change r to r_n right away?

1) Y_n, u_n, and r_n are not directly observable. So, the CB might want to adjust i (and r) slowly and see what happens.

2) It takes time for the economy to react to changes in the monetary policy. Therefore, although the CB changes r to r_n right away, the economy does not move from point A to A' immediately.

Figure 1: Historical Revisions in CBO Estimates of U.S. Potential Output.

Panel A: The Great Recession



- Congressional Budget Office estimates of Y_n, made in different years.
- It may take a long time to have a better guess of the current value of Y_n...
- Source: Coibion, Gorodnichenko and Ulate (2018), The Cyclical Sensitivity in Estimates of Potential Output, *Brookings Papers on Economic Activity,* 343-434.

Policy makers think that gradual changes in i may be beneficial.

- "In their discussion of the relative merits of smaller and more frequent adjustments versus larger and less frequent adjustments …, [FOMC] participants generally agreed that large adjustments had been appropriate when economic activity was declining sharply in response to the financial crisis. In current circumstances, however, **most saw advantages to a more incremental approach that would involve smaller changes … calibrated to incoming data**."
  — Minutes of the FOMC video conference meeting, October 15, 2010.

It takes time for the effect of MP to materialize.

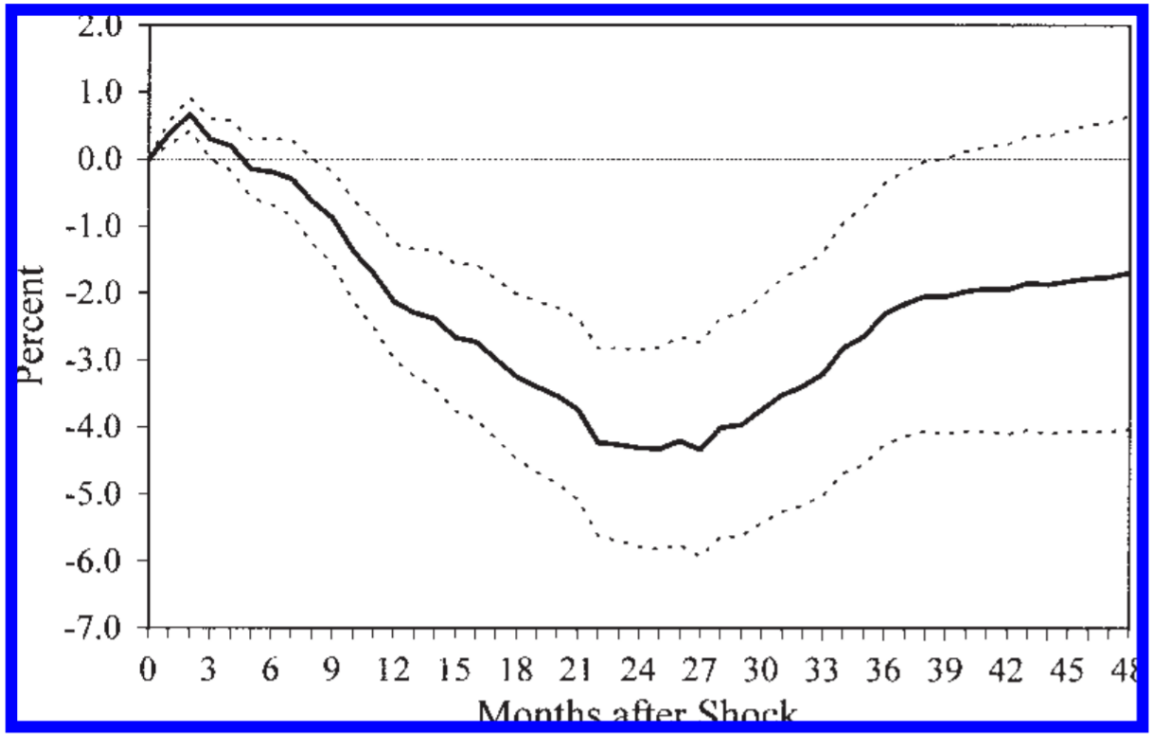


FIGURE 2. THE EFFECT OF MONETARY POLICY ON OUTPUT

- Responses of output to a 100bp increase in the interest rate.
- The "peak" effect occurs after about 2 years.
- The real effects of monetary policy vanishes after 4-5 years.

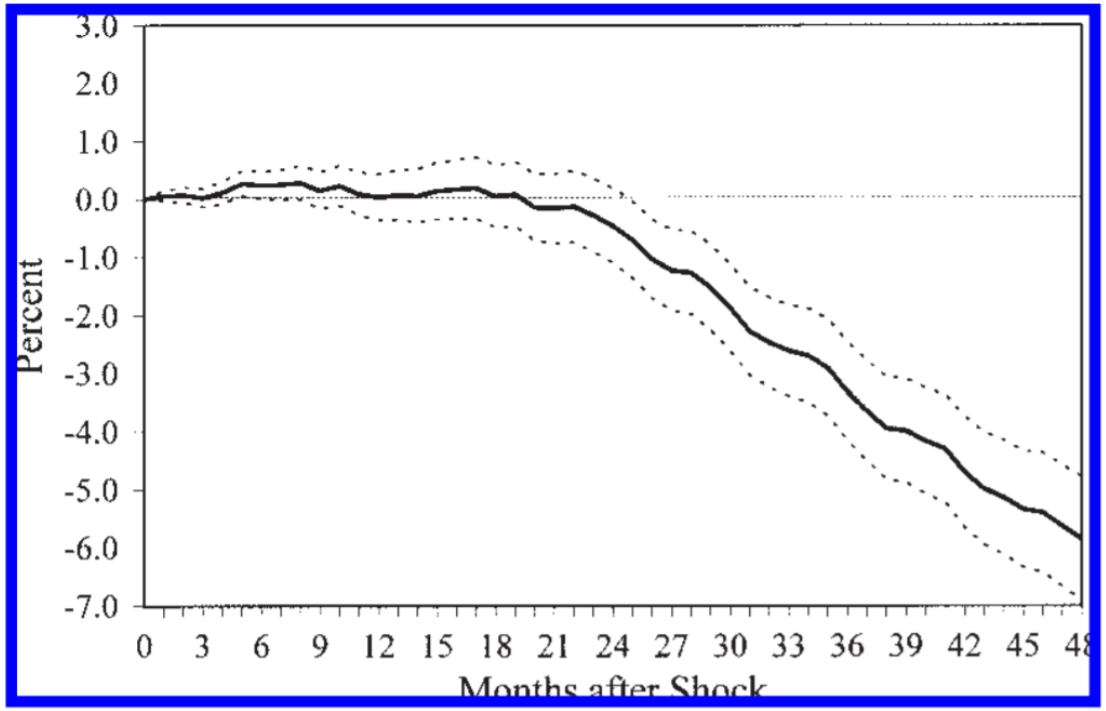


FIGURE 4. THE EFFECT OF MONETARY POLICY ON THE PRICE LEVEL

- Responses of price level to a 100bp increase in the interest rate.
- The price level reacts negatively and very slowly.
- Source: Romer, C. D. and D. H. Romer (2004), A New Measure of Monetary Shocks: Derivation and Implications, *American Economic Review* 94(4), 1055-1084.

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The ZLB and Deflation Spirals

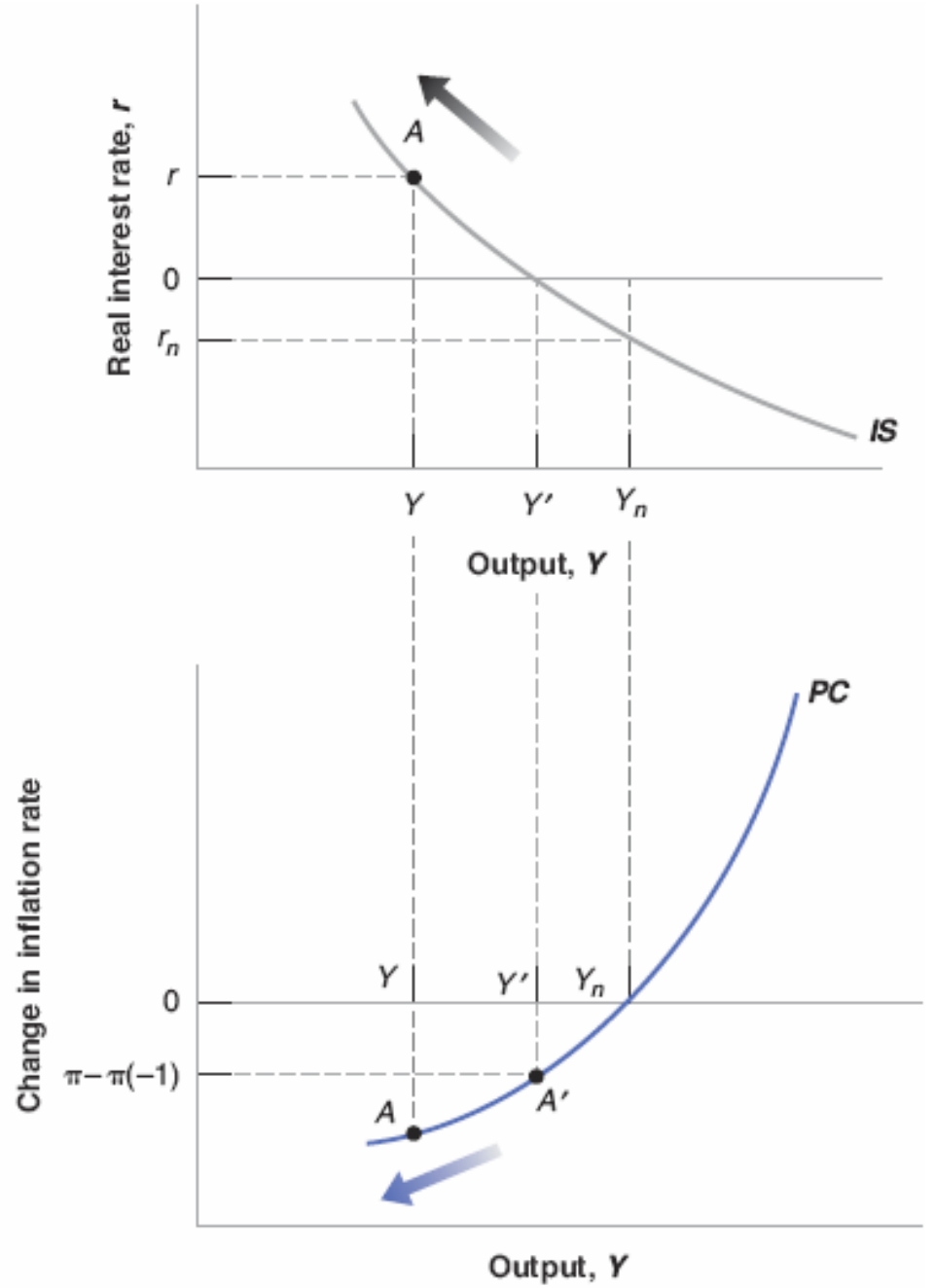
- $r_t = i_t - \pi_t^e = i_t - \pi_{t-1}$
- (ZLB) $i_t \geq 0$

- Suppose that the economy is in a recession (point A) and i is already zero.

  $\Rightarrow r_t = -\pi_t^e = -\pi_{t-1}$
- $Y_A \quad Y_n \quad \rightarrow \quad \Delta\pi_t \quad 0 \quad \rightarrow \quad \pi_t \quad \pi_{t-1}$

  $\rightarrow \quad -\pi_t \quad -\pi_{t-1}$

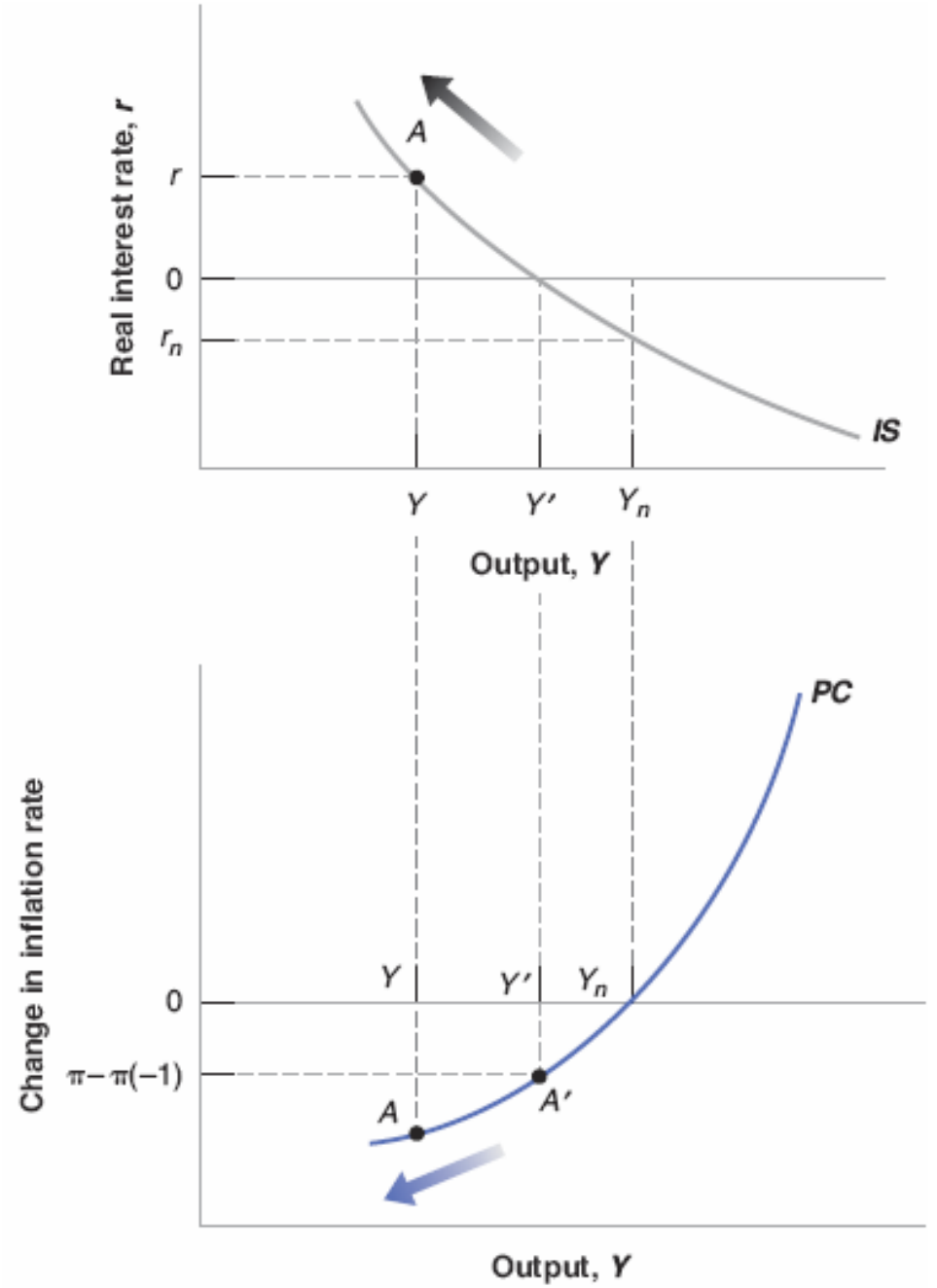
  $\rightarrow \quad r_{t+1} = -\pi_t > -\pi_{t-1} = r_t$
- $r \uparrow$ over time.

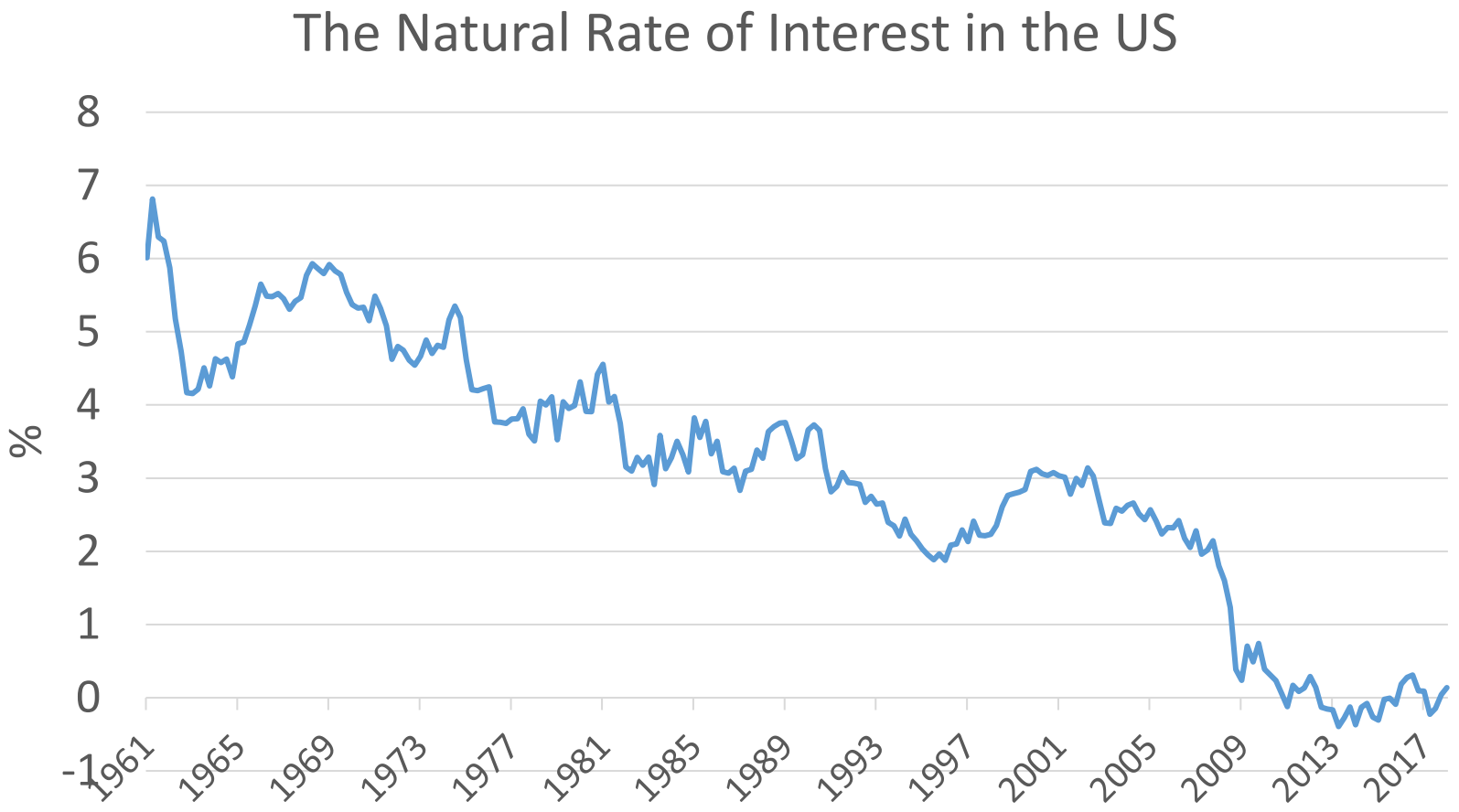


The ZLB and Deflation Spirals

- $r \uparrow$ over time. $\Rightarrow$ The economy moves further away from Y_n along the IS and PC curves.

- A fiscal intervention that shifts the IS curve to the right can help the economy to circumvent the deflation spirals.
- Or, the CB may try to make the inflation expectation anchored, i.e., $\pi^e = \bar{\pi}$. In this case, $\pi_A - \bar{\pi} < 0$, and it does not necessarily lead to $\pi_t \downarrow$ and $r_t \uparrow$ over time.





- r_n has been declining in the US (and in other advanced countries).
- Remember that $i = r + \pi^e$. As $r_n \downarrow$, and the CB tries to maintain low and stable inflation, the ZLB might be binding more frequently.
- This is why we care about the ZLB, deflation spirals, and unconventional MP (Ch. 23-4).

- Source: Laubach, T. and J. Williams (2003). Measuring the Natural Rate of Interest. *Review of Economics and Statistics* 85(4): 1063-1070.

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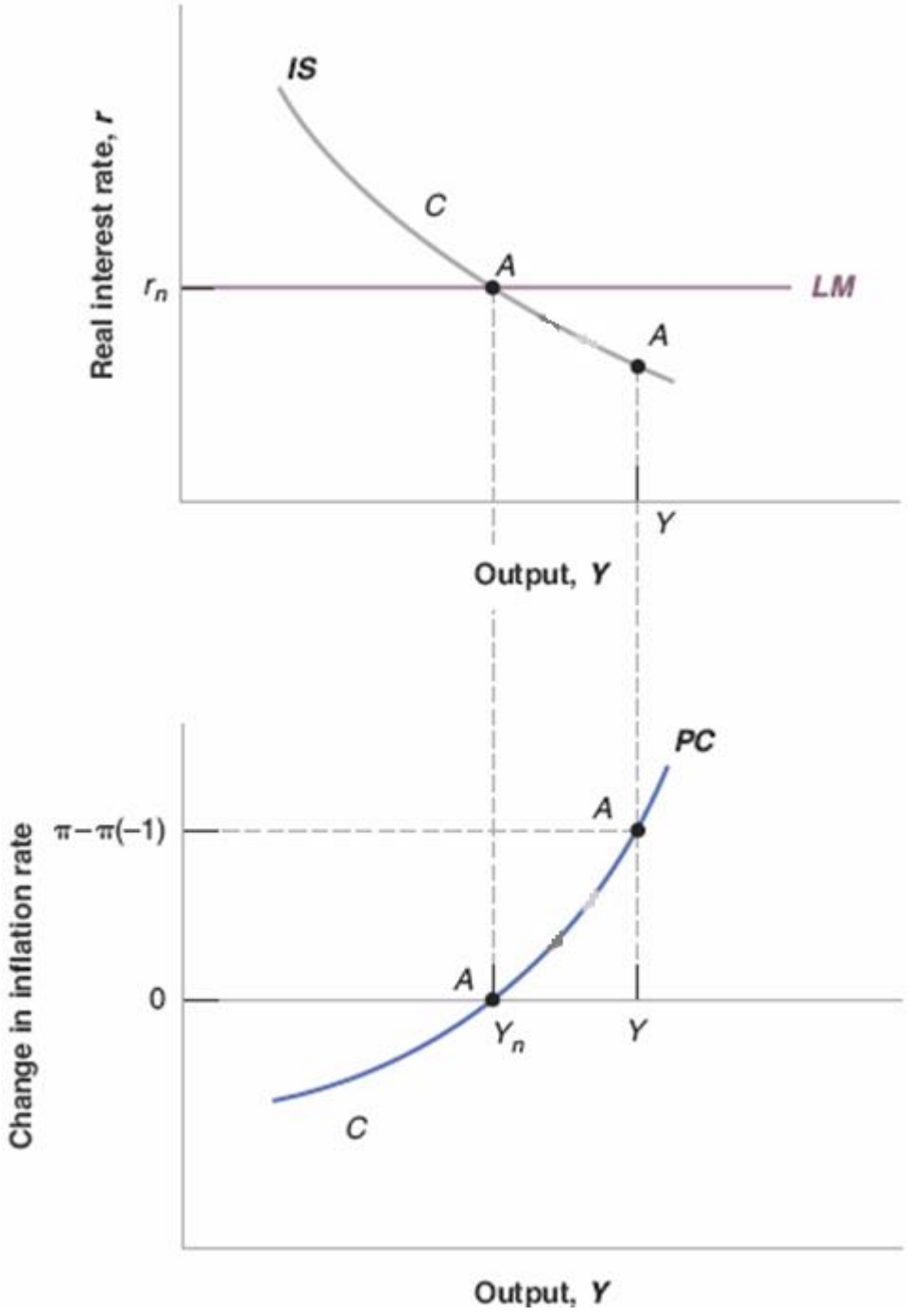
A Monetary Expansion

- Assume that $Y = Y_n$ initially (Point A)
- What happens if the CB lowers r from r_n to r_A,?

- In the short run, the LM curve . Point A' becomes the short-run equilibrium.
- Overtime, the CB observes inflationary pressure ($\Delta\pi$ 0). So, it raises i (and r).
- This process continues until the LM returns to the original level.
- The medium-run equilibrium is represented by point A''=A.



In the short run (A vs. A')

- Y increases.
- i and r decrease.
- How about the following variables?
  - C
  - I
  - G
  - $G - T$
  - u
  - W/P
  - π

In the medium run (A vs. A’’)

- Y and r do not change.
- How about the following variables?
  - C
  - I
  - G
  - $G - T$
  - u
  - W/P
  - π
  - i

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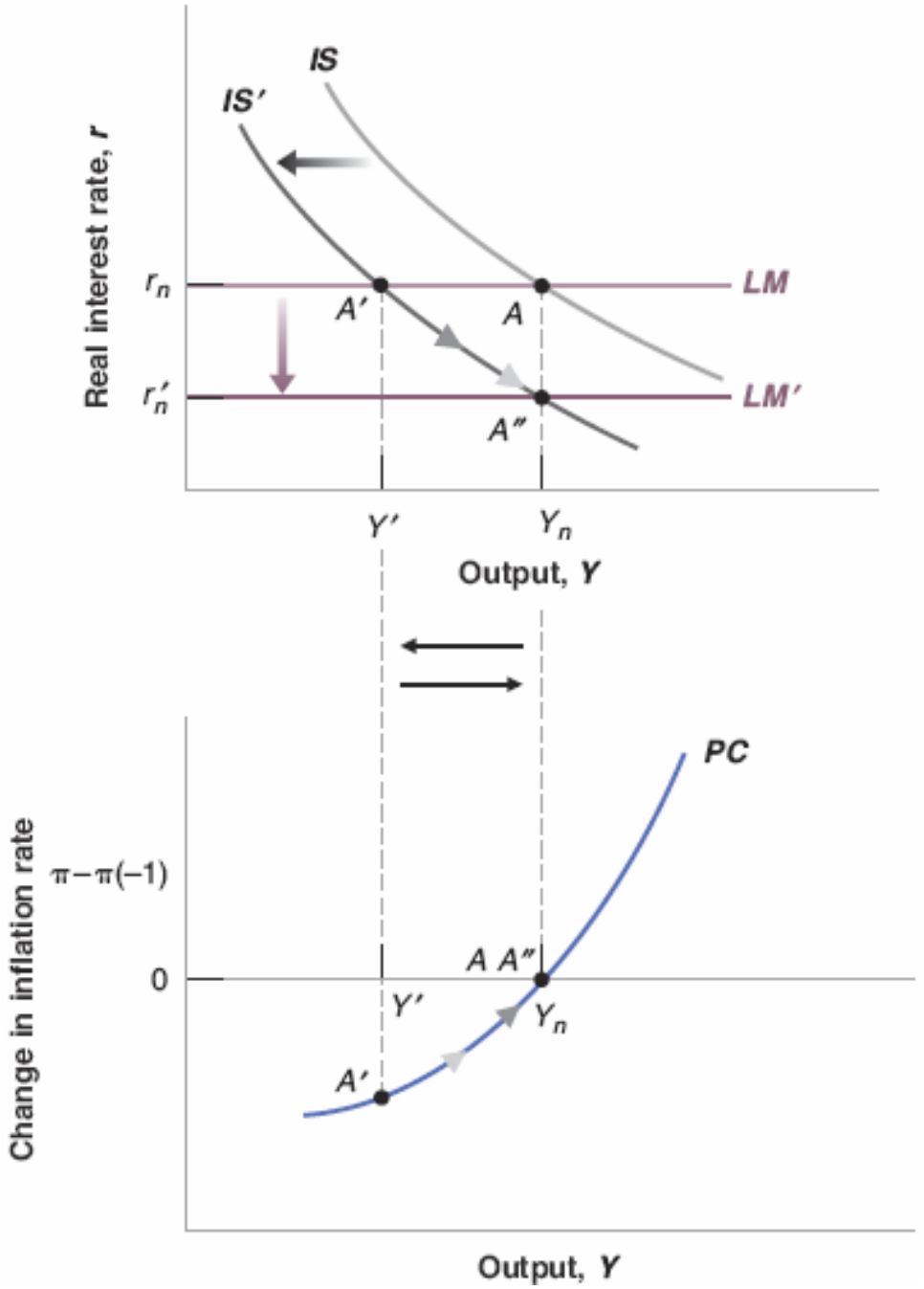
A Fiscal Consolidation

- Assume that $Y = Y_n$ initially (Point A)
- What happens if the government increases T to reduce its debt?

- In the short run, the IS curve . Point A' becomes the short-run equilibrium.
- Overtime, the CB observes that π decreases ($\Delta\pi$ 0). So, it lowers i (and r).
- This process continues until the LM curve shifts to the LM'.
- The medium-run equilibrium is represented by point A''.



In the short run (A vs. A’)

- Y decreases.
- r does not change.
- How about the following variables?
  - C
  - I
  - G
  - $G - T$
  - u
  - W/P
  - π
  - i

In the medium run (A vs. A’’)

- Y does not change.
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- How about the following variables?
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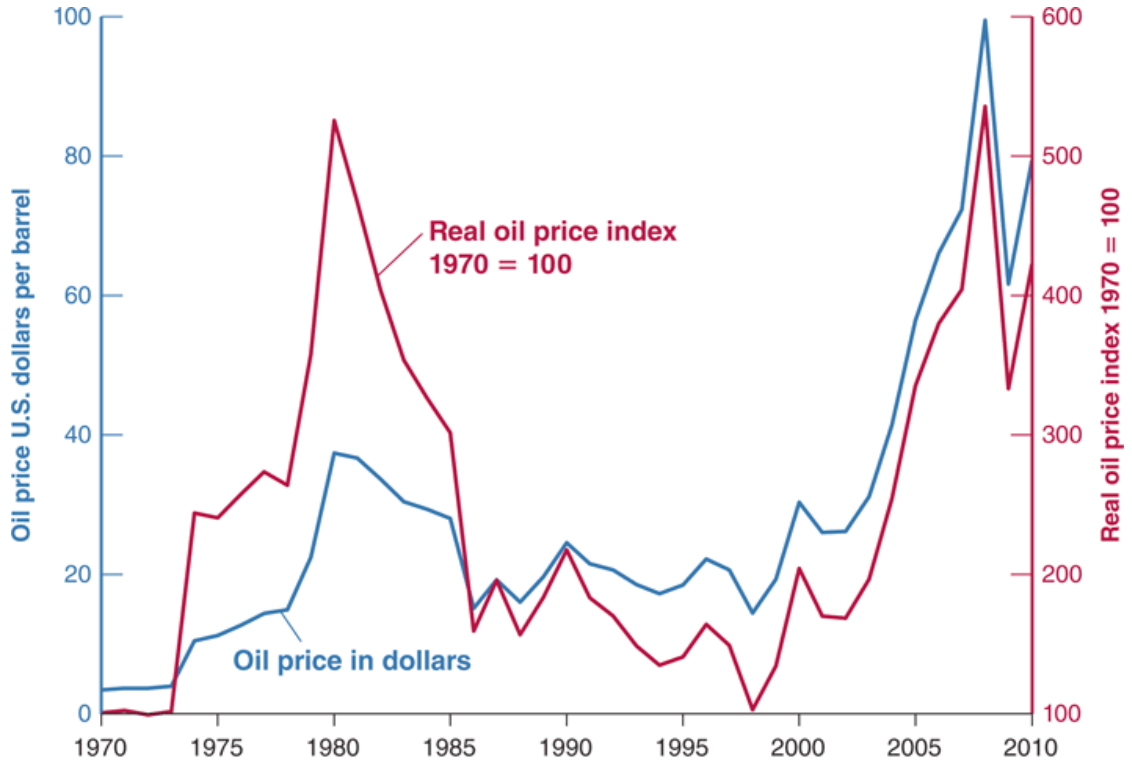
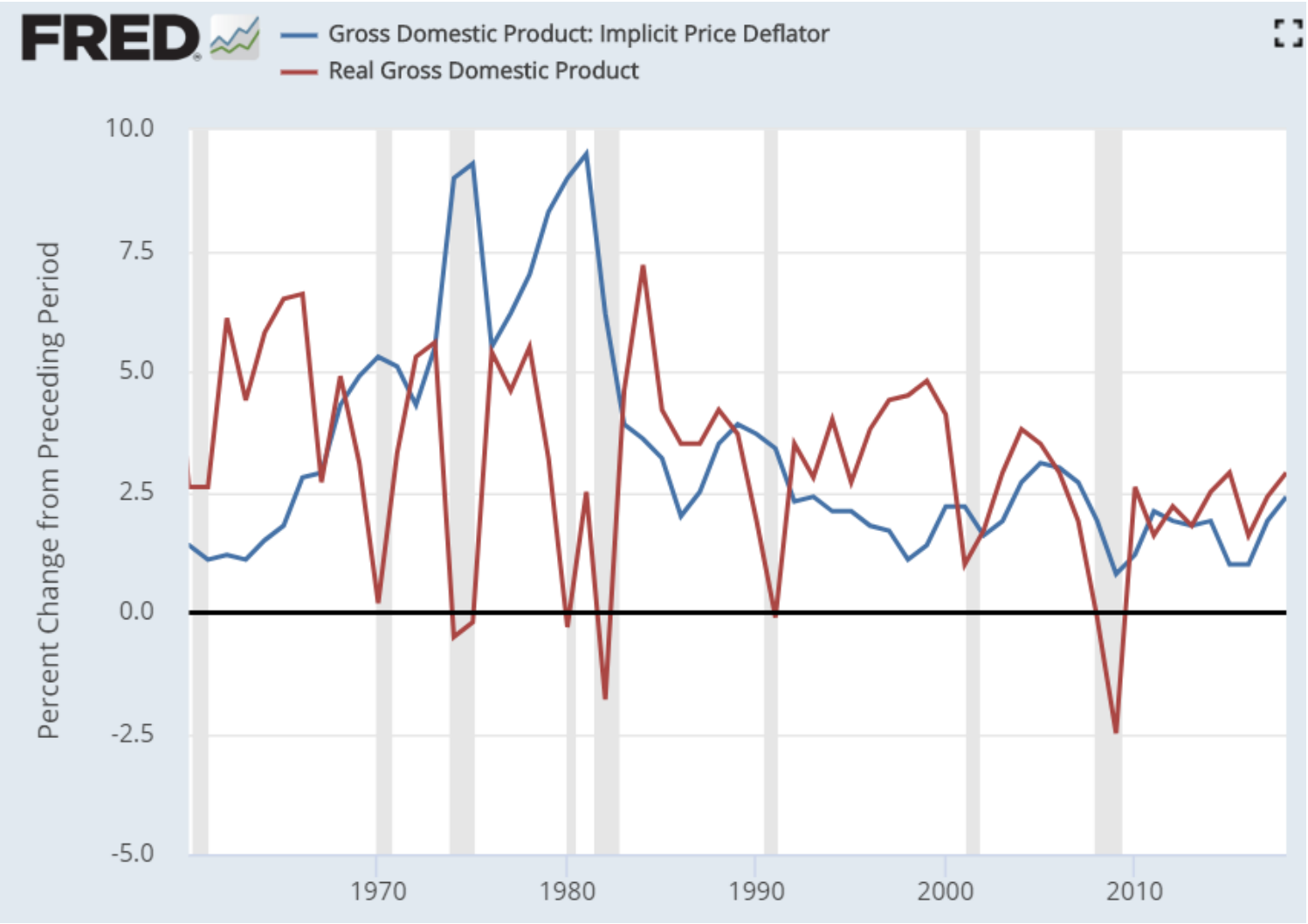
Oil price index

- Two spikes in the 1970s
- The OPEC (the Organization of Petroleum Exporting Countries), a cartel of oil producers, acted as a monopoly and increased prices by reducing the supply of oil at that time.



Source: Series OILPRICE, CPIAUSCL Federal Reserve Economic Data (FRED) http://research.stlouisfed.org/fred2/. The value of the index is set equal to 100 in 1970.)



- Inflation rate based on the GDP deflator (blue) and growth rate of real GDP (red)
- Some people associate the recession in the 70s (stagflation = low output and high inflation) with the rise in oil prices.

- Price setting rule: $P = (1 + m)\, MC$, where $MC = W/\mathcal{A}$.
- An increase in the oil price will raise the marginal costs of production (MC) in the real world.
- But we assumed that $Y = \mathcal{A}N$; therefore $MC = W/\mathcal{A}$, which is not a function of the oil price.
- Thus, we instead raise the markup (m) to capture the increase in the oil price and its effects on the other parts of the economy.

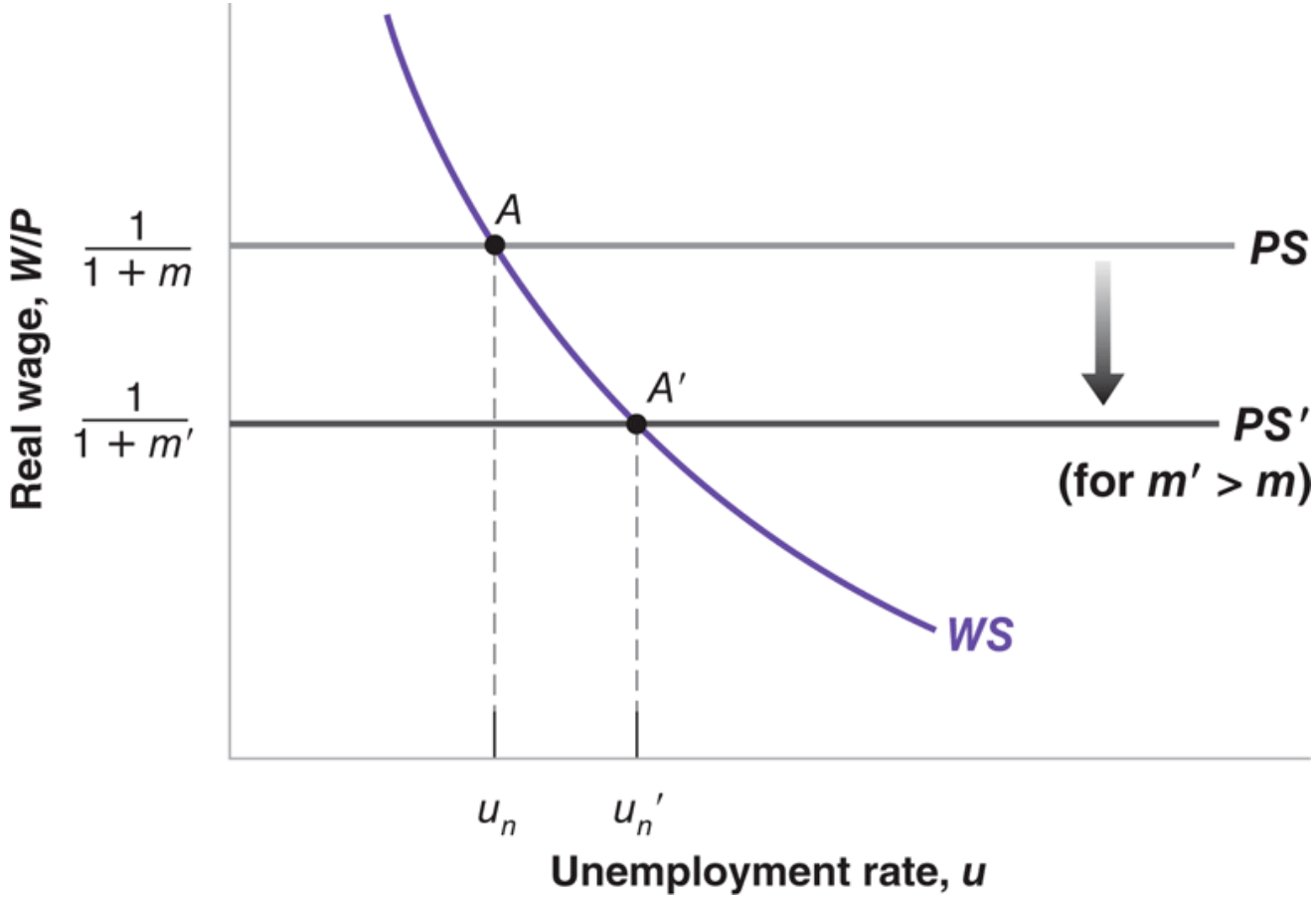
Markup shocks, u_n, and Y_n

- $m \uparrow \rightarrow$ PS shifts downward

$\rightarrow$ The natural rate of unemployment increases from u_n to u_n'.

$\rightarrow$ The natural level of output decreases from Y_n to $Y_n{}'$.

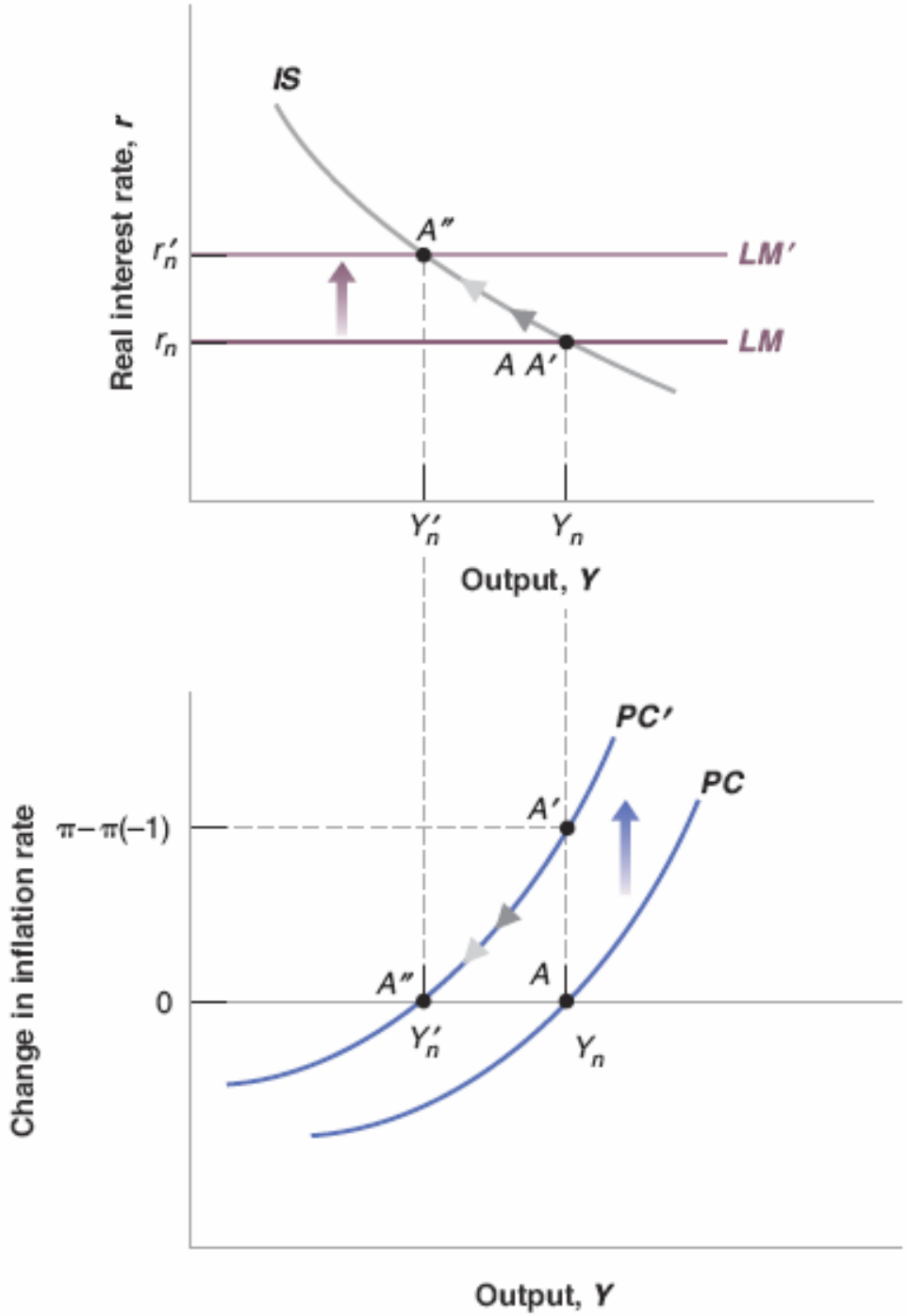
- Hiring less workers and producing less output becomes the medium-run equilibrium.



A Rise in the Oil Price

- Assume that $Y = Y_n$ initially (Point A)
- What happens if $m \uparrow$ (or, the oil price ↑)?

- In the short run, the PC curve as Y_n to Y_n'. Point A' becomes the short-run equilibrium without changes in MP and FP.
- Overtime, the CB observes that π increases ($\Delta\pi$ 0). So, it i (and r).
- This process continues until the LM curve shifts to the LM'.
- The medium-run equilibrium is represented by point A''.



In the short run (A vs. A')

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- How about the following variables?
  - C
  - I
  - G
  - $G - T$
  - u
  - W/P
  - π
  - i

In the medium run (A vs. A’’)

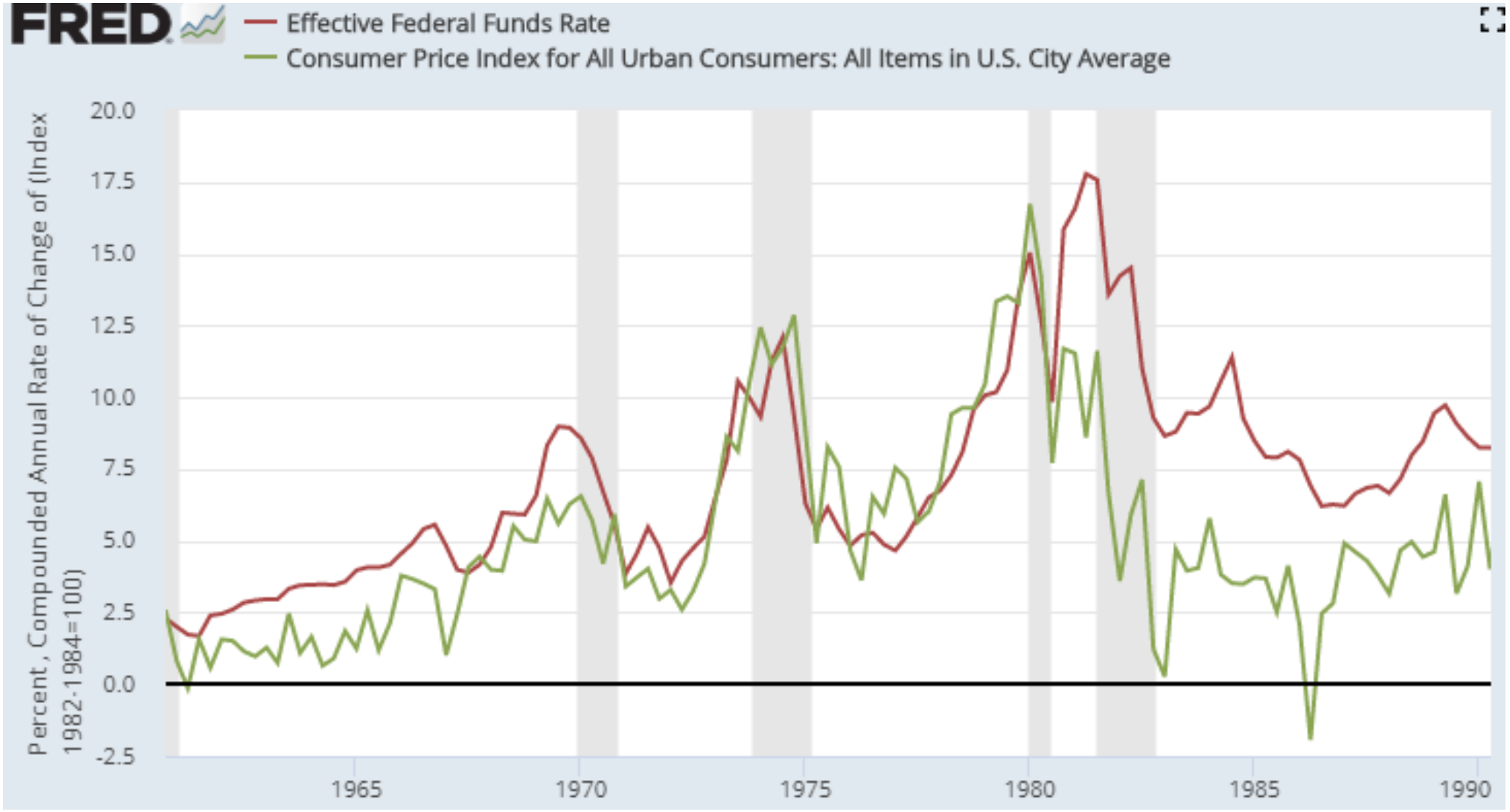
- Y decreases.
- r increases.
- How about the following variables?
  - C
  - I
  - G
  - $G - T$
  - u
  - W/P
  - π
  - i

Can either MP or FP help?

- One may try to maintain the original output Y_n by maintaining the current r, G, and T.
- …at the cost of rising inflation rate ($\because \Delta\pi > 0$ at point A').

- One may instead want to drive the economy to the new medium-run output $Y_n{}'$ quickly by taking contractionary MP and/or FP
- …at the cost of a fast decline in output in the short run.

- Some people think that FRB took the first approach in the 70s, which partly explains the great inflation during the period.
- Then, FRB raised interest rates dramatically in the early 80s under the leadership of Paul Volcker, who was a chairperson of FRB from 1979 to 1987. This lowered π at the cost of initiating a recession.



- Note that during the 70s, the FRB maintained i around π, implying that (ex-post) r was around 0 or even negative.
- Then, since the early 80s, $i > \pi$ and (ex-post) r became positive.

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Productivity shocks (Chapters 13-1 and 13-2)

- What happens to the economy in the short and medium run in response to technological progress?
- An increase in productivity (or a positive productivity shock) is represented by $\mathcal{A} \uparrow$ in our framework.

- We first study the PC curve. Then, we investigate the IS curve and the short and medium-run equilibrium.

u_n and Y_n in our model when $\mathcal{A} \uparrow$

- WS Relation: $W/P = \mathcal{A}F(u, z)$
- PS Relation: $W/P = \mathcal{A}/(1+m)$

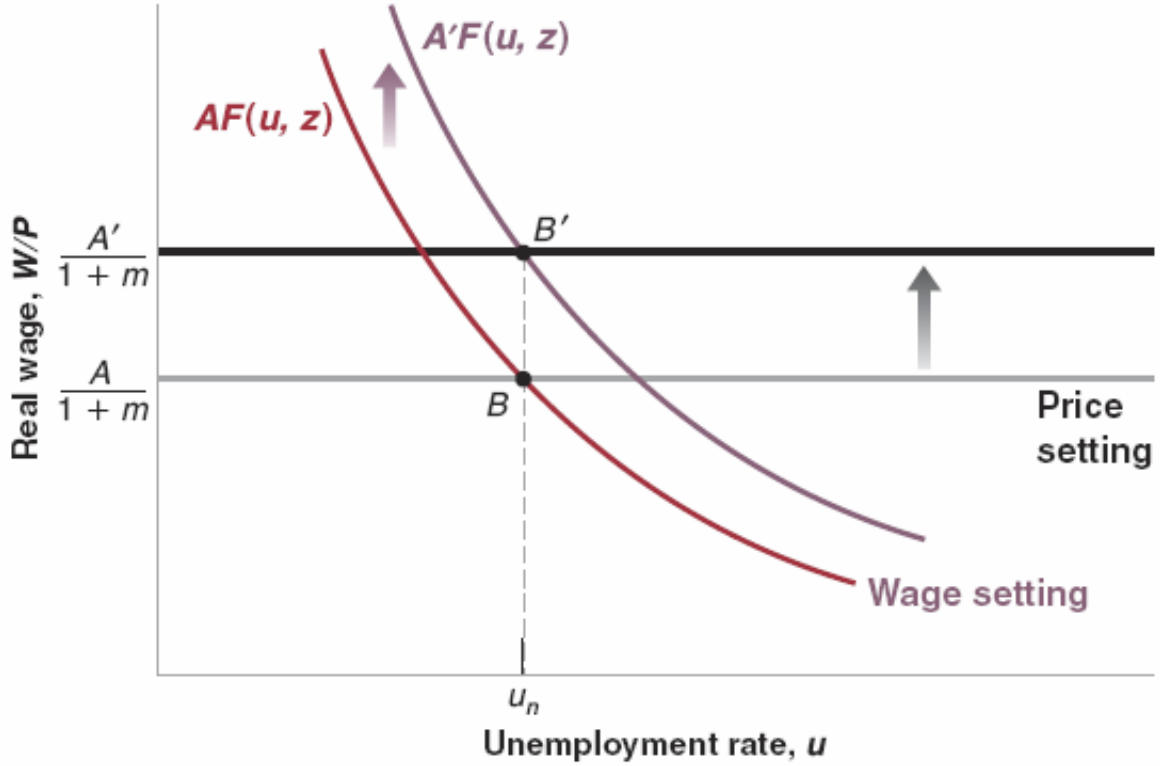
- u_n satisfies the following condition:

$$\mathcal{A}F(u_n, z) = \frac{\mathcal{A}}{1+m}$$

$\Rightarrow u_n$ does not change.

$\Rightarrow N_n = L(1-u_n)$ does not change.

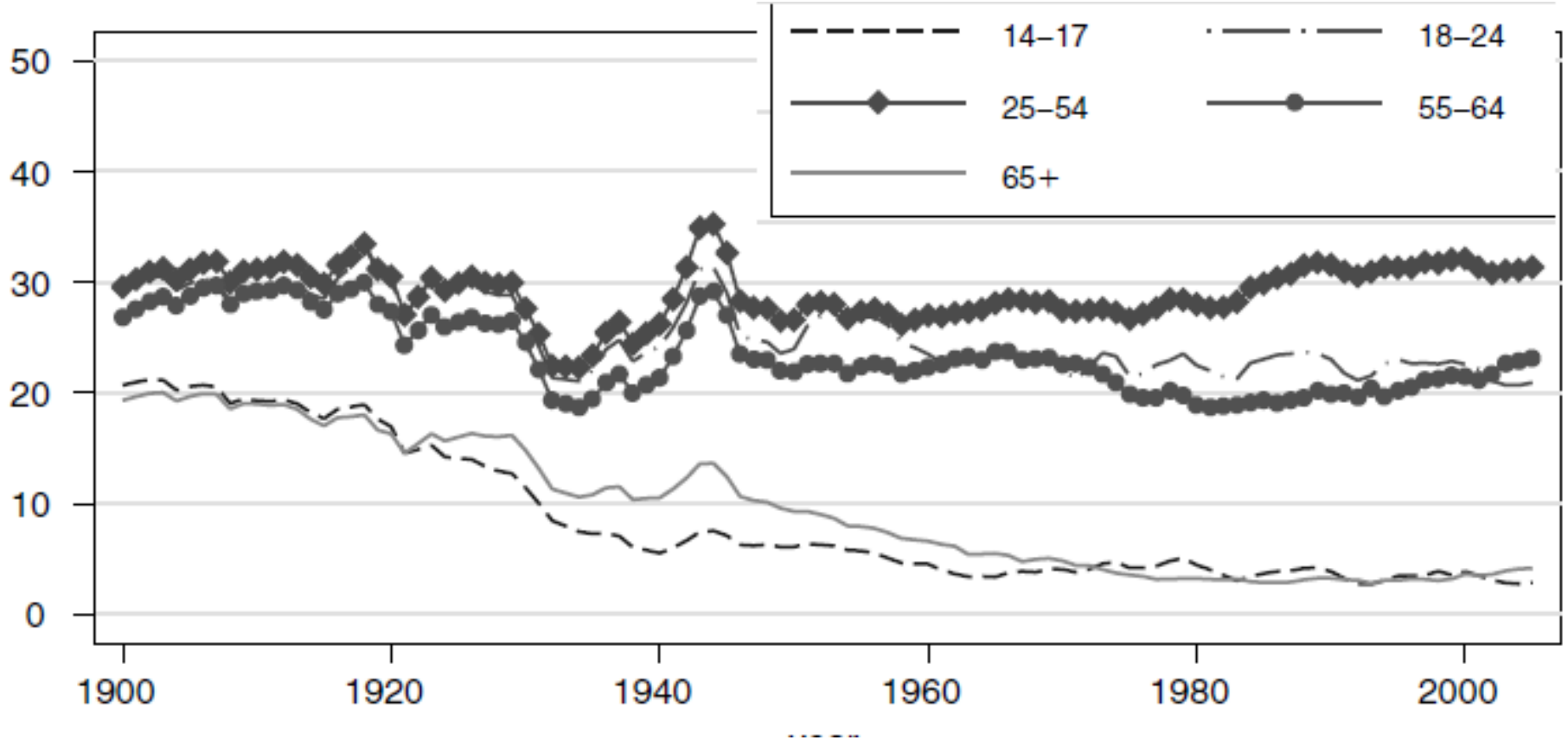
- $Y_n = \mathcal{A}N_n$ increases as $\mathcal{A} \uparrow$.
- The PC curve shifts to the right.



The empirical evidence

- Because u_n, N_n, and Y_n are not directly observable, it is not easy to empirically test (i.e. using data) the model implication that u_n and N_n does not depend on $\mathcal{A}$.

- But we can infer indirectly from the data that N_n does not seem to be very sensitive to $\mathcal{A}$.
- For example, in the U.S., the average hours worked per person did not change much for the working age population during the last century.
- That is, how much people work did not change much, although technology improved dramatically since 1900.



- Average Weekly Hours Worked per Person, by Age Group in the U.S.
- Working hours for the working age population did not change much.
- Source: Ramey, V. and N. Francis (2009). A Century of Work and Leisure. *American Economic Journal: Macroeconomics* 1(2): 189-224.

The IS curve when $\mathcal{A} \uparrow$

- The prospect of higher growth in the future

  → consumer confidence ↑ →
- The prospect of higher profits in the future

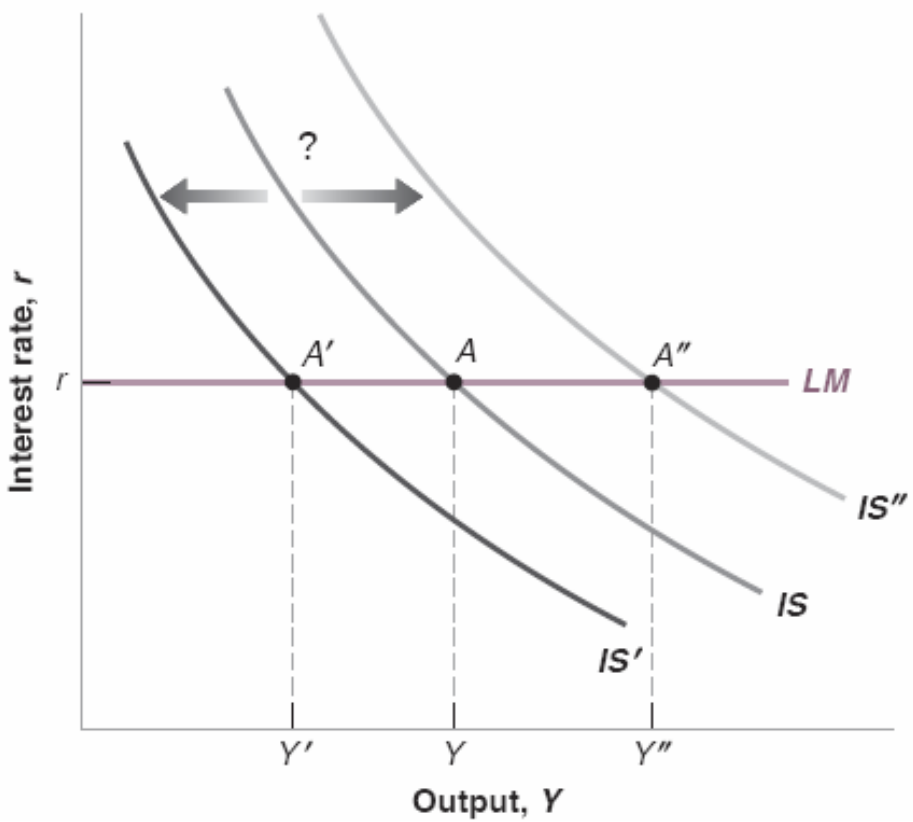
  → stock price ↑ (you expect more dividend in the future)

  → consumers now feel more wealthy →
- Because firms need to put the new technology in place and they want to produce more when $\mathcal{A}$ is high, investment demand .

- As a result, the IS curve shifts to the right.

The IS shifts to the right. But, by how much?

- In the textbook, Blanchard discusses why IS may ← (like IS'). In this course, we focus on cases where IS → (like IS'').

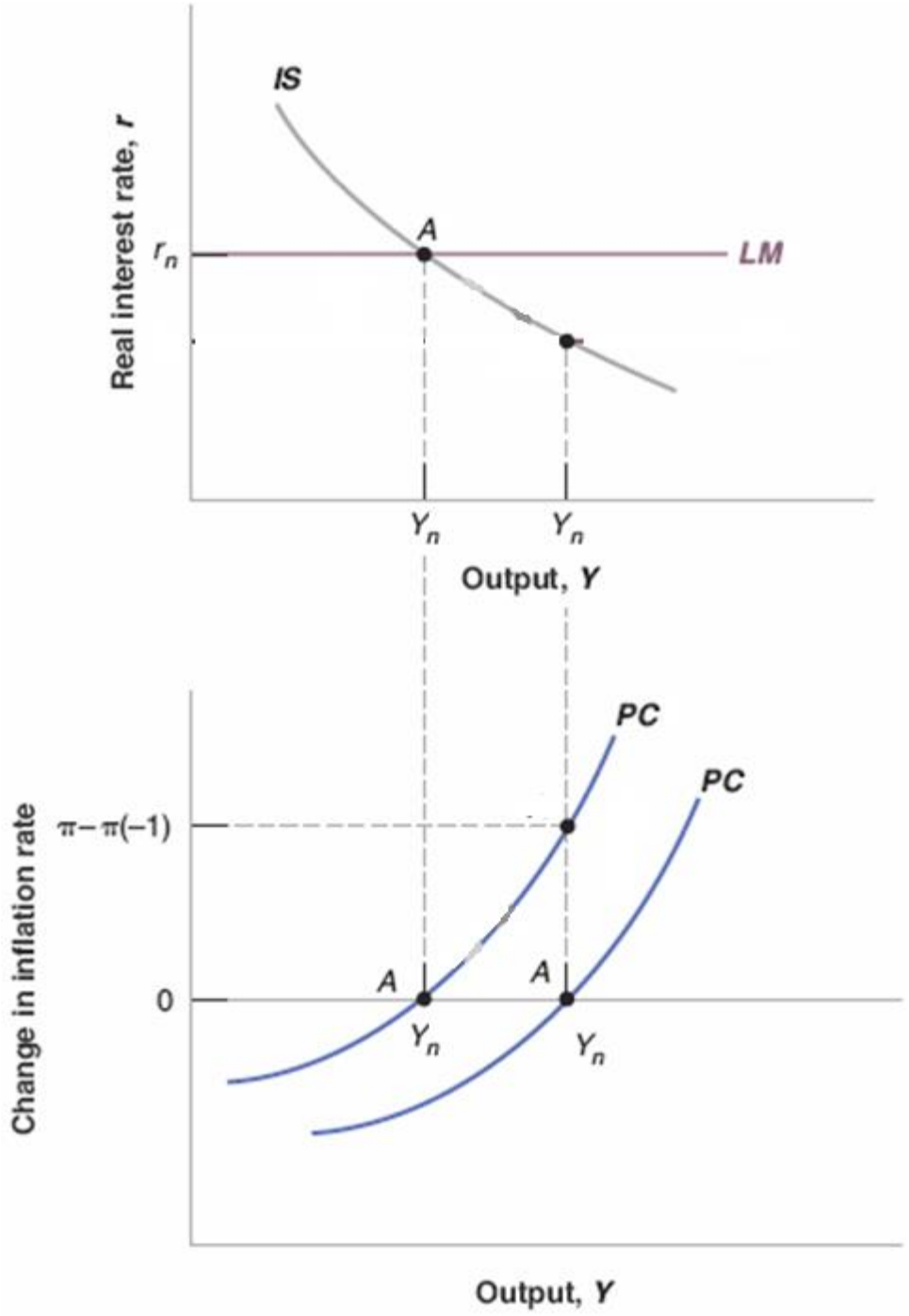


- Suppose that
  - $\mathcal{A} < \mathcal{A}', Y_n = \mathcal{A}N_n < Y_n' = \mathcal{A}'N_n$
  - $Y_A = Y_n$.
- Case 1) $Y'' - Y_A < Y_n' - Y_n$
- Case 2) $Y'' - Y_A = Y_n' - Y_n$
- Case 3) $Y'' - Y_A > Y_n' - Y_n$
- Below, we consider Case 1. Cases 2 and 3 are left as an exercise.

A positive productivity shock

- Assume that $Y = Y_n$ initially (Point A)
- What happens if $\mathcal{A} \uparrow$?

- Point A' represents the short-run equil.
  - PC $\rightarrow$ as $Y_n \uparrow$ to Y_n'
  - IS $\rightarrow$ by less than PC (Case 1)
- Overtime, the CB observes that π decreases ($\Delta\pi < 0$). So, it decreases i (and r) until the LM curve shifts to the LM'.
- The medium-run equilibrium is represented by point A''.



In the short run (A vs. A’)

- $Y \uparrow$
- r does not change.
- How about the following variables?
  - C
  - I
  - u
  - W/P
  - π
  - i

In the medium run (A vs. A’’)

- Y increases.
- r decreases.
- How about the following variables?
  - C
  - I
  - u
  - W/P
  - π
  - i

In the next class…

- We move to our last topic in this semester, the economic growth.

- Basic facts on the (modern) economic growth (Chapter 10)
- The Solow growth model (Chapters 11, 12)