Aggregate Supply and the Short-Run Tradeoff Between Inflation and Unemployment

Chapter 16

Econ 313 – Intermediate Macroeconomics

University of Tennessee, Knoxville

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IN THIS CHAPTER, YOU WILL LEARN:

- About two models of aggregate supply in which output depends positively on the price level in the short run
- About the short-run tradeoff between inflation and unemployment, known as the Phillips curve

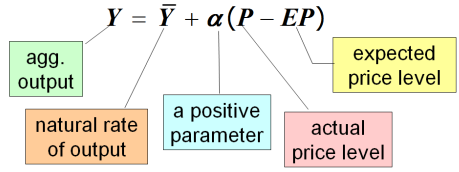
Introduction, part 1

- In previous chapters, we assumed that the price level P was "stuck" in the short run.
  - This implies a horizontal *SRAS* curve.
- Now, we consider two prominent models of aggregate supply in the short run:
  - Sticky-price model
  - Imperfect-information model

Introduction, part 2

Both models imply:

- Other things equal, Y and P are positively related, so the *SRAS* curve is upward sloping.



The sticky-price model, part 1

Reasons for sticky prices:

- long-term contracts between firms and customers
- menu costs
- firms not wishing to annoy customers with frequent price changes

Assumption: firms set their own prices (as in monopolistic competition).

- The next few slides work out the math behind a sticky-price short-run supply curve:
  - start with an individual firm's price-setting behavior;
  - some firms can change prices while others cannot, which together determine the overall price level P;
  - sticky-price firms expect output to equal its natural rate, $EY = E\bar{Y}$;
  - then solve out for our *SRAS* curve.

The sticky-price model, part 2; an individual firm's price-setting decision

An individual firm's desired price is

$$p = P + a(Y - \bar{Y}), \qquad a > 0.$$

- Suppose there are two types of firms:
  - firms with **flexible** prices—set p as above, using the realized P and Y;
  - firms with **sticky** prices—must set p before they know how P and Y will turn out, so they use expectations:

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

The sticky-price model, part 3; expectations of output

- Assume that sticky-price firms expect output will equal its natural rate, $EY = E\bar{Y}$. Then their preset price is simply

$$p = EP.$$

- To derive the aggregate supply curve, first find an expression for the overall price level.
- Let $s =$ fraction of firms with sticky prices. Then the overall price level is the weighted average of the two groups' prices:

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

The sticky-price model, part 4; price level is determined by both sticky-price and flexible-price firms

Subtract $(1-s)P$ from both sides:

$$sP = sEP + (1-s)\,a\,(Y-\bar{Y}).$$

Divide both sides by s:

$$P = EP + \left[\frac{(1-s)\,a}{s}\right](Y-\bar{Y}).$$

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

price set by sticky-price firms

price set by flexible-price firms

The sticky-price model, part 5

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

- High $EP \Rightarrow$ high P. If firms expect high prices, then firms that must set prices in advance will set them high. Other firms respond by setting prices high.
- High $Y \Rightarrow$ high P. When income is high, the demand for goods is high. Firms with flexible prices set prices high.
  - The greater the fraction of flexible-price firms, the smaller is s and the bigger the effect of ΔY on P.

The sticky-price model, part 6; solving for the SRAS equation

- Finally, derive the *SRAS* equation by solving for Y:

$$\boxed{Y = \bar{Y} + \alpha\,(P - EP)} \qquad \text{where} \qquad \alpha = \frac{s}{(1-s)\,a} > 0.$$

- Output rises above its natural rate only when the price level *surprises*: $P > EP$.
- Sticky prices (s large) $\Rightarrow \alpha$ large $\Rightarrow$ flat *SRAS*; flexible prices ($s \to 0$) $\Rightarrow \alpha \to 0$ $\Rightarrow$ vertical *SRAS*.

The imperfect-information model, part 1

Assumptions:

- All wages and prices are perfectly flexible, and all markets are clear.
  - Each supplier produces one good and consumes many goods.
  - Each supplier knows the nominal price of the good they produce but does not know the overall price level.

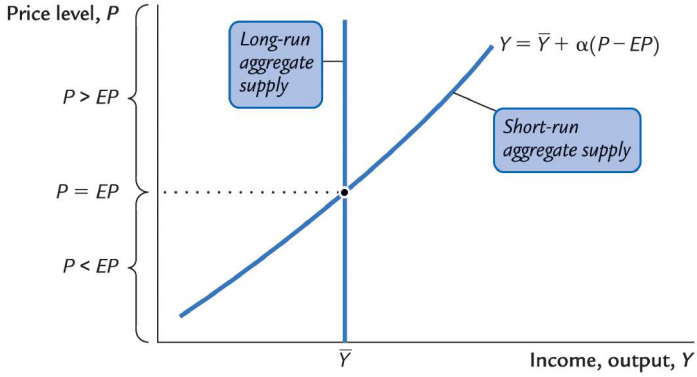
The imperfect-information model, part 2

- The supply of each good depends on its relative price: the nominal price of the good divided by the overall price level.
- The supplier doesn't know price level at the time she makes her production decision so uses EP.
- Suppose P rises but EP does not:
  - Supplier thinks her relative price has risen, so she produces more.
  - With many producers thinking this way, Y will rise whenever P rises above EP.

Once again we obtain

$$Y = \bar{Y} + \alpha(P - EP), \qquad \alpha > 0.$$

Summary and implications, part 1

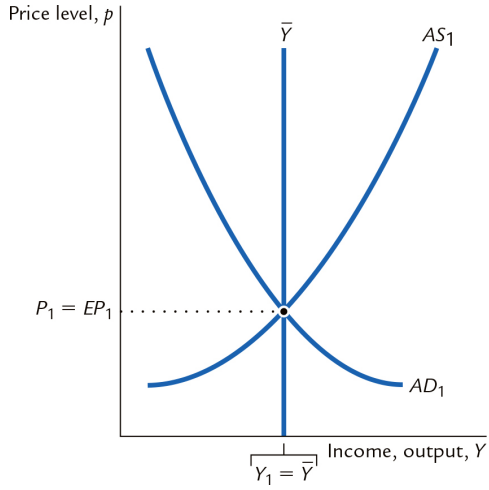


Summary and implications, part 2 (1 of 6)

- How shifts in AD lead to short-run fluctuations.

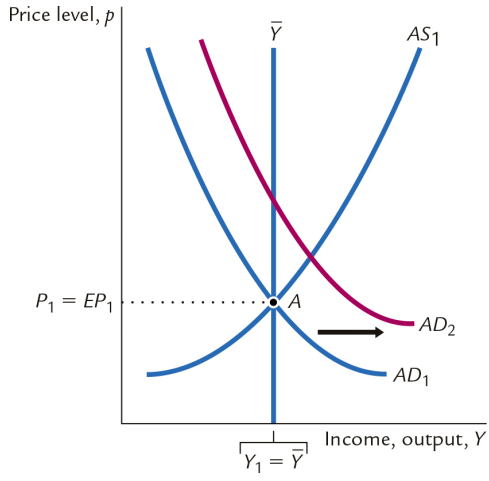
Summary and implications, part 2 (2 of 6)

- Initial equilibrium



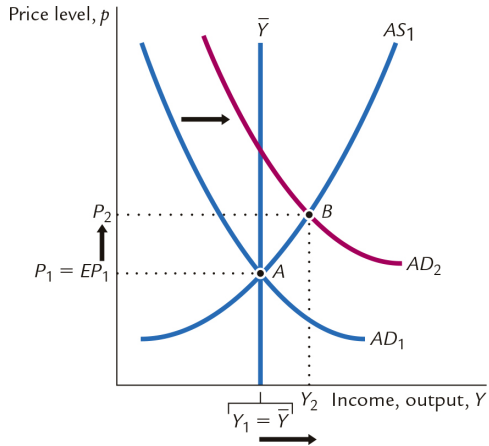
Summary and implications, part 2 (3 of 6)

- AD increases unexpectedly.



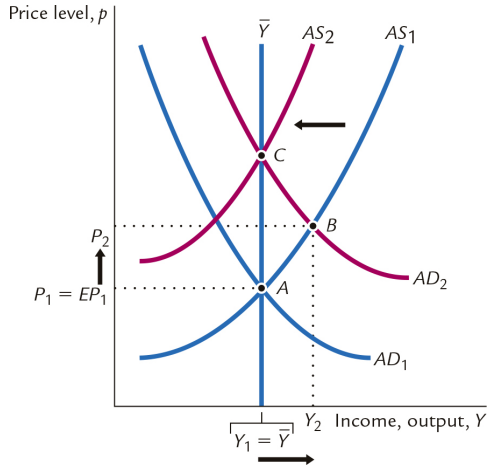
Summary and implications, part 2 (4 of 6)

- Causing a new equilibrium at B. Price level and GDP increase in the short run. Expected price level did not change.



Summary and implications, part 2 (5 of 6)

- In the long run, expected price level rises to EP_3, shifting AS in.



Summary and implications, part 2 (6 of 6)

- Reaching a new long-run equilibrium at C. With higher price level and expected prices, GDP returns to the initial value.

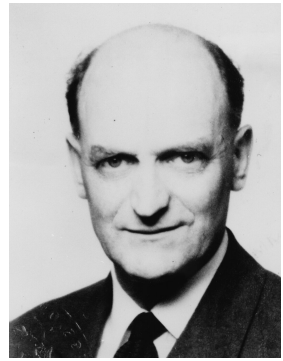
Inflation, unemployment, and the Phillips curve

The **Phillips curve** states that π depends on:

- expected inflation, $E\pi$;
- **cyclical unemployment**: the deviation of the actual rate of unemployment (u) from the natural rate (u^n);
- supply shocks, ν (Greek letter nu).

$$\pi \;=\; E\pi \;-\; \beta\,(u - u^n) \;+\; \nu,$$

where $\beta > 0$ is an exogenous constant.

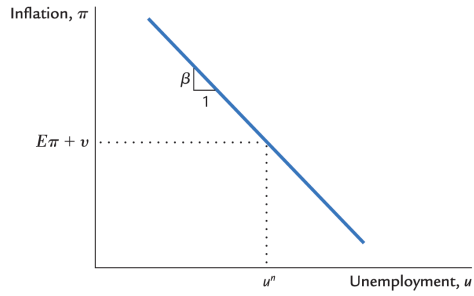


A. W. ("Bill") Phillips (1914–1975), LSE economist who published the curve in 1958.

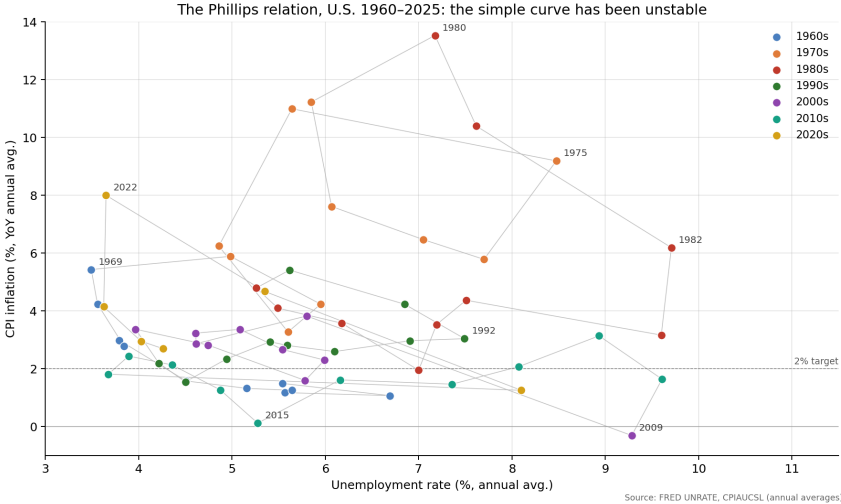
Wikimedia, PD

The Phillips curve

- In the short run, inflation and unemployment are negatively related.
- The curve is drawn for a *given* $E\pi$ and ν; its slope is $-\beta$.



The Phillips relation in the data, 1960–2025



The simple downward Phillips curve holds *within* some decades but shifts across decades — exactly what the natural-rate hypothesis + expectations predict.

Source: FRED `UNRATE`, `CPIAUCSL`, annual averages.

Deriving the Phillips curve from SRAS, part 1

- *SRAS* equation:

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

- Solving (1) for P yields:

$$P = EP + \tfrac{1}{\alpha} (Y - \bar{Y}) \tag{2}$$

- Adding the supply shock term (ν) to (2) yields:

$$P = EP + \tfrac{1}{\alpha} (Y - \bar{Y}) + \nu \tag{3}$$

- Subtracting last year's price level (P_{-1}) from both sides of (3) yields:

$$P - P_{-1} = (EP - P_{-1}) + \tfrac{1}{\alpha} (Y - \bar{Y}) + \nu \tag{4}$$

Deriving the Phillips curve from SRAS, part 2

- Using the fact that inflation is $\pi = P - P_{-1}$ (and $E\pi = EP - P_{-1}$), (4) becomes:

$$\pi \;=\; E\pi + \tfrac{1}{\alpha}\,(Y - \bar{Y}) + \nu \tag{5}$$

- Okun's law tells us that the deviation of output (Y) from its natural rate is inversely related to cyclical unemployment ($u - u^n$):

$$\tfrac{1}{\alpha}\,(Y - \bar{Y}) \;=\; -\,\beta\,(u - u^n) \tag{6}$$

- Plugging (6) into (5) yields the Phillips curve:

$$\pi \;=\; E\pi \;-\; \beta\,(u - u^n) \;+\; \nu \tag{7}$$

Comparing SRAS and the Phillips curves

- *SRAS* curve: output is related to unexpected movements in the *price level*.

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

- Phillips curve: unemployment is related to unexpected movements in the *inflation rate*.

$$\pi - E\pi = -\beta (u - u^n) + \nu$$

Adaptive expectations

- **Adaptive expectations**: an approach that assumes people form their expectations of future inflation based on recently observed inflation
- A simple version: expected inflation = last year's actual inflation,

$$E\pi = \pi_{-1}$$

- Then the Phillips curve equation becomes

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

Inflation inertia

In this form, the Phillips curve implies that inflation has inertia:

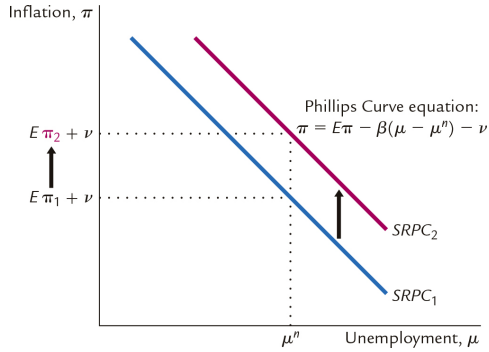
- In the absence of supply shocks or cyclical unemployment, inflation will continue indefinitely at its current rate.
  - Past inflation influences expectations of current inflation, which in turn influences the wages and prices that people set.

Two causes of rising and falling inflation

- **Cost-push inflation**: inflation resulting from supply shocks (the ν term)
  - Adverse supply shocks typically raise production costs and induce firms to raise prices, *pushing* inflation up.
- **Demand-pull inflation**: inflation resulting from demand shocks (the $-\beta(u - u^n)$ term)
  - Positive shocks to aggregate demand cause unemployment to fall below its natural rate, which *pulls* the inflation rate up.

Shifting the Phillips curve

- People adjust their expectations over time, so the tradeoff only holds in the short run.
- For example: an increase in $E\pi$ shifts the short-run Phillips curve upward.



The sacrifice ratio, part 1

- To reduce inflation, policymakers can contract aggregate demand, causing unemployment to rise above the natural rate.
- The **sacrifice ratio** measures the percentage of a year's real GDP that must be forgone to reduce inflation by 1 percentage point.
- A typical estimate of the ratio is 5.

▸ Volcker case + numerics

The sacrifice ratio, part 2

For example: To reduce inflation from 6 percent to 2 percent, must sacrifice 20 percent of one year's GDP:

$$\text{GDP loss} = (\text{inflation reduction}) \times (\text{sacrifice ratio}) = 4 \times 5 = 20\%$$

- This loss could be incurred in one year or spread over several (for example: 5 percent loss for each of four years).
- The cost of disinflation is lost GDP. One could use Okun's law to translate this cost into unemployment.

Rational expectations

Ways of modeling the formation of expectations:

- **Adaptive expectations**: people base their expectations of future inflation on recently observed inflation.
- **Rational expectations**: people base their expectations on all available information, including information about current and prospective future policies.

Painless disinflation?

Proponents of rational expectations believe that the sacrifice ratio may be very small:

- Suppose $u = u^n$ and $\pi = E\pi = 6$ percent, and suppose the Fed announces that it will do whatever is necessary to reduce inflation from 6 percent to 2 percent as soon as possible.
- If the announcement is credible, then $E\pi$ will fall, perhaps by the full 4 points.
- Then, in $\pi = E\pi - \beta(u - u^n) + \nu$, inflation π can fall without an increase in u.

Calculating the sacrifice ratio for the Volcker disinflation, part 1

- In 1981, inflation was 9.3 percent. By 1985, inflation was 3.2 percent. The Fed reduced inflation by 6.1 percentage points in four years.

Calculating the sacrifice ratio for the Volcker disinflation, part 2

- From previous slide: inflation fell by 6.1 percentage points, and total cyclical unemployment was 10 percentage points.
- Okun's law: 1 percentage point of cyclical unemployment = 2 percent of lost output.
- Thus, 10 percentage points of cyclical unemployment = 20.0 percent of a year's real GDP.

$$\text{Sacrifice ratio} = \frac{\text{lost GDP}}{\text{total disinflation}} = \frac{20}{6.1} \approx 3.3$$

That is, 3.3 percentage points of GDP were lost for each 1-percentage-point reduction in inflation.

Anchored expectations (1 of 2)

- Expectations play a crucial role in the Phillips curve.
- How expectations are formed—and whether they remain stable over time—is crucial for the behavior of inflation.
- If a central bank can credibly maintain inflation at its target, then rational agents' inflation expectations will remain anchored to the announced target rate.
- When inflation expectations are anchored around the target, the job of the central bank is much easier.

Anchored expectations (2 of 2)

When inflation expectations are well anchored at the central bank's target π^A:

$$E\pi = \pi^A.$$

Therefore

$$\pi = \pi^A - \beta(u - u^n) + \nu.$$

- As before, π depends on $(u - u^n)$ and ν, but expected inflation is constant at π^A and inflation is no longer inertial.

The natural-rate hypothesis

Our analysis of the costs of disinflation and of economic fluctuations in the preceding chapters is based on the **natural-rate hypothesis**:

- Changes in aggregate demand affect output and employment only in the short run.
- In the long run, the economy returns to the levels of output, employment, and unemployment described by the classical model (Chapters 3–10).

An alternative hypothesis: Hysteresis

- **Hysteresis**: the long-lasting influence of history on variables such as the natural rate of unemployment
- Negative shocks may increase u^n, so the economy may not fully recover.

Hysteresis: Why negative shocks may increase the natural rate

- While workers are cyclically unemployed, their skills may deteriorate, and they may not find a job when the recession ends.
- Cyclically unemployed workers may lose their influence on wage setting; then, insiders (employed workers) may bargain for higher wages for themselves.
  - Result: The cyclically unemployed "outsiders" may become structurally unemployed when the recession ends.

CHAPTER SUMMARY, PART 1

Two models of aggregate supply in the short run:

- sticky-price model
- imperfect-information model

Both models imply that output rises above its natural rate when the price level rises above the expected price level:

$$Y = \bar{Y} + \alpha(P - EP), \qquad \alpha > 0.$$

CHAPTER SUMMARY, PART 2

- Phillips curve
  - derived from the *SRAS* curve: $\pi = E\pi - \beta(u - u^n) + \nu$
  - states that inflation depends on
    - expected inflation, $E\pi$
    - cyclical unemployment, $u - u^n$
    - supply shocks, ν
  - presents policymakers with a short-run tradeoff between inflation and unemployment

CHAPTER SUMMARY, PART 3

How people form expectations of inflation:

- adaptive expectations
  - based on recently observed inflation, $E\pi = \pi_{-1}$
  - imply "inertia"
- rational expectations
  - based on all available information
  - imply that disinflation may be painless
- anchored expectations
  - $E\pi = \pi^A$, the credible target: inflation is no longer inertial

CHAPTER SUMMARY, PART 4

The natural rate hypothesis and hysteresis:

- the natural-rate hypothesis
  - changes in aggregate demand can affect output and employment only in the short run
- hysteresis
  - aggregate demand can have permanent effects on output and employment

Appendix: Sacrifice ratio — worked example

Definition.

$$\text{Sacrifice ratio (SR)} = \frac{\text{cumulative \% GDP lost}}{\text{permanent reduction in } \pi \text{ (pp)}}$$

Example — disinflating from 8% to 4%. Suppose SR $= 2.5$ (a modern estimate). Then cumulative GDP loss:

$$\underbrace{4\text{pp}}_{\Delta\pi} \times \underbrace{2.5}_{\text{SR}} = 10\% \text{ of one year's GDP.}$$

Spread over 4 years: about 2.5% per year of below-trend GDP.
Using Okun's law ($\%\Delta Y \approx 3\% - 2 \times \Delta u$), each 2.5% GDP shortfall $\Rightarrow \Delta u \approx +1.25$pp above the natural rate for those 4 years.

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Appendix — the Volcker disinflation (1979–82)

Paul Volcker took over the Fed in Aug 1979. Fed funds rate peaked at 20% in June 1981.

Year	CPI inflation	Unemployment	Real GDP growth
1979	11.3%	5.9%	$+3.2\%$
1980	13.5%	7.2%	-0.3%
1981	10.4%	7.6%	$+2.5\%$
1982	6.1%	9.7%	-1.8%
1983	3.2%	9.6%	$+4.6\%$

Inflation fell ≈ 8pp (from $\sim 11\%$ to $\sim 3\%$). Cumulative shortfall from potential GDP: $\approx 15\%$ across 1980–82.
Implied sacrifice ratio: $15/8 \approx 1.9$ — *lower* than the textbook 5.

Some economists (Sargent, Lucas) argue the sacrifice ratio can be near *zero if* the disinflation is announced credibly and expectations adjust. Volcker's SR came out below the textbook estimate because his commitment to the fight was credible.