Homework 3 — Complete Solutions

Intermediate Macroeconomics

Contents

10 Classical Business Cycle Analysis: Market-Clearing Macroeconomics

10.1 Review Questions

1. **What main feature of the classical IS-LM model distinguishes it from the Keynesian IS-LM model? Why is the distinction of practical importance?**

   Answer: The key distinguishing feature is the assumption of **complete wage and price flexibility** that ensures markets continuously clear. In the classical IS-LM model, output is always at its full-employment level ($\bar{Y}$), determined entirely by supply-side factors (labor market equilibrium, capital stock, productivity). The IS-LM framework only determines the real interest rate and the price level.

   In contrast, the Keynesian IS-LM model assumes wage and/or price stickiness, allowing output to deviate from full-employment in the short run. Here, the IS-LM intersection determines both output *and* the real interest rate, and aggregate demand shocks can cause recessions or booms.

   The distinction is practically important because it determines the **role of stabilization policy**:

   - If the classical view is correct, government stabilization policy is unnecessary and potentially harmful—the economy self-corrects quickly.
   - If the Keynesian view is correct, active monetary and fiscal policy can help smooth business cycles and reduce the welfare costs of recessions.

2. **What are the two main components of any theory of the business cycle? Describe these two components for the real business cycle theory.**

   Answer: The two main components of any business cycle theory are:

   (a) **The impulse (or shock)** — the initial disturbance that sets the cycle in motion.

   (b) **The propagation mechanism** — the way the economy transmits and amplifies the initial shock over time.

   In **real business cycle (RBC) theory**:

   - **Impulse:** Productivity shocks (changes in the Solow residual), primarily from technological change, but also from changes in regulations, weather, input prices, etc. These are *real* shocks, not nominal/monetary shocks.
   - **Propagation mechanism:** Intertemporal substitution of labor and consumption, investment dynamics (capital accumulation takes time), and inventory adjustments. For instance, a positive productivity shock raises current real wages relative to expected future wages, inducing workers to supply more labor now (intertemporal substitution), which amplifies the initial output effect.

3. **Define real shock and nominal shock. What type of real shock do real business cycle economists consider the most important source of cyclical fluctuations?**

   Answer:

- **Real shock:** A disturbance to the real side of the economy that affects the production function, such as changes in technology (productivity), weather, regulations, or the relative price of inputs (e.g., oil prices). Real shocks shift the IS curve or the FE line.
- **Nominal shock:** A disturbance to the money supply or money demand that primarily affects the LM curve and the price level.

RBC economists consider **productivity shocks** (technological changes that affect the Solow residual) to be the most important source of cyclical fluctuations. These include not just pure technological innovations but also changes in the legal and regulatory environment, weather patterns, and the availability of raw materials—anything that affects how much output can be produced from given inputs.

4. **What major business cycle facts does the RBC theory explain successfully? Does it explain any business cycle facts less well?**

   Answer: RBC theory explains several business cycle facts well:

   - **Procyclical employment:** Productivity shocks shift labor demand, causing employment and output to move together.
   - **Procyclical consumption and investment:** Both respond positively to productivity shocks.
   - **Procyclical real wage:** Higher productivity raises the marginal product of labor and thus real wages.
   - **Persistence in output movements:** Capital accumulation and technology diffusion create serial correlation in output.
   - **Investment is more volatile than consumption:** Optimal smoothing of consumption combined with the accelerator effect on investment.

   However, RBC theory explains some facts less well:

   - **Procyclical price level/inflation:** RBC theory predicts that prices should be countercyclical (positive supply shocks increase output but reduce prices), whereas U.S. data shows prices are mildly procyclical or acyclical before the 1980s.
   - **The procyclical behavior of money:** RBC theory treats money as endogenous (reverse causation), but many economists find the money-output correlation too strong to be entirely explained by reverse causation.
   - **The depth and duration of recessions:** The Great Depression and Great Recession seem too severe to be explained solely by productivity shocks.

5. **What is the Solow residual and how does it behave over the business cycle? What factors cause the Solow residual to change?**

   Answer: The **Solow residual** (also called total factor productivity, or TFP) is the part of output growth that cannot be explained by measured growth in capital and labor inputs. For a Cobb-Douglas production function $Y = AK^{\alpha}N^{1-\alpha}$, the Solow residual is the growth rate of A:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha\frac{\Delta K}{K} - (1-\alpha)\frac{\Delta N}{N}.$$

The Solow residual is strongly **procyclical**—it rises in expansions and falls in recessions. This procyclical behavior is the central empirical motivation for RBC theory.

Factors that cause the Solow residual to change include:

- Genuine technological progress (new production techniques, innovations)
- Changes in resource utilization (labor hoarding, capital utilization rates)
- Measurement error (unobserved variations in effort or hours)
- Changes in the composition of output across industries
- Government regulations, weather, and other supply-side disturbances

Critics argue that the Solow residual's procyclicality partly reflects **labor hoarding** (firms retain workers during downturns but reduce their effort/hours) and variable capacity utilization rather than true technology shocks.

6. **What effects does an increase in government purchases have on the labor market, according to the classical theory? What effects does it have on output, the real interest rate, and the price level? According to classical economists, should fiscal policy be used to smooth out the business cycle? Why or why not?**

   Answer: In the classical model, a temporary increase in government purchases:

   - **Labor market:** Higher government spending represents a negative wealth effect for households (higher current or future taxes). Workers respond by increasing labor supply at any given real wage, shifting the labor supply curve to the right. This reduces the equilibrium real wage and increases employment. Output rises because more labor is employed.
   - **Output:** Output rises above the initial full-employment level (though this is the *new* full-employment level with higher labor supply).
   - **Real interest rate:** Higher government purchases reduce desired national saving ($S^d = Y - C^d - G$), shifting the IS curve right/up, raising the real interest rate. This crowds out investment and consumption.
   - **Price level:** With output fixed at the new full-employment level and higher G raising the real interest rate (reducing real money demand), the price level must rise to clear the money market for a given nominal money supply.

   Classical economists argue that fiscal policy should **NOT** be used to smooth the business cycle because:

   (a) The economy self-corrects quickly through wage and price flexibility—there is no involuntary unemployment.

   (b) Fiscal expansion crowds out private investment via higher real interest rates.

   (c) The increase in output comes from workers substituting leisure for labor due to a negative wealth effect—workers are not necessarily better off; they're working more because they feel poorer.

   (d) Political lags and implementation delays make discretionary fiscal policy poorly timed.

7. **In the context of the relationship between the money supply and real economic activity, what is meant by reverse causation? Explain how reverse causation could occur. What business cycle fact is it intended to explain?**

   Answer: Reverse causation means that the observed positive correlation between money and output arises because output changes *cause* money supply changes, rather than the other way around. This is the opposite of the traditional monetarist view that money causes output.

   Reverse causation could occur through several channels:

   (a) **Bank lending channel:** When firms expect higher future output, they demand more loans to finance working capital and investment. Banks respond by creating more deposits, which increases the measured money supply (particularly M2).

   (b) **Central bank accommodation:** If the central bank targets interest rates, an increase in output raises money demand. To prevent interest rates from rising, the central bank increases the money supply endogenously.

   (c) **Transactions demand:** Higher expected future output leads firms to hold more money balances for transactions purposes today, increasing real money demand and (for a given price level) the measured money stock.

   This is intended to explain the **procyclical behavior of the money supply**—money grows faster during expansions and slower (or declines) during recessions. RBC economists use reverse causation to argue that this correlation does not imply that monetary policy drives business cycles.

8. **According to the misperceptions theory, what effect does an increase in the price level have on the amount of output supplied by producers? Explain. Does it matter whether the increase in the price level was expected?**

   Answer: According to the **misperceptions theory** (Lucas supply function), an increase in the price level leads producers to **increase** the amount of output they supply, but only if the increase was **unanticipated**.

   The mechanism: Each producer observes the price of their own good but cannot perfectly observe the overall price level. When a producer sees their own price rise, they don't know whether it reflects:

   (a) An increase in the overall price level (which leaves relative prices unchanged, so optimal output is unchanged), or

   (b) An increase in the relative demand for their specific good (which raises the relative price and should prompt higher production).

   Producers rationally attribute part of any observed price increase to an increase in their relative price. This leads them to increase production. The aggregate supply curve becomes:

$$Y = \bar{Y} + b(P - P^e),$$

   where $b > 0$. Output exceeds full employment when $P > P^e$.

   It matters crucially whether the price level increase was expected:

   - If the price level increase is **fully anticipated** ($P = P^e$), producers recognize it correctly and do not change output. Output remains at $\bar{Y}$.

- If the price level increase is **unanticipated** ($P > P^e$), the misperception causes output to rise above $\bar{Y}$.

9. **What conclusion does the basic classical model (with no misperceptions of the price level) allow about the neutrality or nonneutrality of money? In what ways is this conclusion modified by the extended classical model based on the misperceptions theory?**

   Answer: In the **basic classical model** (no misperceptions), money is **completely neutral** in both the short run and the long run. An increase in the money supply leads to a proportional increase in the price level, with no effect on output, employment, the real interest rate, or any other real variable. The classical dichotomy holds perfectly: nominal variables do not affect real variables.

   In the **extended classical model with misperceptions theory**:

   - **Unanticipated monetary changes are non-neutral in the short run.** If the central bank unexpectedly increases the money supply, aggregate demand shifts right along the short-run aggregate supply curve (which slopes upward due to misperceptions). Output and the price level both rise in the short run.
   - **Anticipated monetary changes remain neutral.** If the public correctly anticipates monetary expansion, they adjust their price expectations accordingly, the SRAS shifts up by the same amount, and output remains at $\bar{Y}$.
   - **Money is neutral in the long run.** Once expectations adjust (P^e converges to P), output returns to $\bar{Y}$ and only the price level is permanently higher.

   Thus, the misperceptions theory modifies the neutrality conclusion by allowing **short-run non-neutrality of unanticipated money**, while preserving long-run neutrality and the neutrality of systematic/anticipated monetary policy.

10. **Define rational expectations. According to the classical model, what implications do rational expectations have for the ability of the central bank to use monetary policy to smooth business cycles?**

    Answer: Rational expectations means that individuals form expectations about the future using all available information and an understanding of the underlying economic model. Formally, the subjective expectation of a variable equals its mathematical expectation conditional on all available information: $P^e = E[P \mid \text{information}]$. Rational expectations do not imply perfect foresight; people make errors, but those errors are random and uncorrelated with available information—there are no systematic, predictable mistakes.

    Under rational expectations in the classical/misperceptions model, the central bank **cannot systematically use monetary policy to smooth business cycles**. The reasoning:

    (a) Only *unanticipated* monetary policy has real effects. Systematic policy rules (e.g., "increase M whenever output is below $\bar{Y}$") become anticipated by rational agents.

    (b) If the central bank follows a predictable rule, the public will anticipate the money supply changes and adjust their price expectations accordingly. The SRAS curve shifts to offset any aggregate demand shift, and output remains at $\bar{Y}$.

(c) The only way monetary policy affects output is through **surprises**, which are inherently unsystematic. The central bank cannot create a systematic pattern of surprises because rational agents would learn the pattern and incorporate it into their expectations.

This is the **policy ineffectiveness proposition**: systematic, predictable monetary policy has no real effects in a classical model with rational expectations. Only random, unforecastable monetary shocks matter—and these add noise rather than systematically stabilizing the economy.

10.2 Numerical Problems

1. **Productivity shock in the labor market.**

   a. Labor supply: $NS = 45 + 0.1w$**.**

   Before the shock ($A = 1.0$**):** Labor demand: $w = MPN = 1.0(100-N) = 100-N$. Equilibrium: $NS = ND \Rightarrow 45 + 0.1w = 100 - w$.

   $$45 + 0.1w = 100 - w \;\Rightarrow\; 1.1w = 55 \;\Rightarrow\; w = 50.$$

   $N = 100 - 50 = 50$ (or $N = 45 + 0.1(50) = 50$). $Y = 1.0(100 \times 50 - 0.5 \times 50^2) = 5000 - 1250 = 3750$.

   After the shock ($A = 1.1$**):** Labor demand: $w = MPN = 1.1(100 - N)$. Equilibrium: $45 + 0.1w = N$, where $w = 1.1(100 - N)$. Substitute: $N = 45 + 0.1[1.1(100 - N)] = 45 + 11 - 0.11N = 56 - 0.11N$. $1.11N = 56 \;\Rightarrow\; N \approx 50.45$. $w = 1.1(100 - 50.45) = 1.1 \times 49.55 = 54.505 \approx 54.50$. $Y = 1.1(100 \times 50.45 - 0.5 \times 50.45^2) = 1.1(5045 - 1272.6) = 1.1 \times 3772.4 \approx 4149.64$.

   Summary:

	w	N	Y
Before shock ($A = 1.0$)	50.00	50.00	3750.00
After shock ($A = 1.1$)	54.50	50.45	4149.64

   b. Labor supply: $NS = 10 + 0.8w$**.**

   Before the shock ($A = 1.0$**):** Labor demand: $w = 100-N$. $N = 10+0.8(100-N) = 10+80-0.8N = 90-0.8N$. $1.8N = 90 \;\Rightarrow\; N = 50$. $w = 100-50 = 50$. $Y = 3750$ (same as before).

   After the shock ($A = 1.1$**):** $w = 1.1(100 - N)$. $N = 10 + 0.8[1.1(100 - N)] = 10+88-0.88N = 98-0.88N$. $1.88N = 98 \;\Rightarrow\; N \approx 52.13$. $w = 1.1(100-52.13) = 1.1 \times 47.87 \approx 52.66$. $Y = 1.1(100 \times 52.13 - 0.5 \times 52.13^2) = 1.1(5213 - 1358.77) = 1.1 \times 3854.23 \approx 4239.65$.

   Summary:

	w	N	Y
Before shock ($A = 1.0$)	50.00	50.00	3750.00
After shock ($A = 1.1$)	52.66	52.13	4239.65

   c. For the real wage to be only slightly procyclical (real wage doesn't change much over the cycle), the RBC model fits better if labor supply is **relatively sensitive** to the real wage (high elasticity, as in part (b) with $NS = 10 + 0.8w$).

   Diagrammatic justification: With highly elastic labor supply (flat labor supply curve), a positive productivity shock shifts the labor demand curve outward, and the new equilibrium has a large increase in employment with only a small increase in the real wage. With inelastic labor supply (steep curve, as in part (a)), the same shock produces a larger wage increase and smaller employment increase.

   Comparing parts (a) and (b): with inelastic supply (a), w rose from 50 to 54.50 (9% increase); with elastic supply (b), w rose from 50 to 52.66 (5.3% increase). The more elastic labor supply produces a smaller procyclical wage movement, matching the empirical finding that real wages are only slightly procyclical.

2. **Classical IS-LM with balanced budget.**

a. In the classical model, output equals full-employment output: $Y = \bar{Y} = 2210$.
Goods market equilibrium: $Y = C^d + I^d + G$.

$$2210 = [600 + 0.5(2210 - 150) - 50r] + [450 - 50r] + 150$$

$$2210 = 600 + 1030 + 450 - 100r + 150$$

$$2210 = 2230 - 100r \;\Rightarrow\; 100r = 20 \;\Rightarrow\; r = 0.20 = 20\%.$$

Consumption: $C = 600 + 0.5(2210 - 150) - 50(0.20) = 600 + 1030 - 10 = 1620$.
Investment: $I = 450 - 50(0.20) = 440$.
Price level: From money market equilibrium $M/P = L$:

$$4320/P = 0.5(2210) - 100(r + \pi^e) = 1105 - 100(0.20 + 0.05) = 1105 - 25 = 1080.$$

$$P = 4320/1080 = 4.00.$$

Check: $C + I + G = 1620 + 440 + 150 = 2210 = Y$. ✓

b. $M = 4752$. Output remains at $Y = \bar{Y} = 2210$. Real interest rate r is unchanged at 0.20 (determined entirely by goods market, which is unchanged). $C = 1620$, $I = 440$ (same as before).

Price level: $4752/P = 1080 \;\Rightarrow\; P = 4752/1080 = 4.40$.

Since P increased in exact proportion to M (from 4.00 to 4.40, a 10% increase matching the 10% increase in M), and all real variables are unchanged, **money is neutral**.

c. $G = T = 190$, $M = 4320$ (back to original). $Y = \bar{Y} = 2210$.
Goods market:

$$2210 = [600 + 0.5(2210 - 190) - 50r] + [450 - 50r] + 190$$

$$2210 = 600 + 1010 - 50r + 450 - 50r + 190 = 2250 - 100r$$

$$100r = 40 \;\Rightarrow\; r = 0.40 = 40\%.$$

$C = 600 + 0.5(2210 - 190) - 50(0.40) = 600 + 1010 - 20 = 1590$. $I = 450 - 50(0.40) = 430$.
Price level: $L = 0.5(2210) - 100(0.40 + 0.05) = 1105 - 45 = 1060$. $P = 4320/1060 \approx 4.075$.

Fiscal policy is **not neutral**. Higher G crowds out both consumption (by \$30) and investment (by \$10) through a higher real interest rate, and changes the price level. The composition of output changes (more government spending, less private spending). Under the classical assumption that $\bar{Y}$ is fixed (and ignoring labor supply effects), the total output level is unchanged, so fiscal policy is neutral with respect to total output *in this simplified case*—but it is **not neutral with respect to the composition of output or the real interest rate**. If we relax the assumption that $\bar{Y}$ is fixed (as in the full classical model where government spending affects labor supply through wealth effects), then even total output could change.

3. **IS-LM and AD curve.**

a. $T = G = 200$, $M = 7650$.

IS curve: $Y = C^d + I^d + G = [250 + 0.5(Y - 200) - 500r] + [250 - 500r] + 200$.

$$Y = 250 + 0.5Y - 100 - 500r + 250 - 500r + 200 = 600 + 0.5Y - 1000r$$

$$0.5Y = 600 - 1000r \;\Rightarrow\; Y = 1200 - 2000r.$$

So IS: $r = 0.6 - 0.0005Y$.

LM curve: $M/P = L \;\Rightarrow\; 7650/P = 0.5Y - 500(r + \pi^e) = 0.5Y - 500r$ (since $\pi^e = 0$).

$$7650/P = 0.5Y - 500r.$$

Substitute r from IS: $7650/P = 0.5Y - 500(0.6 - 0.0005Y) = 0.5Y - 300 + 0.25Y = 0.75Y - 300$. So LM relationship: $7650/P = 0.75Y - 300$.

AD curve: Solve for P:

$$0.75Y = 300 + 7650/P \;\Rightarrow\; Y = 400 + 10200/P.$$

Equilibrium: In the classical model, $Y = \bar{Y} = 1000$.

$$1000 = 400 + 10200/P \;\Rightarrow\; 600 = 10200/P \;\Rightarrow\; P = 17.$$

From IS: $r = 0.6 - 0.0005(1000) = 0.6 - 0.5 = 0.10 = 10\%$. $C = 250 + 0.5(1000 - 200) - 500(0.10) = 250 + 400 - 50 = 600$. $I = 250 - 500(0.10) = 200$. Check: $C + I + G = 600 + 200 + 200 = 1000 = Y$. ✓

b. $T = G = 200$, $M = 9000$.

IS curve unchanged: $Y = 1200 - 2000r$ (or $r = 0.6 - 0.0005Y$).

LM: $9000/P = 0.5Y - 500r = 0.5Y - 500(0.6 - 0.0005Y) = 0.75Y - 300$. AD: $0.75Y = 300 + 9000/P \;\Rightarrow\; Y = 400 + 12000/P$.

Equilibrium ($Y = \bar{Y} = 1000$): $1000 = 400 + 12000/P \;\Rightarrow\; 600 = 12000/P \;\Rightarrow\; P = 20$. $r = 0.10$ (unchanged). $C = 600$, $I = 200$ (unchanged).

c. $T = G = 300$, $M = 7650$.

IS curve: $Y = C^d + I^d + G = [250 + 0.5(Y - 300) - 500r] + [250 - 500r] + 300$.

$$Y = 250 + 0.5Y - 150 - 500r + 250 - 500r + 300 = 650 + 0.5Y - 1000r$$

$$0.5Y = 650 - 1000r \;\Rightarrow\; Y = 1300 - 2000r \text{ or } r = 0.65 - 0.0005Y.$$

LM: $7650/P = 0.5Y - 500r = 0.5Y - 500(0.65 - 0.0005Y) = 0.5Y - 325 + 0.25Y = 0.75Y - 325$. AD: $0.75Y = 325 + 7650/P \;\Rightarrow\; Y = \frac{1300}{3} + 10200/P \approx 433.33 + 10200/P$.

Equilibrium ($Y = 1000$): $1000 = 433.33 + 10200/P \;\Rightarrow\; 566.67 = 10200/P \;\Rightarrow\; P \approx 18.00$. $r = 0.65 - 0.0005(1000) = 0.15 = 15\%$. $C = 250 + 0.5(1000 - 300) - 500(0.15) = 250 + 350 - 75 = 525$. $I = 250 - 500(0.15) = 175$. Check: $C + I + G = 525 + 175 + 300 = 1000$. ✓

Note: Higher government purchases shift the IS curve right, raising r (from 10% to 15%), crowding out both C and I, and changing the price level. With $\bar{Y}$ fixed, fiscal policy changes the composition but not the level of output.

4. **AD-AS with misperceptions.**

a. $M = 400$, $P^e = 60$, $\bar{Y} = 500$.

AD: $Y = 300 + 30(400/P) = 300 + 12000/P$. AS: $Y = 500 + 10(P - 60) = 500 + 10P - 600 = -100 + 10P$.

Equate AD and AS:

$$300 + 12000/P = -100 + 10P$$

$$400 + 12000/P = 10P$$

Multiply by P: $400P + 12000 = 10P^2$. $10P^2 - 400P - 12000 = 0 \Rightarrow P^2 - 40P - 1200 = 0$.

$$P = \frac{40 \pm \sqrt{1600 + 4800}}{2} = \frac{40 \pm \sqrt{6400}}{2} = \frac{40 \pm 80}{2}.$$

Positive root: $P = 60$ (since $P = -20$ is not economically meaningful). $Y = -100 + 10(60) = 500 = \bar{Y}$.

b. $M = 700$ (unanticipated), $P^e = 60$.

AD: $Y = 300 + 30(700/P) = 300 + 21000/P$. AS: $Y = -100 + 10P$ (unchanged since P^e unchanged).

$$300 + 21000/P = -100 + 10P$$

$400 + 21000/P = 10P \Rightarrow 400P + 21000 = 10P^2$. $10P^2 - 400P - 21000 = 0 \Rightarrow P^2 - 40P - 2100 = 0$.

$$P = \frac{40 \pm \sqrt{1600 + 8400}}{2} = \frac{40 \pm \sqrt{10000}}{2} = \frac{40 \pm 100}{2}.$$

Positive root: $P = 70$. $Y = -100 + 10(70) = 600 > \bar{Y}$.

c. $M = 700$ (announced and believed), so $P^e = P$ (rational expectations).

In the long run / with correct expectations, $Y = \bar{Y} = 500$. AS becomes: $Y = 500 + 10(P - P^e)$. With $P^e = P$ and $Y = 500$: AD: $500 = 300 + 30(700/P) \Rightarrow 200 = 21000/P \Rightarrow P = 105$. Since the announcement is believed, $P^e = P = 105$, and $Y = \bar{Y} = 500$.

Summary: Anticipated monetary expansion is neutral (Y unchanged at 500, P rises from 60 to 105). Unanticipated monetary expansion has real effects (Y rises to 600, P rises only to 70).

5. **Solow residual calculation.**

a. Production function: $Y = AK^{0.3}N^{0.7}$, with $K = 30$, $N = 100$.
Solow residual = $A = \frac{Y}{K^{0.3}N^{0.7}}$.
$K^{0.3}N^{0.7} = 30^{0.3} \times 100^{0.7}$.
First compute: $30^{0.3} \approx 2.774$, $100^{0.7} \approx 25.119$. Product ≈ 69.66.
2006: $A_{2006} = 100/69.66 \approx 1.4355$. 2007: $A_{2007} = 105/69.66 \approx 1.5072$.
Growth rate of Solow residual: $(1.5072-1.4355)/1.4355 = 0.0717/1.4355 \approx 0.050 = 5.0\%$.

b. When utilization rates of capital and labor remain unchanged, the growth in the Solow residual **equals** the growth in productivity parameter A. Since K and N are fixed, any change in Y must come from A. Therefore:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} = \frac{105 - 100}{100} = 0.05 = 5\%.$$

c. With labor utilization increasing by 3%, effective labor is $N_{\text{eff}} = N \times (1+\text{utilization change})$. Following Eq. (10.2), $Y = AK^{0.3}(u_N N)^{0.7}$ where u_N is the utilization rate.
Growth decomposition:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + 0.7\frac{\Delta u_N}{u_N}.$$

$0.05 = \Delta A/A + 0.7(0.03)$. $\Delta A/A = 0.05 - 0.021 = 0.029 = 2.9\%$.
The measured Solow residual growth (5%) overstates true productivity growth (2.9%) because part of the output increase is due to higher labor utilization rather than higher A.

d. With both labor and capital utilization increasing by 3%: $Y = A(u_K K)^{0.3}(u_N N)^{0.7}$.

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + 0.3\frac{\Delta u_K}{u_K} + 0.7\frac{\Delta u_N}{u_N}.$$

$0.05 = \Delta A/A + 0.3(0.03) + 0.7(0.03) = \Delta A/A + 0.03$. $\Delta A/A = 0.02 = 2.0\%$.
The Solow residual growth of 5% overstates true productivity growth even more severely when both factors have variable utilization. The true increase in A is only 2%.

6. **Coin flip experiment.**

   Answer: No, fifty small independent random shocks will generally not produce large, sustained cycles in output. The resulting time path of output will resemble a **random walk** (since we're cumulating the coin flips starting from $Y = 50$). While the series will drift up and down, the movements are statistically random and do not exhibit the regular, recurring pattern that we associate with business cycles. There may be runs of several "heads" (positive shocks) producing a temporary upward trend, or runs of "tails" producing a temporary decline, but these are not systematic cycles. They lack:

   - **Persistence mechanisms** (like capital accumulation or technology diffusion) that could propagate a shock over many periods.
   - **Cyclical regularity** in periodicity or amplitude.

   This illustrates a key critique of early RBC models: purely random shocks without a strong propagation mechanism cannot generate the observed persistence and comovement of business cycles. Real business cycle models incorporate propagation mechanisms (investment dynamics, intertemporal substitution) precisely to transform random productivity shocks into cyclical patterns with the persistence we observe in actual data.

7. **Labor market dynamics (job loss and job finding rates).**

   a. Labor force $L = 100$ (million). Let E_t = employed, U_t = unemployed. $E_t + U_t = 100$.
   Transition: $U_{t+1} = (1-f)U_t + sE_t$, where $f = 0.19$ (finding rate), $s = 0.01$ (separation rate initially).
   January: $u_{\text{Jan}} = 5\%$, so $U_{\text{Jan}} = 5$, $E_{\text{Jan}} = 95$.
   February: $U_{\text{Feb}} = (1 - 0.19) \times 5 + 0.01 \times 95 = 0.81 \times 5 + 0.95 = 4.05 + 0.95 = 5.00$. $u_{\text{Feb}} = 5.00/100 = 5.0\%$.
   March: $U_{\text{Mar}} = 0.81 \times 5.00 + 0.01 \times 95.00 = 4.05 + 0.95 = 5.00$. $u_{\text{Mar}} = 5.0\%$.
   The unemployment rate stays at 5% because $sE = 0.01 \times 95 = 0.95 = fU = 0.19 \times 5 = 0.95$, i.e., the flows into and out of unemployment are equal—the economy is in steady state.

   b. April: $s = 0.03$ (adverse shock). May onward: $s = 0.01$.
   April: Start from March steady state ($U_{\text{Mar}} = 5.00$). $U_{\text{Apr}} = 0.81 \times 5.00 + 0.03 \times 95.00 = 4.05 + 2.85 = 6.90$. $u_{\text{Apr}} = 6.90\%$. $E_{\text{Apr}} = 100 - 6.90 = 93.10$.
   May: $s = 0.01$, starting from April. $U_{\text{May}} = 0.81 \times 6.90 + 0.01 \times 93.10 = 5.589 + 0.931 = 6.52$. $u_{\text{May}} = 6.52\%$. $E_{\text{May}} = 100 - 6.52 = 93.48$.
   June: $s = 0.01$. $U_{\text{Jun}} = 0.81 \times 6.52 + 0.01 \times 93.48 = 5.281 + 0.935 = 6.216$. $u_{\text{Jun}} \approx 6.22\%$. $E_{\text{Jun}} = 93.784$.
   July: $s = 0.01$. $U_{\text{Jul}} = 0.81 \times 6.216 + 0.01 \times 93.784 = 5.035 + 0.938 = 5.973$. $u_{\text{Jul}} \approx 5.97\%$.
   Notice that unemployment rises sharply in April due to the shock, then gradually converges back toward the steady-state rate of 5% once the separation rate returns to normal. The speed of convergence is $1 - (1 - s - f) = s + f = 0.20$ per month, so the half-life of the deviation is about $\ln(0.5)/\ln(0.80) \approx 3.1$ months.

8. **(Appendix 10.B) Parameter extraction and AD curve.**

a. IS curve: $r = 2.47 - 0.0004Y$.

From Appendix 9.B/10.B, the IS curve is $r = \alpha_{IS} - \beta_{IS}Y$. Thus: $\alpha_{IS} = 2.47$, $\beta_{IS} = 0.0004$.

Real money demand: $L = 0.5Y - 500(r + \pi^e)$ with $\pi^e = 0$, so $L = 0.5Y - 500r$.
Asset market equilibrium: $M/P = L \Rightarrow 88950/P = 0.5Y - 500r$.

From Appendix, LM: $r = \alpha_{LM} - \beta_{LM}Y + (1/l_r)(M/P)$ where $l_r = 500$.

Solve: $500r = 0.5Y - 88950/P \;\Rightarrow\; r = 0.001Y - 177.9/P$.

Rewrite in LM form: $r = -\frac{1}{500}\frac{M}{P} + \frac{0.5}{500}Y = -\frac{M}{500P} + 0.001Y$.

So: $\alpha_{LM} = 0$, $\beta_{LM} = -\frac{1}{500}$ (coefficient on M/P), and $\frac{\partial r}{\partial Y} = 0.001$ (the LM slope).

Alternatively using textbook notation where $r = \alpha_{LM} + \beta_{LM}Y + \gamma_{LM}(M/P)$: $\alpha_{LM} = 0$, $\beta_{LM} = 0.001$, $\gamma_{LM} = -1/500 = -0.002$.

$\bar{Y} = 6000$, $b = 100$ (coefficient on $P - P^e$ in SRAS).

b. AD curve: Eliminate r between IS and LM.

IS: $r = 2.47 - 0.0004Y$. LM: $88950/P = 0.5Y - 500r$.

Substitute: $88950/P = 0.5Y - 500(2.47 - 0.0004Y) = 0.5Y - 1235 + 0.2Y = 0.7Y - 1235$.

$0.7Y = 1235 + 88950/P$. $Y = 1764.29 + 127071.4/P$.

c. Short-run equilibrium: $P^e = 29.15$.

AD: $Y = 1764.29 + 127071.4/P$. AS: $Y = 6000 + 100(P - 29.15) = 6000 + 100P - 2915 = 3085 + 100P$.

Equate: $1764.29 + 127071.4/P = 3085 + 100P$. $127071.4/P = 1320.71 + 100P$.
Multiply by P: $127071.4 = 1320.71P + 100P^2$. $100P^2 + 1320.71P - 127071.4 = 0$.

Dividing by 100: $P^2 + 13.2071P - 1270.714 = 0$. $P = \frac{-13.2071 + \sqrt{174.43 + 5082.86}}{2} = \frac{-13.2071 + \sqrt{5257.29}}{2} = \frac{-13.2071 + 72.51}{2} \approx 29.65$.

$Y = 3085 + 100(29.65) \approx 6050$ (or from AD: $1764.29 + 127071.4/29.65 \approx 6050$).

d. Long-run equilibrium: $Y = \bar{Y} = 6000$, $P = P^e$.

From AD: $6000 = 1764.29 + 127071.4/P$. $4235.71 = 127071.4/P \;\Rightarrow\; P \approx 30.00$.

Since $P = P^e = 30.00$ in long-run equilibrium.

10.3 Analytical Problems

1. **Increase in expected future MPK.**

   a. Classical IS-LM model: An increase in the expected future marginal product of capital raises desired investment at any given real interest rate (firms want to invest more today to build up the capital stock that will be more productive in the future). The IS curve shifts right/up.

   Effects:

   - **Real interest rate:** Rises (to clear the goods market as investment demand increases).
   - **Output:** Unchanged at $\bar{Y}$ (determined by labor market equilibrium; current productivity is unaffected).
   - **Employment:** Unchanged (labor market is unaffected by future MPK changes that don't affect current productivity or labor supply).
   - **Real wages:** Unchanged (labor market unchanged).
   - **Consumption:** Falls slightly (higher r may reduce consumption, though the effect depends on intertemporal substitution).
   - **Investment:** Rises (the increase in desired investment outweighs the dampening effect of higher r; otherwise the IS curve wouldn't have shifted right).
   - **Price level:** Falls. With Y unchanged and higher r reducing real money demand (L depends negatively on r), for a given M, P must fall to clear the money market.

   b. Misperceptions theory (AD-AS): The increase in investment demand shifts AD right. In the short run, with P^e fixed, this raises both P and Y above $\bar{Y}$ as the economy moves along the upward-sloping SRAS curve.

   Key difference: In the classical IS-LM (no misperceptions), output is always at $\bar{Y}$ because prices are fully flexible and markets clear continuously. The increase in investment demand only changes the composition of output and the price level. In the misperceptions model, the price level increase is partially unanticipated ($P > P^e$), causing producers to misinterpret it as a relative price increase, and they increase output. In the long run, as expectations adjust, the economy returns to $\bar{Y}$.

   The difference arises because the misperceptions model allows short-run output deviations from full employment when price level changes are not fully anticipated, while the pure classical model assumes markets clear instantaneously.

2. **Permanent increase in government purchases.**

   a. Labor market effects:

   A **temporary** increase in G creates a negative wealth effect (higher taxes today only), shifting labor supply right. Employment rises, real wage falls.

   A **permanent** increase in G (financed by permanent increase in T) has an even larger negative wealth effect because the tax increase is permanent. Workers feel permanently poorer and increase labor supply more than under a temporary increase. However, if consumers reduce consumption by the full amount of the tax increase (Ricardian equivalence), the wealth effect on labor supply depends on whether the government spending provides equivalent utility to private consumption. If government spending does not substitute for private consumption, workers still feel poorer and labor supply shifts right, but by less than if consumers didn't adjust consumption one-for-one.

   b. If consumers reduce consumption by the full \$100 of the tax increase (at any given Y and r), then:

$$C^d = C_0 + \text{MPC}(Y - T) - cr.$$

   With T up by 100 and consumption down by exactly 100 (MPC $\times$ tax change = 100 if MPC = 1, or through a lump-sum reduction in autonomous consumption), then:

$$\text{Desired national saving } S^d = Y - C^d - G.$$

   The change in $S^d = -\Delta C^d - \Delta G = -(-100) - 100 = 0$. National saving is **unchanged**. Therefore the IS curve **does not shift**. This is an example of Ricardian equivalence: a tax-financed increase in government purchases does not affect national saving or the real interest rate if consumers fully internalize the government's budget constraint.

   c. With Ricardian equivalence holding (consumption falls by exactly 100 at each Y, r), the IS curve does not shift. Therefore:

   - **Output:** Unchanged at $\bar{Y}$ (unless labor supply changes).
   - **Real interest rate:** Unchanged.
   - **Price level:** Unchanged.

   If consumers reduce consumption by **less than** 100 (perhaps because they don't fully internalize the future tax burden, or have liquidity constraints, or are not fully Ricardian), then desired national saving falls (since $\Delta C^d > -100$, so $\Delta S^d = -\Delta C^d - \Delta G < 0$). In this case:

   - The IS curve shifts right/up (lower national saving at each r).
   - Real interest rate rises.
   - Investment is crowded out.
   - If labor supply responds to the wealth effect, output may change as well.

3. **Business cycle theory based on temporary government purchase shocks.**

   a. Employment: Explains well. In the classical model, temporary increases in G generate a negative wealth effect, increasing labor supply and employment. Employment would be procyclical, matching observed business cycle facts. However, this theory predicts that employment rises because workers feel poorer and want to work more—during "booms" driven by government spending, workers are actually worse off in welfare terms, which seems counterintuitive.

   b. Real wage: Explains poorly. In the classical model, an increase in labor supply (from higher G) reduces the equilibrium real wage (movement along the labor demand curve). This predicts **countercyclical** real wages. However, empirical evidence generally shows real wages are **procyclical** (or at least acyclical). This is a major weakness of a pure government-spending-driven business cycle theory.

   c. Average labor productivity: Explains poorly. With the production function $Y = AF(K, N)$, as N increases (from higher labor supply), the marginal product of labor falls due to diminishing returns. Average labor productivity (Y/N) also falls. This predicts countercyclical productivity, contradicting the well-established fact that productivity is procyclical.

   d. Investment: Explains poorly or mixed. Higher government purchases raise the real interest rate (crowding out), which should reduce investment. This predicts **countercyclical** investment. In reality, investment is strongly **procyclical**—it rises in booms and falls in recessions. This is a significant failure of the government-spending theory.

   e. Price level: Explains mixed. With output fixed (or rising slightly) and G rising (reducing national saving, raising r), real money demand falls (since higher r reduces money demand). For a given M, the price level must rise to maintain money market equilibrium. This predicts procyclical prices. Historically, U.S. prices were procyclical before the mid-1980s but have been acyclical or mildly countercyclical since then.

4. **Reverse causation—a detailed example.**

   a. Suppose real money demand depends on expected future output: $L = L(Y, r, Y^e_{\text{future}})$, with $\partial L/\partial Y^e_{\text{future}} > 0$ (higher expected future output increases current transactions demand for money).

   An increase in expected future output (Y^e_{future} rises) increases current real money demand. In the classical IS-LM model:

   - The IS curve is unaffected (by assumption, effects on saving and investment are negligible).
   - The FE line is unaffected ($\bar{Y}$ unchanged).
   - The LM curve shifts left/up: at any Y, higher money demand for given M means higher r needed to clear the money market. Equivalently, for money market equilibrium at given Y and M, the price level must fall (since M/P must equal the higher L).

   Thus: **The current price level falls.**

   b. If the Fed wants to stabilize the current price level (prevent it from falling), it must increase the nominal money supply M to accommodate the increase in real money demand. By increasing M, the Fed keeps M/P equal to the new, higher L without requiring P to fall.

This is an example of **reverse causation** because:

i. The original cause is an increase in expected future output (a real factor).

ii. This leads to higher money supply through Fed accommodation.

iii. An outside observer sees: higher M is correlated with higher future output (which is indeed higher, as expected).

iv. But the causation runs from expected output to money, not from money to output.

The observed correlation between money growth and output growth could thus reflect the Fed's endogenous response to expected economic conditions, rather than monetary policy driving the business cycle.

5. **Temporary wage tax to finance foreign aid.**

   (a) **Labor supply effect:** A temporary 10% tax on current wages reduces the after-tax real wage workers receive: $w_{\text{after-tax}} = (1 - 0.10)w = 0.90w$. This has two effects:

   - **Substitution effect:** The lower after-tax wage makes leisure relatively cheaper, reducing labor supply.
   - **Income/wealth effect:** The tax reduces workers' disposable income, making them feel poorer, which increases labor supply.

   For a **temporary** tax (future wages untaxed), the substitution effect likely dominates because the negative wealth effect is limited (only current income is affected, not permanent income). Therefore, labor supply **decreases** (shifts left).

   (b) **Effects in the classical IS-LM model:**

   - **Employment:** Falls (labor supply shifts left; equilibrium N decreases).
   - **Output:** Falls (lower N means lower Y—the FE line shifts left).
   - **Before-tax real wage:** Rises. With lower labor supply at each before-tax wage, the equilibrium before-tax wage increases (movement along labor demand). The after-tax real wage may rise or fall depending on the magnitudes.
   - **Real interest rate:** The foreign aid program (government purchases goods to ship abroad) is an increase in G. Higher G reduces national saving, shifting IS right and tending to raise r. But lower output reduces saving as well. The net effect on r is ambiguous. With lower Y, $S^d = Y - C^d - G$ likely falls (unless C^d falls enough), so r likely rises.
   - **Price level:** Ambiguous—lower Y (from reduced labor supply) increases the price level (lower output with unchanged M) while higher r reduces money demand, further raising P.

11 Keynesianism: The Macroeconomics of Wage and Price Rigidity

11.1 Review Questions

1. **Define efficiency wage. What assumption about worker behavior underlies the efficiency wage theory? Why does it predict that the real wage will remain rigid even if there is an excess supply of labor?**

   Answer: An **efficiency wage** is a real wage set above the market-clearing level that maximizes the firm's profit by eliciting the highest *effort per dollar* of wage expenditure. The key insight is that worker effort/productivity depends positively on the real wage paid.

   The underlying assumption is that **worker effort is an increasing function of the real wage**: $e = e(w)$, with $e'(w) > 0$. This can arise from several mechanisms:

   - **Nutrition models:** Higher wages allow better nutrition, making workers more productive (relevant in developing countries).
   - **Shirking models:** Higher wages increase the cost of job loss, deterring workers from shirking when monitoring is imperfect.
   - **Turnover models:** Higher wages reduce quits, lowering recruitment and training costs.
   - **Adverse selection:** Higher wages attract a better pool of applicants.
   - **Fairness/morale:** Workers who feel well-paid work harder.

   The efficiency wage remains rigid even with excess labor supply because it is **profit-maximizing** for the firm, not just a market outcome. A firm that cuts wages would:

   (a) Pay less per worker, but

   (b) Get disproportionately less effort from each worker, reducing the *efficiency* of its wage bill.

   The condition for the optimal efficiency wage is that the elasticity of effort with respect to the wage equals 1: the firm sets w such that $w \cdot e'(w)/e(w) = 1$. At this wage, the firm minimizes its wage bill per efficiency unit of labor. Even if unemployed workers offer to work for less, the firm will not hire them at a lower wage because the decline in effort would more than offset the wage savings. This creates equilibrium involuntary unemployment that persists because the efficiency wage does not adjust downward.

2. **How is full-employment output determined in the Keynesian model with efficiency wages? How is full-employment output affected by productivity changes and labor supply changes?**

   Answer: In the Keynesian model with efficiency wages, **full-employment output** $\bar{Y}$ is the level of output when the labor market is in equilibrium *given the efficiency wage*. Specifically:

   - The efficiency wage w^* is determined by the condition that the effort-per-dollar is maximized: $e'(w^*) = e(w^*)/w^*$ (or equivalently, the effort elasticity equals 1).
   - At w^*, firms demand labor where $MPN = w^*$ (the labor demand curve).

- Full-employment output is then $\bar{Y} = AF(K, N_{\text{FE}})$, where N_{FE} is the amount of labor demanded at w^*, and there may be involuntary unemployment (the difference between labor supply at w^* and N_{FE}).

Effects of changes:

- **Productivity increase (positive supply shock):** Shifts the MPN curve right/up. At the fixed efficiency wage w^*, firms demand more labor (N_{FE} rises). $\bar{Y}$ increases both because of higher A and higher N.
- **Labor supply increase:** Has **no effect** on $\bar{Y}$ or employment! An increase in labor supply (e.g., immigration) shifts the labor supply curve right but does not affect the efficiency wage w^* or the MPN curve. At w^*, firms still demand the same amount of labor. The only effect is to increase the pool of involuntarily unemployed workers. This is a key difference from the classical model.

3. **What is price stickiness? Why do Keynesians believe that allowing for price stickiness in macroeconomic analysis is important?**

   Answer: Price stickiness is the empirical phenomenon that prices of many goods and services do not adjust immediately or continuously to changes in supply and demand conditions. Instead, prices tend to remain fixed for periods of time (the median duration of price spells varies by product but is often several months to a year), and adjust only intermittently.

   Keynesians believe price stickiness is important for macroeconomic analysis because:

   (a) **It breaks monetary neutrality in the short run.** With sticky prices, an increase in the nominal money supply is an increase in the real money supply (M/P rises because P is fixed), which shifts the LM curve down/right, lowering real interest rates and stimulating aggregate demand and output.

   (b) **It provides a role for aggregate demand in determining output.** When prices don't adjust to equate supply and demand in all markets, output is determined by the level of aggregate demand (the Keynesian cross or IS-LM intersection), not just by supply-side factors.

   (c) **It explains involuntary unemployment and recessions.** If prices cannot fall to clear goods markets during a demand shortfall, firms produce less and employ fewer workers.

   (d) **It justifies stabilization policy.** Because the economy does not self-correct quickly, monetary and fiscal policy can improve outcomes by managing aggregate demand.

4. **Define menu cost. Why might small menu costs lead to price stickiness in monopolistically competitive markets but not in perfectly competitive markets?**

   Answer: Menu costs are the physical and managerial costs of changing prices—the costs of printing new menus, catalogs, price tags, reprogramming computers, and the managerial time spent deciding on new prices. Named after the cost of printing new menus in a restaurant.

   Small menu costs can lead to significant price stickiness in **monopolistically competitive** markets but not in **perfectly competitive** markets because of the different profit implications of a price deviation:

- **Perfect competition:** The firm is a price-taker facing a horizontal demand curve at the market price. If the firm's own price deviates slightly from the market price, it either loses all customers (if too high) or fails to maximize revenue (if too low). The **private cost of not adjusting** price is **first-order** (large), so even small menu costs are outweighed. Prices are flexible.
- **Monopolistic competition:** The firm faces a downward-sloping demand curve. At the profit-maximizing price, the profit function is **flat** (first-order condition: marginal profit = 0). A small deviation from the optimal price produces only a **second-order** (very small) loss in profits. Therefore, even small menu costs can exceed the private benefit of price adjustment. Prices remain sticky.

When actual demand is greater than anticipated, a monopolistically competitive firm can **profitably meet the higher demand at its fixed price** because price exceeds marginal cost ($P > MC$). The firm earns additional profit on each extra unit sold, even though the price is not at the new *ex post* optimum. This is in contrast to a perfectly competitive firm where $P = MC$, so meeting extra demand at the fixed price adds nothing to profit.

5. **What does the Keynesian model predict about monetary neutrality? Compare with the basic classical model and the extended classical model with misperceptions.**

   Answer:

	Basic Classical	**Extended Classical (Misperceptions)**	**Keynesian**
Short run	Money is neutral	Money is non-neutral only if **unanticipated**	Money is non-neutral regardless of whether anticipated
Long run	Money is neutral	Money is neutral	Money is neutral

   Keynesian model details:

   - **Short run:** With sticky prices, a change in M changes the real money supply (M/P), shifting LM and AD. Output, employment, and real interest rates all change. Even **anticipated** monetary policy has real effects because prices don't adjust immediately. This is the fundamental difference from the classical misperceptions model, where only unanticipated money matters.
   - **Long run:** Eventually, prices adjust fully (P changes proportionally to M), the real money supply returns to its original level, and all real variables return to their original values. Money is neutral in the long run.

   Basic classical: Prices adjust immediately and proportionally; money is always neutral.

   Extended classical (misperceptions): Unanticipated monetary changes have short-run real effects through producer confusion; anticipated changes are neutral even in the short run. This is the **policy ineffectiveness proposition**.

6. **In the Keynesian model, how do increased government purchases affect output and the real interest rate in the short run? In the long run? How do they affect the composition of output in the long run?**

Answer:

Short run (prices fixed):

- **Output:** Increases through the multiplier effect. Higher G directly increases aggregate demand; the increase in income leads to higher consumption (MPC $\times \Delta Y$), further raising demand. The IS curve shifts right, and with sticky prices, the LM curve is upward-sloping, so both Y and r rise. The multiplier is less than the simple Keynesian cross multiplier because of crowding out through higher interest rates.
- **Real interest rate:** Rises (higher Y increases money demand, requiring higher r to clear the money market at the fixed price level).

Long run (prices adjust fully):

- **Output:** Returns to full-employment $\bar{Y}$. In the long run, the price level rises (shifting LM left/up) until output is back at $\bar{Y}$.
- **Real interest rate:** Higher than initially. The long-run r rises to clear the goods market at $\bar{Y}$ with higher G.
- **Composition of output:** Government purchases permanently claim a larger share of $\bar{Y}$, **crowding out** private investment and possibly consumption. Investment falls because r is permanently higher. Consumption may fall if higher r reduces consumption or if Ricardian equivalence does not hold perfectly.

7. **Describe three alternative responses available to policymakers when the economy is in recession. Advantages and disadvantages of each. Practical difficulties.**

Answer:

Policy 1: Expansionary Monetary Policy (increase M).

- **How it works:** Increase money supply, shifting LM right/down, lowering real interest rates, stimulating investment and consumption, shifting AD right.
- **Advantages:** Can be implemented quickly (central bank decisions are fast); does not increase government debt; relatively well-understood transmission mechanism.
- **Disadvantages:** May be ineffective in a liquidity trap (when nominal interest rates are near zero); risk of future inflation if overdone; long and variable lags (Friedman); may fuel asset bubbles.
- **Effects:** Employment rises, price level may rise in short run, composition shifts toward investment.

Policy 2: Expansionary Fiscal Policy (increase G or cut T).

- **How it works:** Increases aggregate demand directly (G) or through consumption (T cuts), shifting IS right, raising output.
- **Advantages:** Effective even in a liquidity trap (doesn't rely on interest rate channel); direct impact on output and employment; can be targeted to specific sectors.
- **Disadvantages:** Increases government debt (future taxes); implementation lags (legislative process); potential for permanent increases in government size; crowding out of private investment through higher interest rates.

- **Effects:** Employment rises, price level may rise in short run, composition shifts toward government spending and away from investment.

Policy 3: Do Nothing (wait for self-correction).

- **How it works:** Allow wage and price flexibility to eventually restore full employment; the recession creates downward pressure on prices, which increases real money supply (M/P rises), shifting LM right and restoring $\bar{Y}$.
- **Advantages:** No policy errors or unintended consequences; no increase in debt; avoids moral hazard.
- **Disadvantages:** The self-correction mechanism may be very slow (Keynes: "In the long run we are all dead"); prolonged unemployment imposes large welfare costs (lost output, human capital deterioration, poverty); deflation can be destabilizing (debt-deflation spiral).

Practical difficulties in stabilization policy:

(a) **Lags:** Recognition lag (time to identify recession), implementation lag (legislative process for fiscal policy), and impact lag (time for policy to affect the economy).

(b) **Uncertainty:** Unknown magnitude of multipliers; uncertainty about the natural rate of unemployment and full-employment output.

(c) **Political constraints:** Fiscal expansion is politically easier than fiscal contraction; monetary policy may face political pressure.

(d) **Expectations:** If policy is anticipated, it may be less effective (Lucas critique).

(e) **Risk of overshooting:** Aggressive policy may push the economy past full employment, causing inflation.

8. **Use the Keynesian model to explain the procyclical behavior of employment, money, inflation, and investment.**

Answer:

- **Employment (procyclical):** In booms (AD shifts right or positive IS shock), output and employment rise together. In the Keynesian model with sticky prices, firms meet the higher demand by hiring more workers. In the efficiency wage version, higher demand shifts the labor demand curve right along the horizontal efficiency wage, raising employment. The procyclicality of employment is a natural prediction: firms produce more, so they hire more.
- **Money (procyclical):** In booms, higher output increases transactions demand for money (L depends positively on Y). For a given money supply and price level, this would raise interest rates. If the central bank accommodates (increases M to stabilize interest rates), the money supply expands endogenously. Additionally, the banking system creates more inside money (deposits) through increased lending during expansions. This explains the procyclical behavior of money without money causing the cycle.
- **Inflation (procyclical):** In the short run, expansionary AD shocks raise both output and the price level. The Phillips curve relationship ($\pi = \pi^e - h(u - \bar{u})$) predicts that when output is above potential (unemployment below natural rate), inflation rises.

In booms, tight labor markets put upward pressure on wages and prices. Conversely, recessions create slack that dampens inflation. The procyclicality of inflation is thus a prediction of both demand-driven cycles and the Phillips curve mechanism.

- **Investment (procyclical):** Investment is the most volatile component of GDP and strongly procyclical. In the Keynesian model, booms raise output and income, which increases desired investment through the accelerator effect (firms need more capital to produce more). Additionally, higher output and income improve business confidence about future profitability. Lower real interest rates (if monetary policy is accommodative) also stimulate investment. During recessions, excess capacity and pessimistic expectations depress investment.

9. **What does the Keynesian model predict about the cyclical behavior of average labor productivity? How does labor hoarding help?**

   Answer: The **basic Keynesian model** (without labor hoarding) predicts that average labor productivity (Y/N) is **countercyclical**. The reasoning: firms operate on their production function with diminishing marginal product of labor. During a boom, firms hire more workers, which drives down the marginal product of labor (and average product). During recessions, with fewer workers, average productivity should be higher. This prediction contradicts the data, which shows productivity is **procyclical**.

   Labor hoarding resolves this contradiction. The idea is that firms do not adjust employment one-for-one with output changes because:

   - Hiring and firing are costly (training costs, severance pay, loss of firm-specific human capital).
   - Firms want to retain skilled workers through temporary downturns.

   Instead of laying off workers during recessions, firms "hoard" labor—keeping workers on the payroll but utilizing them less intensively (fewer hours, less effort, maintenance work, training). As a result:

   - During **booms:** Firms increase output primarily by raising the **utilization rate** of existing workers (more hours, higher effort). Measured employment rises modestly while output rises sharply. Measured productivity (Y/N) rises.
   - During **recessions:** Firms reduce utilization rather than laying off workers proportionally. Output falls more than employment. Measured productivity falls.

   With labor hoarding, productivity becomes **procyclical**, matching the data. The Solow residual is procyclical partly because variable effort/utilization is not captured in measured inputs.

10. **According to Keynesian analysis, in what two ways does an adverse supply shock reduce output? What problems do supply shocks create for stabilization policy?**

    Answer: An adverse supply shock reduces output in two ways:

    (a) **Direct reduction in productive capacity:** The supply shock lowers productivity (reduces A or shifts the production function). At any given level of employment, output is lower. The FE line (full-employment output) shifts left. In the efficiency wage model,

lower productivity reduces the MPN at the efficiency wage, so firms demand less labor, further reducing output.

(b) **Reduction in aggregate demand (indirect effect):** The supply shock typically raises prices (negative supply shock shifts SRAS up/left). The higher price level reduces real money balances (M/P falls), shifting the LM curve left/up, raising interest rates, and reducing investment and consumption. Additionally, the price increase may reduce real wealth and consumer confidence, further depressing aggregate demand. So a supply shock can cause **stagflation**—simultaneous recession (low output) and inflation.

Problems for stabilization policy:

- **Policy dilemma:** If the central bank expansionarily responds to the output decline (increasing M), it will further increase inflation. If it tightens to fight inflation, it will deepen the recession. There is no policy that simultaneously restores full employment *and* price stability.
- **Output-inflation tradeoff worsens:** The Phillips curve shifts unfavorably (higher inflation at any unemployment rate, or higher $\bar{u}$).
- **Uncertainty:** It's hard to distinguish supply shocks from demand shocks in real time, risking inappropriate policy responses.
- **The natural rate may change:** Persistent supply shocks can change the natural rate of unemployment, making it difficult to know the appropriate policy target.

11.2 Numerical Problems

1. **Efficiency wage choice.**

   The firm chooses the wage that minimizes the wage bill per efficiency unit, i.e., the wage that maximizes effort per dollar E/w.

Real Wage w	Effort E	E/w	w/E (cost per effort unit)
8	7	0.875	1.143
10	10	1.000	1.000
12	15	1.250	0.800
14	17	1.214	0.824
16	19	1.188	0.842
18	20	1.111	0.900

   The firm maximizes E/w, which is maximized at $w = 12$ (where $E/w = 1.25$). Equivalently, the firm minimizes cost per efficiency unit w/E, which is minimized at $w = 12$ (where $w/E = 0.80$). So the firm should choose $w = 12$.

   At $w = 12$, $E = 15$. The labor demand is where $w = MPN$:

$$12 = \frac{15(100 - N)}{15} = 100 - N \;\Rightarrow\; N = 88.$$

   The firm employs **88 workers**.

   With 200 workers willing to work at $w = 8$: This does not change the firm's decision. The efficiency wage theory holds that the firm pays $w = 12$ not because it *has* to (to attract workers) but because it *wants* to (to maximize effort per dollar). Even though 200 workers are willing to work at $w = 8$, the firm would not hire them at that wage because effort would be too low. At $w = 8$, effort is only 7, and the cost per efficiency unit is $8/7 \approx 1.143$, higher than 0.80 at $w = 12$.

   The firm hires 88 workers at $w = 12$, leaving 112 workers either unemployed or working elsewhere. The availability of cheap labor does not change the efficiency wage calculus.

2. **Keynesian IS-LM with investment optimism.**

   a. IS and LM equations.

   IS: $Y = C^d + I^d + G$.

$$Y = [130 + 0.5(Y - 100) - 500r] + [100 - 500r] + 100$$

$$Y = 130 + 0.5Y - 50 - 500r + 100 - 500r + 100 = 280 + 0.5Y - 1000r$$

$$0.5Y = 280 - 1000r \;\Rightarrow\; Y = 560 - 2000r.$$

   IS: $r = 0.28 - 0.0005Y$.

   LM: $M/P = L \;\Rightarrow\; 1320/P = 0.5Y - 1000r$. With P not yet determined, this is: $r = 0.0005Y - (1320/P)/1000 = 0.0005Y - 1.32/P$.

b. Full-employment equilibrium.

At full employment, $Y = \bar{Y} = 500$.

From IS: $500 = 560 - 2000r \;\Rightarrow\; 2000r = 60 \;\Rightarrow\; r = 0.03 = 3\%$.

From LM: $1320/P = 0.5(500) - 1000(0.03) = 250 - 30 = 220$. $P = 1320/220 = 6.00$.

$C = 130{+}0.5(500{-}100){-}500(0.03) = 130{+}200{-}15 = 315$. $I = 100{-}500(0.03) = 85$. Check: $C + I + G = 315 + 85 + 100 = 500 = \bar{Y}$. ✓

c. Investment optimism: $I^d = 200 - 500r$.

New IS:

$$Y = 130 + 0.5Y - 50 - 500r + 200 - 500r + 100 = 380 + 0.5Y - 1000r$$

$$0.5Y = 380 - 1000r \;\Rightarrow\; Y = 760 - 2000r \text{ or } r = 0.38 - 0.0005Y.$$

Short run (price fixed at $P = 6.00$):

LM at $P = 6$: $1320/6 = 220 = 0.5Y - 1000r \;\Rightarrow\; r = 0.0005Y - 0.22$.

Equate IS and LM: $0.38 - 0.0005Y = 0.0005Y - 0.22$. $0.60 = 0.001Y \;\Rightarrow\; Y = 600$. $r = 0.38 - 0.0005(600) = 0.38 - 0.30 = 0.08 = 8\%$.

$C = 130{+}0.5(600{-}100){-}500(0.08) = 130{+}250{-}40 = 340$. $I = 200{-}500(0.08) = 160$. $C + I + G = 340 + 160 + 100 = 600$. ✓

Short-run results: $Y = 600$, $r = 8\%$, $P = 6.00$, $C = 340$, $I = 160$.

Long run ($Y = \bar{Y} = 500$, P adjusts):

From IS: $500 = 760 - 2000r \;\Rightarrow\; r = 0.13 = 13\%$.

LM: $M/P = 0.5(500) - 1000(0.13) = 250 - 130 = 120$. $P = 1320/120 = 11.00$.

$C = 130{+}0.5(500{-}100){-}500(0.13) = 130{+}200{-}65 = 265$. $I = 200{-}500(0.13) = 135$. Check: $C + I + G = 265 + 135 + 100 = 500$. ✓

Long-run results: $Y = 500$, $r = 13\%$, $P = 11.00$, $C = 265$, $I = 135$.

Graphical analysis: The investment boom shifts IS right. In the short run (fixed P), output rises to 600 with higher r. In the long run, as P rises (from 6 to 11), the LM curve shifts left/up (real money balances fall), raising r further and returning output to $\bar{Y}$. The long run features complete crowding out of the initial investment optimism's output effect, but I is still higher than originally (135 vs. 85), while C is lower (265 vs. 315) due to higher r.

3. **Liquidity trap.**

a. At full employment $Y = \bar{Y} = 8000$.

Goods market equilibrium ($S^d = I^d$ approach):

$S^d = Y - C^d - G = Y - [600 + 0.8(Y - 1000) - 500r] - 1000$.

At $Y = 8000$: $S^d = 8000 - [600 + 0.8(7000) - 500r] - 1000 = 8000 - 600 - 5600 + 500r - 1000 = 800 + 500r$.

$I^d = 400 - 500r$.

Equilibrium: $S^d = I^d \Rightarrow 800 + 500r = 400 - 500r \Rightarrow 1000r = -400 \Rightarrow r = -0.40 = -40\%$.

Since $\pi^e = 0$, the nominal interest rate $i = r + \pi^e = -0.40 = -40\%$, which is **impossible** (violates the zero lower bound since $i \geq 0$). The economy is in a **liquidity trap**: at $i = 0$, people are indifferent between money and bonds, and the LM curve is horizontal. The real interest rate cannot go below 0% (since $i = r$ when $\pi^e = 0$), but full employment requires $r = -40\%$.

Can monetary policy alone restore full employment? No. At the zero lower bound, increasing M simply shifts the LM curve's horizontal portion rightward, but since interest rates cannot fall below zero, additional money is held as idle balances. Output remains below full employment. This is the **liquidity trap**: conventional monetary policy is impotent.

b. Policy to restore full employment at $i = 0$:

At $i = 0$ ($r = 0$ since $\pi^e = 0$): $S^d = Y - C^d - G = Y - [600 + 0.8(Y - T) - 0] - G$. At $Y = \bar{Y} = 8000$: $S^d = 8000 - 600 - 0.8(8000 - T) - G = 7400 - 0.8(8000 - T) - G$.

$I^d = 400 - 0 = 400$.

For equilibrium at $Y = 8000$, $r = 0$: $S^d = I^d \Rightarrow 7400 - 0.8(8000 - T) - G = 400$. Also, balanced budget or any G, T combination works. Simplify with $T = G$: $7400 - 0.8(8000 - G) - G = 400$. $7400 - 6400 + 0.8G - G = 400$. $1000 - 0.2G = 400 \Rightarrow 0.2G = 600 \Rightarrow G = 3000$.

So $G = T = 3000$ restores full employment at $r = 0$.

Money supply: $M/P = L = 0.5(8000) - 200(0) = 4000$. $M = 4000P = 4000 \times 2.0 = 8000$ (or any M large enough, since at $i = 0$, LM is horizontal—the exact M doesn't matter for equilibrium, as long as it's large enough to be on the flat portion of LM).

Relevance to Japan in the 1990s: Japan experienced a liquidity trap with near-zero interest rates, deflation, and persistent output below potential. The analysis suggests that fiscal expansion (increased government spending, perhaps combined with tax cuts or at least not offset by higher taxes) can restore full employment when monetary policy is constrained by the zero lower bound. This is exactly the policy prescription many economists advocated for Japan during its "Lost Decade."

4. **AD curve and equilibrium.**

a. Aggregate demand curve.

Goods market: $Y = C^d + I^d + G = [300 + 0.5(Y - 100) - 300r] + [100 - 100r] + 100$.

$$Y = 300 + 0.5Y - 50 - 300r + 100 - 100r + 100 = 450 + 0.5Y - 400r$$

$$0.5Y = 450 - 400r \;\Rightarrow\; Y = 900 - 800r \text{ or } r = 1.125 - 0.00125Y.$$

Asset market: $M/P = L \Rightarrow 6300/P = 0.5Y - 200r$. Substitute r: $6300/P = 0.5Y - 200(1.125 - 0.00125Y) = 0.5Y - 225 + 0.25Y = 0.75Y - 225$.

AD curve: $0.75Y = 225 + 6300/P \;\Rightarrow\; Y = 300 + 8400/P$.

b. Short-run equilibrium at $P = 15$.

$Y = 300 + 8400/15 = 300 + 560 = 860$. $r = 1.125 - 0.00125(860) = 1.125 - 1.075 = 0.05 = 5\%$. $C = 300 + 0.5(860 - 100) - 300(0.05) = 300 + 380 - 15 = 665$. $I = 100 - 100(0.05) = 95$. Check: $C + I + G = 665 + 95 + 100 = 860 = Y$. ✓

c. Long-run equilibrium.

In the long run, $Y = \bar{Y} = 700$.

From AD: $700 = 300 + 8400/P \;\Rightarrow\; 400 = 8400/P \;\Rightarrow\; P = 21$.

From goods market at $Y = 700$: $700 = 900 - 800r \;\Rightarrow\; 800r = 200 \;\Rightarrow\; r = 0.25 = 25\%$.

$C = 300 + 0.5(700 - 100) - 300(0.25) = 300 + 300 - 75 = 525$. $I = 100 - 100(0.25) = 75$. Check: $C + I + G = 525 + 75 + 100 = 700$. ✓

Long-run equilibrium: $Y = 700$, $r = 25\%$, $P = 21$, $C = 525$, $I = 75$.

5. **(Appendix 11.A) Contract nominal wage model.**

a. The labor demand curve: firms hire until $MPN = w$, where $w = W/P$ is the real wage. $MPN = 10/\sqrt{N} = w$. Therefore: $w = 10/\sqrt{N}$ or $N = 100/w^2$.

b. With $W = 20$, the real wage is $w = 20/P$. Labor demand: $20/P = 10/\sqrt{N} \Rightarrow 2/P = 1/\sqrt{N} \Rightarrow \sqrt{N} = P/2 \Rightarrow N = P^2/4$.

c. Output supplied: $Y = 20\sqrt{N} = 20\sqrt{P^2/4} = 20 \cdot P/2 = 10P$.

So the **aggregate supply curve** is $Y = 10P$ (for $W = 20$). This is an upward-sloping AS curve—higher price level reduces the real wage (since nominal wage is fixed), firms hire more workers, and output rises.

d. AD curve derivation ($M = 300$).

IS: $Y = 120 - 500r$. LM: $300/P = 0.5Y - 500r$.

From IS: $r = 0.24 - 0.002Y$. Substitute into LM: $300/P = 0.5Y - 500(0.24 - 0.002Y) = 0.5Y - 120 + Y = 1.5Y - 120$.

AD: $1.5Y = 120 + 300/P \Rightarrow Y = 80 + 200/P$.

e. Equilibrium with $M = 300$:

AD: $Y = 80 + 200/P$. AS: $Y = 10P$.

Equate: $10P = 80 + 200/P$. Multiply by P: $10P^2 - 80P - 200 = 0$. $P^2 - 8P - 20 = 0$. $(P - 10)(P + 2) = 0$. $P = 10$.

$Y = 10(10) = 100$. $N = P^2/4 = 100/4 = 25$. Real wage: $w = W/P = 20/10 = 2$. Real interest rate: from IS, $Y = 120 - 500r \Rightarrow 100 = 120 - 500r \Rightarrow r = 0.04 = 4\%$.

f. Equilibrium with $M = 135$:

AD: $Y = 80 + 200/P$ (same form, but with $M = 135$): Actually, recalculate: $135/P = 0.5Y - 500r$. From IS: $r = 0.24 - 0.002Y$. $135/P = 0.5Y - 500(0.24 - 0.002Y) = 0.5Y - 120 + Y = 1.5Y - 120$. AD: $Y = 80 + 90/P$.

AS: $Y = 10P$.

$10P = 80 + 90/P \Rightarrow 10P^2 - 80P - 90 = 0 \Rightarrow P^2 - 8P - 9 = 0$. $(P - 9)(P + 1) = 0$. $P = 9$.

$Y = 10(9) = 90$. $N = 81/4 = 20.25$. $w = 20/9 \approx 2.22$. r: $90 = 120 - 500r \Rightarrow r = 0.06 = 6\%$.

Comparison: Lower money supply ($M = 135$ vs. $M = 300$) leads to lower price level (9 vs. 10), lower output (90 vs. 100), lower employment (20.25 vs. 25), higher real wage (2.22 vs. 2.00), and higher real interest rate (6% vs. 4%). Money is non-neutral in this model because the nominal wage is fixed by contract.

6. **(Appendix 11.C) Government purchases multiplier.**

a. Full-employment equilibrium.

Goods market: $Y = C^d + I^d + G$. $Y = [325 + 0.5(Y - 150) - 500r] + [200 - 500r] + 150$. $Y = 325 + 0.5Y - 75 - 500r + 200 - 500r + 150 = 600 + 0.5Y - 1000r$. $0.5Y = 600 - 1000r \Rightarrow Y = 1200 - 2000r$.

At $Y = \bar{Y} = 1000$: $1000 = 1200 - 2000r \Rightarrow r = 0.10 = 10\%$.

$C = 325 + 0.5(1000 - 150) - 500(0.10) = 325 + 425 - 50 = 700$. $I = 200 - 500(0.10) = 150$. Check: $700 + 150 + 150 = 1000$. ✓

Money market: $M/P = L = 0.5Y - 1000r$. At $Y = 1000, r = 0.10$: $L = 0.5(1000) - 1000(0.10) = 500 - 100 = 400$. $P = M/L = 6000/400 = 15$.

Full-employment: $r = 10\%$, $P = 15$, $C = 700$, $I = 150$.

b. Parameters.

From Appendix 9.B: IS: $Y = \alpha_{IS} - \beta_{IS} r$, where from goods market $Y = 1200 - 2000r$, so $\alpha_{IS} = 1200$, $\beta_{IS} = 2000$.

LM: From $M/P = 0.5Y - 1000r$, solve for r: $r = 0.0005Y - M/(1000P)$. In the form $r = \alpha_{LM} + \beta_{LM} Y + \gamma_{LM}(M/P)$: $\alpha_{LM} = 0$, $\beta_{LM} = 0.0005$, $\gamma_{LM} = -1/1000 = -0.001$.

$l_r = 1000$ (the coefficient on r in money demand).

c. Short-run equilibrium at $\bar{P} = 15$.

LM at $P = 15$: $6000/15 = 400 = 0.5Y - 1000r \Rightarrow r = 0.0005Y - 0.4$.

IS: $Y = 1200 - 2000r$. Substitute: $Y = 1200 - 2000(0.0005Y - 0.4) = 1200 - Y + 800 = 2000 - Y$. $2Y = 2000 \Rightarrow Y = 1000$. $r = 0.0005(1000) - 0.4 = 0.5 - 0.4 = 0.10 = 10\%$.

At $P = 15$, the economy is at full employment (coincidentally, $P = 15$ is the long-run price).

d. Increase in G to 250 (price fixed).

New IS: $Y = 325 + 0.5(Y - 150) - 500r + 200 - 500r + 250$. $Y = 325 + 0.5Y - 75 - 500r + 200 - 500r + 250 = 700 + 0.5Y - 1000r$. $0.5Y = 700 - 1000r \Rightarrow Y = 1400 - 2000r$. So $\alpha_{IS} = 1400$.

Short-run: LM at $P = 15$ gives $r = 0.0005Y - 0.4$. $Y = 1400 - 2000(0.0005Y - 0.4) = 1400 - Y + 800 = 2200 - Y$. $2Y = 2200 \Rightarrow Y = 1100$. $r = 0.0005(1100) - 0.4 = 0.55 - 0.4 = 0.15 = 15\%$.

Short-run: $Y = 1100$, $\alpha_{IS} = 1400$.

e. Government purchases multiplier.

Eq. (11.C.5): $\Delta Y/\Delta G = \frac{1}{1 - MPC + (I_r/l_r)\beta_{IS}}$.

Here MPC = 0.5, $I_r = 500$ (from $I^d = 200 - 500r$), $l_r = 1000$, $\beta_{IS} = 2000$ (the coefficient on r in the IS curve—actually, wait: β_{IS} from Appendix is the coefficient on r in IS, which is 2000 as $Y = \alpha_{IS} - \beta_{IS} r$).

Actually, let me be careful. The IS is $Y = \alpha_{IS} - \beta_{IS} r$, so $\beta_{IS} = 2000$. $I_r = 500$ (sensitivity of investment to r). $l_r = 1000$ (sensitivity of money demand to r, $L = \ldots - l_r r$).

Multiplier = $\frac{1}{1 - 0.5 + (500/1000) \times 2000} = \frac{1}{0.5 + 0.5 \times 2000} \ldots$ Hmm, this doesn't look right. Let me re-examine.

From Appendix 11.C: The multiplier is $\frac{\Delta Y}{\Delta G} = \frac{\beta_{IS}}{(1-MPC)\beta_{IS}+I_r(\beta_{IS}+\beta_{LM}l_r)}$ or similar. The exact formula depends on the textbook notation.

Using Eq. (11.C.5): multiplier $= \frac{1}{1-MPC+(I_r/l_r)(\text{slope of IS with respect to } r)}$.

From IS: $Y = \alpha_{IS} - 2000r$, so $dY/dr = -2000$, meaning a 1 pp increase in r reduces Y by 2000. The multiplier in the fixed-price case depends on how much r rises, which depends on the LM slope.

Let me compute directly: $\Delta Y = 1100 - 1000 = 100$, $\Delta G = 100$. $\Delta Y/\Delta G = 1.0$ (computed directly from parts (c) and (d)).

Using formula: multiplier $= \frac{1}{1-0.5+(500/1000)(0.001)} = \frac{1}{0.5+0.0005} \approx 1.998...$ this doesn't match.

Let me re-derive the multiplier. With fixed P: IS: $Y = C_0 + \text{MPC}(Y - T) - I_r r + I_0 - I_r r + G$. $Y = A + \text{MPC} \cdot Y - (I_r + C_r + I_r)r$ where A is autonomous spending.

Better approach: $Y = 1200 - 2000r$ initially, $Y = 1400 - 2000r$ after. The horizontal shift of IS is $\Delta Y|_{\text{fixed } r} = 200$, but part of this is crowded out.

LM: $r = \beta_{LM} Y - M/(l_r P)$. With $l_r = 1000$, $\beta_{LM} = 0.5/1000 = 0.0005$ (from $0.5Y$ term in L).

Solve: $Y = \alpha_{IS} - \beta_{IS}(\beta_{LM} Y - M/(l_r P))$. $Y(1 + \beta_{IS}\beta_{LM}) = \alpha_{IS} + \beta_{IS} M/(l_r P)$. $Y = \frac{\alpha_{IS}}{1+\beta_{IS}\beta_{LM}} + \frac{\beta_{IS} M/(l_r P)}{1+\beta_{IS}\beta_{LM}}$.

Multiplier: $\frac{\partial Y}{\partial \alpha_{IS}} = \frac{1}{1+\beta_{IS}\beta_{LM}} = \frac{1}{1+2000(0.0005)} = \frac{1}{2} = 0.5$.

But $\Delta \alpha_{IS} = 200$ (from 1200 to 1400). So $\Delta Y = 0.5 \times 200 = 100$. This matches!

The multiplier in terms of ΔG: since $d\alpha_{IS}/dG = 1/(1-\text{MPC}) = 2$ (simple Keynesian cross multiplier), $\Delta Y = \frac{1}{1+\beta_{IS}\beta_{LM}} \times \frac{1}{1-\text{MPC}} \Delta G = 0.5 \times 2 \times 100 = 100$.

So $\Delta Y/\Delta G = 1.0$, matching direct computation.

11.3 Analytical Problems

1. **Effects of various shocks in the Keynesian IS-LM model.**

   a. Increased tax incentives for investment (offset by lump-sum taxes).

   The investment tax incentive shifts the investment function: at any r, firms want to invest more. The IS curve shifts right.

   Short run (prices fixed):

   - Output Y: Rises (IS shifts right along fixed LM).
   - Real interest rate r: Rises (higher Y increases money demand).
   - Employment: Rises (firms hire more to meet higher demand).
   - Price level: Fixed (by assumption of short-run stickiness).

   Long run (prices adjust):

   - The increase in Y above $\bar{Y}$ puts upward pressure on prices. As P rises, real money balances fall (M/P decreases), shifting LM left/up.
   - Y returns to $\bar{Y}$.
   - r rises further (full crowding out).
   - Employment returns to full-employment level.
   - Price level is permanently higher.

   b. Increased tax incentives for saving (offset by lump-sum taxes).

   Higher saving incentives increase desired saving at each r, reducing consumption demand. The IS curve shifts **left** (lower aggregate demand).

   Short run: Y falls, r falls, employment falls, P fixed. **Long run:** P falls (deflation restores real money balances), r falls further, Y returns to $\bar{Y}$, employment returns to full employment.

   c. Wave of investor pessimism about future capital profitability.

   This reduces desired investment at each r, shifting IS left.

   Short run: Y falls, r falls, employment falls, P fixed. **Long run:** P falls, r falls further, Y returns to $\bar{Y}$.

   d. Increase in consumer confidence (higher expected future incomes).

   This increases consumption demand at each Y and r (households save less, consume more today). The IS curve shifts right.

   Short run: Y rises, r rises, employment rises, P fixed. **Long run:** P rises, r rises further, Y returns to $\bar{Y}$.

   Note: In all cases, the long-run real interest rate moves in the **same direction** as the short run, but **further** (since the price-level adjustment reinforces the interest rate movement by changing real money balances).

2. **More Keynesian IS-LM shocks.**

   a. Financial deregulation allows higher interest on checking accounts.

   This increases the opportunity cost of holding money at any interest rate, reducing real money demand. The LM curve shifts **right/down** (at given M/P, lower money demand means lower r for each Y).

Short run: Y rises, r falls, employment rises, P fixed. **Long run:** P rises (as economy is above $\bar{Y}$), shifting LM back left/up. Y returns to $\bar{Y}$, r returns to original level (since the long-run r is determined by the goods market, which is unchanged). P is permanently higher.

b. Introduction of sophisticated credit cards reduces transactions money demand.

Same mechanism as (a): lower real money demand shifts LM right/down.

Short run: Y rises, r falls, employment rises. **Long run:** P rises, Y returns to $\bar{Y}$, r returns to original.

c. Severe water shortage (adverse supply shock).

This is a negative supply shock: it reduces productivity (lowers $\bar{Y}$, shifts FE line left) and raises prices. In the Keynesian model:

Short run: The SRAS shifts up/left. At the initial price level, firms want to produce less. Output falls and prices rise (stagflation). The higher P reduces M/P, shifting LM left, raising r, which further depresses C and I.

Long run: $\bar{Y}$ is permanently lower. The economy settles at a lower output and higher price level. The real interest rate is ambiguous (depends on how S^d and I^d respond to the supply shock).

d. Temporary beneficial supply shock (but firms don't change prices in short run).

The supply shock raises productivity and shifts FE right and SRAS right. But since firms don't change prices, in the short run output is demand-determined.

Short run: If firms hold prices fixed and meet demand, output is determined by AD (unchanged). No short-run effect on Y or employment. But the economy now has more slack (potential output is higher, so the same actual output represents a larger output gap).

Long run: As firms eventually adjust, prices fall (to reflect higher productivity and lower costs). Lower P increases M/P, shifting LM right, lowering r, stimulating C and I. Y rises to the new, higher $\bar{Y}$. Employment may rise or fall depending on the nature of the productivity shock.

3. **Fed policy with recognition and implementation lags.**

   If the Fed increases M when it observes a recession, but monetary policy takes six months to affect AD (the same time firms take to reset prices), the policy is likely **destabilizing**:

   - The Fed observes recession at $t = 0$, increases M.
   - By $t = 6$ months, monetary policy expands AD.
   - But by $t = 6$ months, firms have also reset their prices downward (the self-correction mechanism has already worked).
   - The economy is returning to $\bar{Y}$ on its own, and now expansionary monetary policy hits, potentially pushing the economy **above** full employment and creating inflation.
   - The Fed then tightens, creating another cycle.

   This is an example of the **"long and variable lags"** problem identified by Milton Friedman: poorly timed stabilization policy can amplify rather than dampen cycles.

   Variations:

   (a) **Fed can forecast recessions:** If the Fed has forecasting ability, it can act *before* the recession begins, so the monetary policy impact coincides with the downturn rather than the recovery. This improves stabilization.

   (b) **Price adjustment takes longer than six months:** If prices adjust more slowly than monetary policy, then policy can be effective—the Fed can raise AD and restore output before self-correction occurs.

4. **Does fiscal expansion make workers better off?**

   If the Keynesian model is correct, a fiscal expansion that restores full employment:

   - **Real wage:** Depends on the source of the recession. If it's a demand-side recession, the real wage may be roughly unchanged in the short run (nominal wages may be sticky too, or the price level might rise with output). In the efficiency wage model, the real wage is fixed at the efficiency wage anyway.
   - **Employment:** Increases (workers who were involuntarily unemployed get jobs).
   - **Consumption:** Rises for those who become employed; may fall for those who face higher future taxes, but on net likely rises due to the multiplier.
   - **Current and future taxes:** Higher G today implies higher taxes today or in the future. Workers face a higher lifetime tax burden.

   Is this better than doing nothing? It depends on:

   (a) **Direct benefits of government spending:** If the government spending provides valuable public goods, workers gain directly from the spending itself. If it's wasteful, the gain comes only from the employment effect. If government spending worth G provides utility equal to or exceeding G, workers are unambiguously better off.

   (b) **Speed of self-correction:** If prices adjust very slowly, doing nothing means prolonged unemployment with large cumulative output and welfare losses. In this case, fiscal expansion is strongly beneficial even if future taxes rise. If prices adjust quickly, the benefit is small and may not justify the tax cost.

Compared to the classical argument (that fiscal policy doesn't help because workers are already at their optimal labor supply), the Keynesian case for fiscal policy rests on the premise that unemployment is **involuntary**—workers want to work at the prevailing wage but cannot find jobs due to insufficient demand.

5. **Dual labor market (primary and secondary sectors).**

   a. **Expansionary monetary policy increases demand for primary sector output.**

   Primary sector: Higher demand shifts the labor demand curve right. Since the efficiency wage is unchanged (determined by the effort curve, not by demand), employment in the primary sector rises, output rises. Real wage in the primary sector remains at the efficiency wage. **Secondary sector:** As workers move from the secondary to the primary sector (attracted by new primary-sector jobs), secondary-sector labor supply decreases, raising the secondary-sector real wage, reducing secondary employment and possibly secondary output (though output effect depends on relative productivity).

   b. **Immigration increases the labor force.**

   Primary sector: Unaffected. The efficiency wage and primary-sector employment are determined by the efficiency wage condition and the MPN curve, neither of which shifts with immigration. Primary real wage, employment, and output are unchanged. Wait: more workers may queue for primary jobs, increasing measured unemployment but not affecting primary employment. **Secondary sector:** The increased labor force shifts secondary-sector labor supply right, lowering the secondary real wage, raising secondary employment, and raising secondary output.

   c. **Effort curve shifts—higher wage needed for same effort.**

   Primary sector: The new efficiency wage is higher (the wage that maximizes effort per dollar is now at a higher point on the effort curve). At the higher efficiency wage, firms demand less labor (move up along the MPN curve). Primary employment and output fall. Real wage rises. **Secondary sector:** Displaced primary workers move to the secondary sector, shifting labor supply right, lowering the secondary real wage, raising secondary employment and output.

   d. **Temporary productivity improvement in the primary sector.**

   Primary sector: The MPN curve shifts right. At the unchanged efficiency wage, firms demand more labor. Primary employment and output rise. Real wage unchanged. **Secondary sector:** Workers are pulled from the secondary sector to fill new primary jobs. Secondary labor supply shifts left, raising the secondary real wage, reducing secondary employment and output.

   e. **Temporary productivity improvement in the secondary sector.**

   Secondary sector: The MPN curve shifts right, raising labor demand, the secondary real wage, secondary employment, and output. **Primary sector:** The higher secondary wage may attract some workers from the primary-sector queue. But primary employment is determined by the efficiency wage and primary MPN, which are unchanged. The queue for primary jobs may shrink (lower unemployment). Primary real wage, employment, and output are unchanged.

12 Unemployment and Inflation

12.1 Review Questions

1. **What is the Phillips curve? Does the Phillips curve relationship hold for U.S. data? Explain.**

   Answer: The **Phillips curve** is an empirical inverse relationship between inflation and unemployment. A.W. Phillips (1958) originally documented a negative correlation between wage inflation and unemployment in the UK. The relationship was subsequently confirmed for price inflation in the United States by Samuelson and Solow (1960). The basic Phillips curve is:

   $$\pi = -h(u - \bar{u}),$$

   where π is inflation, u is unemployment, $\bar{u}$ is the natural rate, and $h > 0$.

   For U.S. data, the simple Phillips curve relationship **does not hold as a stable, permanent tradeoff**. The U.S. experience can be divided into periods:

   - **1960s:** A clear negative relationship between inflation and unemployment appeared to hold, leading many to believe in a permanent inflation-unemployment tradeoff.
   - **1970s:** The relationship broke down dramatically with **stagflation**—simultaneously high inflation *and* high unemployment (the Phillips curve appeared to shift outward).
   - **1980s–1990s:** The disinflation under Volcker produced high unemployment initially (as predicted) but inflation expectations eventually fell, shifting the curve inward.
   - **2000s–2010s:** The relationship appears to have flattened considerably.

   The empirical instability of the simple Phillips curve led to the development of the **expectations-augmented Phillips curve**, which incorporates expected inflation as a shift factor.

2. **How does the expectations-augmented Phillips curve differ from the traditional Phillips curve? Under what conditions should the traditional Phillips curve relationship appear in the data?**

   Answer: The traditional Phillips curve is $\pi = -h(u - \bar{u})$, which suggests a **stable** negative relationship between inflation and unemployment—policymakers could permanently trade higher inflation for lower unemployment.

   The **expectations-augmented Phillips curve** adds expected inflation:

   $$\pi = \pi^e - h(u - \bar{u}),$$

   where π^e is expected inflation. The key difference is that the Phillips curve **shifts** whenever expected inflation changes. There is no permanent tradeoff: in the long run, $\pi = \pi^e$ and $u = \bar{u}$ (the long-run Phillips curve is vertical at the natural rate).

   The traditional Phillips curve relationship appears in the data only under **stable expected inflation**. If π^e is constant, then the negative π-u relationship emerges from the expectations-augmented curve. In the 1960s, inflation expectations were relatively stable (people expected low, stable inflation based on the gold standard and post-war experience), so the traditional Phillips curve appeared to hold. Once expectations began adjusting in the 1970s, the relationship broke down.

3. **How do changes in expected inflation account for the behavior of the Phillips curve in the 1960s, 1970s, and 1980s? What role do supply shocks play?**

   Answer:

   - **1960s:** Expected inflation was low and stable ($\pi^e \approx 1 - 2\%$) because the U.S. had experienced low inflation for decades. The Phillips curve was stable and appeared to offer a permanent tradeoff. Expansionary policy could reduce unemployment at the cost of modestly higher inflation, and expected inflation barely moved.
   - **1970s:** Two factors shifted the Phillips curve outward:
     - **Rising expected inflation:** The sustained inflation of the late 1960s and early 1970s caused π^e to rise. Workers and firms began to expect and build in higher inflation. The Phillips curve shifted up/right.
     - **Adverse supply shocks:** The 1973–74 and 1979–80 oil price shocks increased production costs, directly raising inflation at any unemployment rate *and* raising the natural rate $\bar{u}$ (as energy-intensive capital became obsolete, increasing structural unemployment).

     The result was **stagflation**: both π and u were high simultaneously.
   - **1980s:** The Volcker disinflation (tight monetary policy) raised unemployment sharply in 1981–82. Over time, as inflation fell, π^e also fell (though slowly—expectations are sticky). The Phillips curve shifted down/left. By the late 1980s, both inflation and unemployment had declined. The episode demonstrated the importance of credibility: the more quickly expectations adjust, the less unemployment is needed to achieve disinflation.

4. **Can policymakers exploit the Phillips curve by trading more inflation for less unemployment in the short run? In the long run? Explain both the classical and Keynesian points of view.**

   Answer:

   Short run:

   - **Keynesian view:** Yes. With sticky prices and/or wages, expansionary monetary or fiscal policy can raise output and reduce unemployment. The economy moves along the short-run Phillips curve, accepting higher inflation for lower unemployment. Because prices/wages are slow to adjust, this tradeoff is exploitable for a meaningful period.
   - **Classical (misperceptions) view:** Yes, but only if the expansion is **unanticipated**. An unexpected increase in M creates a positive price-level surprise ($P > P^e$), causing producers to increase output. This moves the economy along the short-run Phillips curve. But anticipated monetary expansion has no real effect even in the short run.

   Long run:

   - **Both views agree:** There is **no long-run tradeoff**. In the long run, expectations adjust (π^e converges to π), and unemployment returns to the natural rate $\bar{u}$. The long-run Phillips curve is vertical at $u = \bar{u}$. Attempting to permanently keep unemployment below $\bar{u}$ requires **ever-accelerating** inflation (as π^e catches up, the central bank must create more and more inflation surprises to stay at the lower unemployment rate).

5. **Why do policymakers want to keep inflation low? Who suffers when there is unemployment?**

   Answer: Policymakers want to keep inflation low because:

   - **Costs of anticipated inflation:** Shoe-leather costs (increased trips to the bank as people hold less cash), menu costs (costs of changing prices more frequently), distortions from the interaction of inflation with the tax system (e.g., bracket creep, taxation of nominal capital gains), and the erosion of the unit-of-account function of money.
   - **Costs of unanticipated inflation:** Arbitrary redistributions of wealth between creditors and debtors (unexpected inflation hurts creditors, helps debtors); increased uncertainty that hampers long-term contracting and investment; noise in relative price signals, which reduces economic efficiency.
   - **Hyperinflation:** Extremely high inflation destroys the monetary system, leading to barter, economic collapse, and severe social disruption.

   When there is unemployment, the following groups suffer:

   - **The unemployed themselves:** Loss of income, psychological distress, deterioration of skills (human capital depreciation), lower lifetime earnings, health problems, family stress.
   - **Workers in general:** Higher unemployment weakens workers' bargaining power, potentially reducing wages even for the employed.
   - **Society at large:** Lost output (the output gap represents goods and services that could have been produced but weren't), lower tax revenues, higher government spending on safety-net programs (unemployment benefits, food stamps), and social problems (crime, social unrest).
   - **Minorities and youth:** These groups typically experience disproportionately higher unemployment during recessions.

6. **Why is the natural unemployment rate an important economic variable? What factors explain its changes over time? What government policies might reduce it?**

   Answer: The natural rate of unemployment $\bar{u}$ is important because:

   - It determines the **sustainable** level of unemployment—the rate at which inflation neither accelerates nor decelerates (NAIRU).
   - It represents the economy's normal level of unemployment when output is at full employment.
   - Policy errors in estimating $\bar{u}$ can lead to inflationary or deflationary pressure. If the central bank targets unemployment below $\bar{u}$, it will create accelerating inflation.

   Factors explaining changes in $\bar{u}$ over time:

   - **Demographics:** Changes in the age and gender composition of the labor force. Younger workers have higher frictional unemployment. The entry of baby boomers in the 1970s raised $\bar{u}$; their aging lowered it in the 1990s–2000s.

- **Structural changes:** Sectoral shifts (decline of manufacturing, rise of services) create mismatches between worker skills and available jobs, raising structural unemployment.
- **Institutional factors:** Changes in unemployment insurance generosity, minimum wage laws, unionization rates, and employment protection legislation.
- **Productivity growth:** Higher productivity growth may lower $\bar{u}$ by allowing real wage growth without inflationary pressure.
- **Hysteresis:** Prolonged recessions can raise $\bar{u}$ permanently as the long-term unemployed become detached from the labor market and lose skills.

Government policies to reduce $\bar{u}$:

- Job training and retraining programs to reduce skill mismatches.
- Improved job-matching services (employment exchanges, online platforms).
- Reform of unemployment insurance to maintain job-search incentives.
- Policies to increase labor market flexibility (e.g., reducing excessive employment protection).
- Education investments to improve workforce skills.
- Relocation assistance to reduce geographic mismatches.

7. **Give two costs of anticipated inflation and two costs of unanticipated inflation. How are these affected by hyperinflation?**

   Answer:

   Two costs of anticipated inflation:

   (a) **Shoe-leather costs:** Higher inflation raises the nominal interest rate ($i = r + \pi$), increasing the opportunity cost of holding non-interest-bearing money. People hold less cash and make more frequent trips to the bank, wearing out "shoe leather." This is a deadweight loss from economizing on real money balances.

   (b) **Menu costs:** Firms must change prices more frequently, incurring the costs of printing new catalogs, reprogramming computers, updating websites, etc. These resources could have been used productively elsewhere.

   Two costs of unanticipated inflation:

   (a) **Arbitrary wealth redistribution:** Unanticipated inflation transfers wealth from creditors to debtors (because loans are repaid in less-valuable dollars). Long-term nominal contracts (mortgages, bonds, pensions) redistribute wealth in ways that were not intended by the parties. This undermines the willingness to enter long-term nominal contracts.

   (b) **Increased uncertainty and misallocation:** Unpredictable inflation makes relative price signals noisy, leading to inefficient production and investment decisions. It also raises the risk premium on long-term investments, reducing capital accumulation.

   Hyperinflation effect: All these costs are magnified enormously. With hyperinflation (e.g., 50%+ per month):

- Shoe-leather costs become extreme—people may be paid daily and rush to spend money before it loses value. The monetary system begins to break down.
- Menu costs become prohibitive—prices may change multiple times per day.
- Wealth redistribution becomes catastrophic—lifetime savings are wiped out, destroying the middle class.
- The currency may cease to function as a unit of account (people quote prices in foreign currency), medium of exchange (barter emerges), and store of value (capital flight).

8. **What is the greatest potential cost associated with disinflation? How does the responsiveness of inflation expectations affect this cost?**

   Answer: The greatest potential cost associated with disinflation (reducing the inflation rate) is the **sacrifice ratio**—the cumulative loss of output and the associated high unemployment required to bring inflation down. Tight monetary policy reduces aggregate demand, and with sticky prices/wages, output falls below full employment. The sacrifice ratio measures the percentage of one year's GDP that must be forgone to reduce inflation by 1 percentage point.

   The **responsiveness of inflation expectations** crucially affects the sacrifice ratio:

   - **Rapidly adjusting expectations (high credibility):** If the public quickly revises π^e downward in response to anti-inflation policy (because the central bank has strong credibility), the short-run Phillips curve shifts down quickly. Less unemployment is needed to achieve a given disinflation. The sacrifice ratio is **low**.
   - **Slowly adjusting expectations (low credibility):** If the public does not believe the central bank's commitment to lower inflation and maintains high π^e, the short-run Phillips curve shifts down only gradually. Sustained high unemployment is required to bring actual inflation down. The sacrifice ratio is **high**. This was the U.S. experience in the early 1980s, when the Volcker disinflation initially caused a severe recession because expectations adjusted slowly after years of high inflation.

   This is why central bank credibility is so important: a credible commitment to low inflation can achieve disinflation at much lower cost.

9. **Discuss at least two strategies for reducing expected inflation rapidly. What are the pros and cons?**

   Answer:

   Strategy 1: Cold turkey (rapid disinflation).

   - **Approach:** The central bank sharply reduces money growth immediately to the rate consistent with the desired lower inflation. Monetary policy is tightened aggressively.
   - **Pros:** If credible, it can shift expectations quickly, minimizing the cumulative output loss. It demonstrates the central bank's resolve.
   - **Cons:** If expectations adjust slowly, the short-run output and employment costs are very high (deep recession). The political backlash may force the central bank to reverse course, destroying credibility.

   Strategy 2: Gradualism.

- **Approach:** The central bank reduces money growth slowly over several years. The policy is pre-announced with clear targets.
- **Pros:** Lower short-run costs (smaller recession at any point). Politically more sustainable. Allows time for wage and price contracts to adjust.
- **Cons:** Takes longer; the cumulative output loss may actually be **larger** (even if the recession is shallower at each point, the stream of lost output over many years could exceed the cold-turkey loss). If the public doubts the central bank's patience, expectations may not adjust.

Strategy 3: Wage and price controls (incomes policy).

- **Approach:** The government directly limits wage and price increases through legislation.
- **Pros:** Can reduce inflation expectations immediately without a recession.
- **Cons:** Treats symptoms, not causes. When controls are removed, inflation typically returns unless the underlying monetary policy has changed. Controls create microeconomic distortions (shortages, black markets). They are difficult to enforce and are generally discredited by historical experience (Nixon's 1971–74 controls failed to stop inflation).

10. **Why does the Federal Reserve work hard to establish its credibility? What benefits does credibility bring?**

Answer: The Fed works hard to establish credibility because credibility dramatically improves the **inflation-unemployment tradeoff**:

- **Lower sacrifice ratio:** If the public believes the Fed is committed to low inflation, π^e will be low and will adjust quickly to policy changes. Disinflations can be achieved with smaller recessions. The Volcker disinflation was so costly partly because the Fed lacked credibility after the inflationary 1970s; once credibility was established (the "Volcker put"), subsequent inflation scares required much smaller policy responses.
- **Self-fulfilling low inflation:** When the Fed is credible, the public's π^e is anchored near the Fed's target. This keeps actual inflation low even without aggressive monetary tightening—the Phillips curve itself is favorably positioned.
- **Ability to respond to shocks:** A credible central bank can temporarily ease policy during a recession without triggering a spike in inflation expectations. The public understands the easing is temporary and does not raise π^e. This gives the Fed more flexibility to stabilize output.
- **Lower long-term interest rates:** Credibility reduces the inflation risk premium embedded in long-term nominal interest rates. Lower long-term rates stimulate investment and growth.

  Benefits to the public:

  – Lower and more stable inflation with less output volatility.
  – Less uncertainty about future prices, facilitating long-term planning, saving, and contracting.
  – Lower long-term borrowing costs (mortgages, corporate bonds).

– Protection of the real value of savings and fixed incomes.

The accumulation of Fed credibility since the 1980s is widely credited for the "Great Moderation"—the period of low inflation and reduced output volatility from the mid-1980s to 2007.

12.2 Numerical Problems

1. **Disinflation with expectations-augmented Phillips curve.**

   a. $\pi = \pi^e - 2(u - \bar{u})$, with $\bar{u} = 0.06$.
   First year: $\pi = 0.04$, $\pi^e = 0.08$. $0.04 = 0.08 - 2(u - 0.06) \Rightarrow -0.04 = -2(u - 0.06) \Rightarrow u - 0.06 = 0.02 \Rightarrow u = 0.08 = 8\%$.

   b. Four-year disinflation:

Year	π	π^e	$u = \bar{u} + (\pi^e - \pi)/2$	u	Output loss
1	0.08	0.10	$0.06 + (0.10 - 0.08)/2 = 0.06 + 0.01$	0.07 (7%)	$2 \times 1\% = 2\%$
2	0.04	0.08	$0.06 + (0.08 - 0.04)/2 = 0.06 + 0.02$	0.08 (8%)	$2 \times 2\% = 4\%$
3	0.04	0.06	$0.06 + (0.06 - 0.04)/2 = 0.06 + 0.01$	0.07 (7%)	$2 \times 1\% = 2\%$
4	0.04	0.04	$0.06 + (0.04 - 0.04)/2 = 0.06 + 0.00$	0.06 (6%)	0%

   Output loss: From Okun's law, each 1 percentage point of u above $\bar{u}$ maintained for one year costs 2% of GDP.

   - Year 1: $(0.07 - 0.06) \times 2 = 2\%$ of GDP
   - Year 2: $(0.08 - 0.06) \times 2 = 4\%$ of GDP
   - Year 3: $(0.07 - 0.06) \times 2 = 2\%$ of GDP
   - Year 4: 0%
   - Total cumulative loss: $2 + 4 + 2 = 8\%$ of one year's GDP.

   Sacrifice ratio: Total reduction in inflation $\Delta\pi = 0.12 - 0.04 = 0.08 = 8$ percentage points. Cumulative excess unemployment = $(1+2+1+0) = 4$ percentage-point-years. From Okun's law, this translates to $4 \times 2 = 8\%$ GDP loss. Sacrifice ratio = $8/8 = 1.0$. That is, 1 percentage point of forgone GDP (relative to full-employment) is needed to reduce inflation by 1 percentage point.
   (Also can be computed as: $\sum(u_t - \bar{u}) = 1 + 2 + 1 + 0 = 4$; sacrifice ratio = $4/8 = 0.5$ in terms of unemployment-percentage-point-years per inflation-percentage-point reduction—equivalent to $8/8 = 1$ in GDP terms via Okun's law.)

2. **Extended classical economy with misperceptions.**

   a. $M = 1000$, $P^e = 50$, $\bar{Y} = 500$.

   Short run: AD: $Y = 300 + 10(1000/P) = 300 + 10000/P$. SRAS: $Y = 500 + P - 50 = 450 + P$.

   Equate: $300 + 10000/P = 450 + P \Rightarrow 10000/P = 150 + P$. Multiply by P: $10000 = 150P + P^2 \Rightarrow P^2 + 150P - 10000 = 0$. $(P + 200)(P - 50) = 0$. $P = 50$ (positive root).

   $Y = 450 + 50 = 500 = \bar{Y}$.

   Okun's law: $(500 - 500)/500 = -2(u - 0.06) \Rightarrow 0 = -2(u - 0.06) \Rightarrow u = 0.06$.

   Short run: $Y = 500$, $P = 50$, $u = 0.06$. **Long run:** Same ($Y = \bar{Y}$, $P = P^e$, so long-run equilibrium is identical).

   b. $M = 1260$ (unanticipated), $P^e = 50$.

   AD: $Y = 300 + 10(1260/P) = 300 + 12600/P$. SRAS: $Y = 450 + P$.

   $300 + 12600/P = 450 + P \Rightarrow 12600/P = 150 + P$. $12600 = 150P + P^2 \Rightarrow P^2 + 150P - 12600 = 0$. $P = \frac{-150+\sqrt{22500+50400}}{2} = \frac{-150+\sqrt{72900}}{2} = \frac{-150+270}{2} = 60$.

   $Y = 450 + 60 = 510$. Okun: $(510 - 500)/500 = -2(u - 0.06) \Rightarrow 0.02 = -2(u - 0.06) \Rightarrow u - 0.06 = -0.01 \Rightarrow u = 0.05$.

   Short run: $Y = 510$, $P = 60$, $u = 5\%$.

   Long run: P^e adjusts to P. In long run, $Y = \bar{Y} = 500$. AD: $500 = 300 + 12600/P \Rightarrow 200 = 12600/P \Rightarrow P = 63$. $P^e = P = 63$, $u = \bar{u} = 0.06$.

   Consistency with expectations-augmented Phillips curve: Short run: $\pi - \pi^e = (P - P_{-1})/P_{-1} - \pi^e = \ldots$ Actually, with $P_{-1} = 50$ (from part a), $\pi = (60 - 50)/50 = 20\%$, $\pi^e = 0\%$ (since P^e was 50, same as previous price). $u = 5\% < \bar{u} = 6\%$. So unanticipated inflation (20%) is associated with below-natural unemployment (5%). This is exactly what the expectations-augmented Phillips curve predicts: when $\pi > \pi^e$, $u < \bar{u}$.

3. **Phillips curve analysis with shocks.**

a. $\pi = \pi^e - 2(u - 0.06)$, with $\pi^e = 0.10$.

Phillips curve: $\pi = 0.10 - 2(u - 0.06) = 0.10 - 2u + 0.12 = 0.22 - 2u$.

If the Fed sets $\pi = 0.10$: $0.10 = 0.10 - 2(u - 0.06) \Rightarrow 0 = -2(u - 0.06) \Rightarrow u = 0.06$.

Graph: A downward-sloping line in (π, u) space passing through $(u = 0.06, \pi = 0.10)$ with slope -2.

b. Aggregate demand shock: π^e rises to 0.12, $\bar{u} = 0.06$ unchanged.

New Phillips curve: $\pi = 0.12 - 2(u - 0.06) = 0.12 - 2u + 0.12 = 0.24 - 2u$.

This is a parallel shift **upward** (rightward shift in (π, u) space—at any u, inflation is 2 percentage points higher).

If the Fed holds $\pi = 0.10$: $0.10 = 0.12 - 2(u - 0.06) \Rightarrow -0.02 = -2(u - 0.06) \Rightarrow u - 0.06 = 0.01 \Rightarrow u = 0.07 = 7\%$.

Unemployment rises to 7% because the Fed is holding actual inflation below expected inflation (disinflation). Workers and firms built in 12% inflation expectations, but the Fed only delivers 10%—real wages are too high, and employment suffers.

If the Fed announces $\pi = 0.10$ and the public fully believes: Then π^e falls to 0.10 (the public believes the announcement). The Phillips curve shifts back down: $\pi = 0.10 - 2(u - 0.06)$. At $\pi = 0.10$, $u = 0.06$. Credibility eliminates the unemployment cost.

c. Supply shock: $\pi^e = 0.12$, $\bar{u} = 0.08$.

New Phillips curve: $\pi = 0.12 - 2(u - 0.08) = 0.12 - 2u + 0.16 = 0.28 - 2u$.

This is a shift up AND to the right (both π^e and $\bar{u}$ increase).

If the Fed holds $\pi = 0.10$: $0.10 = 0.12 - 2(u - 0.08) \Rightarrow -0.02 = -2(u - 0.08) \Rightarrow u - 0.08 = 0.01 \Rightarrow u = 0.09 = 9\%$.

If the Fed announces $\pi = 0.10$ and the public fully believes, π^e falls to 0.10: $\pi = 0.10 - 2(u - 0.08) = 0.26 - 2u$. At $\pi = 0.10$, $u = 0.08$.

Even with full credibility, unemployment remains at the new, higher natural rate (0.08). Credibility can eliminate the excess unemployment due to disinflation but cannot undo the structural damage from the supply shock that raised $\bar{u}$.

4. **AD-AS with Okun's law.**

a. $M = 4000$ (constant and expected to remain constant), $\bar{Y} = 6000$, $\bar{u} = 0.05$.

Long-run equilibrium: $Y = \bar{Y} = 6000$, $P = P^e$, $\pi^e = 0$ (money supply is constant), $u = \bar{u} = 0.05$.

From AD: $6000 = 4000 + 2(4000/P)$. Wait, let me re-read: AD is $Y = 4000 + 2(M/P)$. $6000 = 4000 + 8000/P \Rightarrow 2000 = 8000/P \Rightarrow P = 4$. $P^e = P = 4$.

Equilibrium: $P = 4$, $P^e = 4$, $\pi^e = 0$, $Y = 6000$, $u = 0.05$.

b. Unanticipated increase: $M = 4488$, $P^e = 4$ (unchanged).

AD: $Y = 4000 + 2(4488/P) = 4000 + 8976/P$. SRAS: $Y = 6000 + 100(P - 4) = 6000 + 100P - 400 = 5600 + 100P$.

Equate: $4000 + 8976/P = 5600 + 100P$. $8976/P = 1600 + 100P$. $8976 = 1600P + 100P^2$. $100P^2 + 1600P - 8976 = 0 \Rightarrow P^2 + 16P - 89.76 = 0$.

$P = \frac{-16+\sqrt{256+359.04}}{2} = \frac{-16+\sqrt{615.04}}{2} = \frac{-16+24.80}{2} \approx 4.40$.

$Y = 5600 + 100(4.40) = 5600 + 440 = 6040$.

Okun: $(6040-6000)/6000 = -2(u-0.05) \Rightarrow 40/6000 = 0.00667 = -2(u-0.05)$. $-0.00333 = u - 0.05 \Rightarrow u = 0.04667 \approx 4.67\%$.

Short-run: $P \approx 4.40$, $P^e = 4$, $Y = 6040$, $u \approx 4.67\%$.

Cyclical unemployment: $u - \bar{u} = 0.04667 - 0.05 = -0.00333 \approx -0.33\%$ (negative, meaning the economy is above full employment).

Unanticipated inflation: $\pi - \pi^e$. $\pi = (4.40 - 4)/4 = 0.10 = 10\%$. Since $\pi^e = 0$ (money was constant), unanticipated inflation = 10%.

c. Slope of expectations-augmented Phillips curve:

From Okun's law: $(Y - \bar{Y})/\bar{Y} = -2(u - \bar{u})$. From SRAS: $Y - \bar{Y} = 100(P - P^e)$, so $(Y - \bar{Y})/\bar{Y} = 100(P - P^e)/6000$.

Thus: $100(P - P^e)/6000 = -2(u - \bar{u})$. $P - P^e = -120(u - \bar{u})$.

In terms of inflation: $\pi - \pi^e = -120(u - \bar{u})/P_{-1}$ (approximately). For small changes: $\pi - \pi^e \approx -120(u - \bar{u})/P \approx -120(u - \bar{u})/4 = -30(u - \bar{u})$.

So the slope h in $\pi = \pi^e - h(u - \bar{u})$ is $h = 30$.

More precisely: From (b), $\pi = 0.10$ (unanticipated), $u - \bar{u} = -0.00333$. $h = -(\pi - \pi^e)/(u - \bar{u}) = -0.10/(-0.00333) = 30$.

So $h = 30$: a 1 percentage point reduction in unemployment below the natural rate is associated with 0.3 percentage points of unanticipated inflation (or equivalently, the Phillips curve slope is steep in this economy—small unemployment deviations generate large inflation surprises).

12.3 Analytical Problems

1. **Government program to reduce structural unemployment.**

   a. A program that reduces structural unemployment lowers the natural rate $\bar{u}$. Effects:

   - **Expectations-augmented Phillips curve:** Shifts **left/down**. At any given π^e, the economy can achieve lower unemployment at the same inflation rate. The equation $\pi = \pi^e - h(u - \bar{u})$ with a lower $\bar{u}$ means the entire curve shifts toward the origin in (u, π) space.
   - **Long-run Phillips curve:** Shifts **left** (the vertical line at $u = \bar{u}$ moves to a lower unemployment rate). The sustainable level of unemployment is permanently lower.

   b. Critics argue monetary expansion is a cheaper way to cut unemployment. Their argument has two problems:

   i. **Only temporary:** Monetary expansion can reduce unemployment only in the short run by creating unanticipated inflation ($\pi > \pi^e$). Once expectations adjust, unemployment returns to $\bar{u}$. To keep unemployment below $\bar{u}$ permanently would require ever-accelerating inflation—which eventually becomes intolerable.

   ii. **Long-term costs:** The government training program addresses the *structural* component of unemployment by improving the matching between workers and jobs. This permanently lowers $\bar{u}$, benefiting the economy indefinitely. Monetary expansion merely creates a temporary high-inflation boom followed by either a return to $\bar{u}$ or accelerating inflation.
   The real comparison is between a temporary, self-reversing reduction in unemployment (monetary policy) versus a permanent reduction (structural policies). While the training program has explicit fiscal costs, it produces lasting benefits without the inflation costs or the eventual reversal that monetary expansion entails.

2. **Misperceptions and the slope of the SRAS/Phillips curve.**

   In economy B (history of erratic money growth and inflation), producers have learned from experience that changes in the prices of their goods usually reflect **aggregate** price level changes rather than relative price changes. When a producer in B sees their price rise, they attribute most of it to general inflation and therefore **do not** significantly increase production.

   In economy A (stable monetary environment), producers are more likely to interpret observed price changes as relative price changes, so they respond more strongly with production changes.

   Consequences:

   - **SRAS slope:** Economy B has a **steeper** SRAS curve. A given change in P relative to P^e produces a smaller change in Y in economy B because producers are less "fooled" by price level surprises. Mathematically, the coefficient b in $Y = \bar{Y} + b(P - P^e)$ is smaller for economy B.
   - **Phillips curve slope:** The Phillips curve is **steeper** (flatter in (u, π) space—wait, let me think). The Phillips curve $\pi = \pi^e - h(u - \bar{u})$ has slope $-h$ in (π, u) space. h is related to b from the SRAS and Okun's law. A smaller b (steeper SRAS in (Y, P)

space) implies a smaller h—the Phillips curve is **steeper** in (u, π) space (a given unemployment deviation produces a smaller inflation surprise because output responds less to price surprises). Actually, let me be more precise:

From SRAS: $Y - \bar{Y} = b(P - P^e)$. From Okun: $(Y - \bar{Y})/\bar{Y} = -2(u - \bar{u})$. So $b(P - P^e) = -2\bar{Y}(u - \bar{u})$. In inflation terms: $\pi - \pi^e \approx -(2\bar{Y}/b)(u - \bar{u})/P_{-1}$. So $h = 2\bar{Y}/(b \cdot P_{-1})$.

A smaller b (steeper SRAS in (Y, P) space) means a **larger** h—the Phillips curve is **steeper** (more vertical) in (π, u) space. That is, a given change in unemployment produces a smaller change in unanticipated inflation, because firms are less responsive to price surprises.

So: **Economy B has a steeper SRAS curve and a steeper Phillips curve** (close to vertical). In the limit, if producers completely ignore price signals (attributing all price changes to inflation), $b \to 0$ and the Phillips curve is vertical even in the short run—money is always neutral.

Conclusion: Economy B has a steeper SRAS and a steeper Phillips curve. This is the Lucas islands model insight: the slope of the short-run aggregate supply curve depends on the **variance of monetary shocks relative to real shocks**. High monetary variance makes prices less informative, flattening the output response.

3. **Expectations-augmented Phillips curve from the Keynesian model.**

   a. The money supply grows at 10% per year (all on December 31). Firms set prices on December 31 to target $\bar{Y}$ for the coming year, using expected money supply.

   Before the start: Firms expect 10% money growth each year.

   Each December 31, firms set P based on expected M for the coming year. Since M is expected to grow 10%, firms set P to grow 10% as well (to keep M/P constant, so that AD intersects SRAS at $\bar{Y}$).

   Each year:

   - December 31 of year $t-1$: M_t is set (10% higher). Firms set P_t at the level expected to give $Y = \bar{Y}$.
   - Since M_t and P_t both grow at 10%, M_t/P_t is constant.
   - AD curve for year t: determined by M_t/P_t (fixed within the year).
   - SRAS for year t: horizontal at P_t (prices fixed within the year).
   - Output: $Y = \bar{Y}$ each year (AD intersects SRAS at full employment).

   Unanticipated inflation: $\pi = 10\%$ each year, $\pi^e = 10\%$. Unanticipated inflation = 0. **Cyclical unemployment:** $u = \bar{u}$ always (output is always at $\bar{Y}$). Cyclical unemployment = 0.

   The economy is always at the long-run equilibrium: $\pi = \pi^e$, $Y = \bar{Y}$, $u = \bar{u}$.

   b. June 30, 2007: Unexpected extra 5% increase in M.

   Timeline:

   - January 1, 2007: M is 10% higher than previous year. Firms set P_{2007} expecting M to stay at this level all year. Expected inflation = 10%.
   - January–June 2007: Economy operates at $Y = \bar{Y}$, $P = P_{2007}$ (fixed).

- June 30, 2007: M unexpectedly increases by an additional 5%. Total increase from Jan 1, 2006 to Dec 31, 2007 = 15%. But for the second half of 2007, M is higher than firms expected when setting prices.
- July–December 2007: With higher M and fixed P, M/P is higher, AD shifts right, $Y > \bar{Y}$. Output is above full employment in the second half of the year.
- December 31, 2007: Firms observe the higher M and adjust P for 2008 accordingly (11% higher, reflecting the 10% normal increase plus learning from the one-time shock).

Actual inflation rate during 2007: $\pi_{2007} = (P_{2007} - P_{2006})/P_{2006} = 10\%$ (prices were set in Dec 2006 based on 10% expected money growth). The extra 5% money increase in June did NOT affect 2007 prices because prices are fixed within the year.

But measured December-to-December: No, the textbook says inflation is measured as the % change in prices between January 1 and December 31. Since prices change only on December 31, inflation during 2007 is the price increase on Dec 31, 2007 relative to Dec 31, 2006. Firms set P_{2007} on Dec 31, 2006 based on expected M, which was anticipated to grow 10%. So $\pi_{2007} = 10\%$ (actual, since price was set at start of year).

Unanticipated inflation during 2007: $\pi - \pi^e = 10\% - 10\% = 0$ (prices didn't adjust to the mid-year surprise).

Wait, but this seems odd. Let me re-think. Inflation during 2007 is the change in P from Jan 1, 2007 to Dec 31, 2007. Prices are reset on Dec 31, 2007. The price level on Jan 1, 2007 = price set Dec 31, 2006 (with 10% expected growth). On Dec 31, 2007, firms set new prices having observed total 15% money growth, so they set P_{2008} = $P_{2007} \times 1.15$ to account for the actual money growth.

So inflation measured during 2007 (from Jan 1 to Dec 31): - Price on Jan 1, 2007: P_{2007} (set Dec 31, 2006, reflecting 10% expected growth) - Price on Dec 31, 2007: $P_{2007} \times 1.15$ (firms fully adjust to the new information)

Actual inflation = 15%. Expected inflation (as of Jan 1, 2007) = 10%. Unanticipated inflation = 5%.

Cyclical unemployment during 2007: In the first half, $Y = \bar{Y}$ and $u = \bar{u}$. In the second half, M is 5% higher than anticipated, real money balances are higher, AD is higher, and $Y > \bar{Y}$ (since prices are fixed). So during July–December, $u < \bar{u}$ (negative cyclical unemployment on average). On average during 2007, cyclical unemployment is **negative** (the economy is, on average, above full employment).

Relation to expectations-augmented Phillips curve: During 2007, unanticipated inflation (5%) is associated with below-normal unemployment in the second half of the year. This is exactly the prediction: $\pi - \pi^e = -h(u - \bar{u})$. Unanticipated positive inflation coincides with negative cyclical unemployment.

4. **Costs of inflation in a cashless society.**

   In a cashless society (all payments through centralized electronic accounting), the costs of inflation change as follows:

   Costs of anticipated inflation:

   - **Shoe-leather costs:** Essentially **eliminated**. In a cashless society, money is electronic and bears interest (or can be instantly transferred to interest-bearing accounts). There is no non-interest-bearing currency to economize on. The opportunity cost of holding "money" (transaction balances) becomes negligible because even checking accounts can pay market interest rates. People no longer waste resources minimizing cash holdings.
   - **Menu costs: Reduced but not eliminated.** While physical menu costs (printing new menus, price tags) may vanish, there are still managerial costs of deciding on new prices and updating electronic systems. However, electronic price updates are much cheaper than physical ones, so menu costs would be significantly smaller.
   - **Tax distortions: Unchanged.** The interaction of inflation with the tax system (taxation of nominal interest income and nominal capital gains) would persist unless the tax code is indexed.

   Costs of unanticipated inflation:

   - **Wealth redistribution: Substantially unchanged.** Unanticipated inflation would still arbitrarily redistribute wealth between creditors and debtors through changes in the real value of nominal assets and liabilities. Mortgages, bonds, pensions, and other long-term nominal contracts would still be affected.
   - **Uncertainty and misallocation: Largely unchanged.** Unpredictable inflation still clouds relative price signals and complicates long-term planning.
   - **Unit of account function:** May actually be **more vulnerable** in a cashless society—if the unit of account is destabilized, people might switch to foreign currencies or real units (e.g., indexing all contracts to a price index), undermining the domestic monetary system.

   Overall: A cashless society would mainly eliminate shoe-leather costs and reduce menu costs. The more fundamental costs of inflation—particularly unanticipated inflation's redistributive effects and the distortion of intertemporal decisions—would remain largely intact because these arise from the **unit-of-account** and **store-of-value** functions of money, not from the medium-of-exchange function that goes cashless.

5. **Price controls with ongoing monetary expansion.**

   a. AD-AS analysis with price controls:

   The government imposes price controls (ceiling at the initial price level P_0) while continuing to increase M at 10% per year. The economy starts at $\bar{Y}$.

   - **AD shifts right each year** due to the 10% annual increase in M. With P fixed by controls, M/P rises by 10% per year, steadily increasing aggregate demand.
   - **SRAS is horizontal** at the controlled price P_0 (firms meet demand at the fixed price, as assumed).
   - **Output** rises persistently above $\bar{Y}$ as AD shifts further and further right while prices remain fixed.
   - **Excess demand** develops and grows over time. Since prices cannot rise to clear markets, shortages emerge—queues, waiting lists, black markets.
   - **Employment** rises above the natural rate (firms hire more to meet the artificially high demand at the fixed price).

   This creates an "overheated" economy with repressed inflation. The inflation is not observed in official price indices because controls suppress it, but it manifests in shortages, quality deterioration, and black market premiums.

   b. Removing controls after several years:

   When price controls are removed:

   - **Prices surge:** Years of pent-up monetary expansion (M has grown by 10% per year for several years while P stayed fixed) means the equilibrium price level is much higher than P_0. When freed, prices jump to the market-clearing level. There is a one-time burst of very high measured inflation as prices catch up to the money supply.
   - **Output contracts:** The sharp price increase reduces real money balances (M/P falls), shifting AD left/up in (Y, P) space. The economy may fall into a recession as demand contracts.
   - **Expectations may destabilize:** The burst of inflation after controls are lifted can trigger a wage-price spiral as workers demand higher wages to catch up. Expected inflation may overshoot on the upside.
   - **Credibility damage:** The government's "victory over inflation" was false—it only suppressed the symptoms. The eventual failure destroys the government's anti-inflation credibility.

   This is exactly what happened in many countries that tried wage-price controls in the 1970s (U.S. under Nixon, UK under Heath). Controls temporarily suppressed inflation without addressing the underlying monetary expansion, and inflation returned with a vengeance when controls were lifted. The fundamental lesson: price controls treat the symptom, not the cause. Inflation is a monetary phenomenon that requires monetary restraint.

6. **Factors affecting the natural unemployment rate.**

   a. **Law prohibiting employment before age 18.**

   Decreases the natural rate. Removing teenagers from the labor force eliminates a group with characteristically high frictional unemployment (young workers have higher job turnover as they search for good matches). The labor force participation rate among teenagers drops, and the remaining labor force has a lower average unemployment rate. The natural rate $\bar{u}$ falls because the composition of the labor force shifts toward groups with lower frictional unemployment.

   b. **Findwork.com makes job availability easy to check.**

   Decreases the natural rate. This reduces **frictional unemployment** by dramatically lowering the cost and time of job search. Better information about job vacancies reduces the time workers spend searching between jobs. This shifts the Beveridge curve (job vacancies vs. unemployment) inward—the same vacancy rate is associated with lower unemployment, or equivalently, a given unemployment rate corresponds to more efficient matching.

   c. **Unemployment benefits extended from 6 months to 1 year.**

   Increases the natural rate. Longer unemployment benefits reduce the opportunity cost of remaining unemployed, leading workers to search longer and be more selective in accepting job offers. While this may improve the quality of job matches, it unambiguously raises the average duration of unemployment spells and thus the natural rate. The reservation wage rises, and some workers may wait until benefits are nearly exhausted to accept offers.

   d. **Shift in demand toward electronics, away from traditional goods.**

   Increases the natural rate (at least temporarily). This is a **sectoral shift** that raises **structural unemployment**. Workers in declining sectors (clothing, restaurants) have skills that don't match the requirements of the expanding electronics sector. Even if total labor demand is unchanged, the mismatch creates structural unemployment as workers need time and resources to retrain or relocate. This is an example of how creative destruction can temporarily raise $\bar{u}$.

   e. **Tight monetary policy drives the economy into recession.**

   No effect on the natural rate in the short run, but may increase it in the long run through hysteresis.

   In the standard model, monetary policy affects only cyclical unemployment, not the natural rate. A recession raises u above $\bar{u}$ temporarily; when policy eases and the economy recovers, u returns to $\bar{u}$—the natural rate is unchanged.

   However, **hysteresis** theory suggests that prolonged recessions can permanently raise $\bar{u}$:

   - Long-term unemployed workers lose skills and become detached from the labor force.
   - Employers may discriminate against the long-term unemployed ("scarring").
   - Capital stock deteriorates during prolonged slumps.
   - Insider-outsider dynamics mean the newly unemployed lose bargaining power and influence over wage setting.

The European experience of the 1980s suggests hysteresis can be significant: high unemployment persisted long after the shocks that caused it had faded. So while the textbook answer is "no effect," the hysteresis hypothesis suggests tight monetary policy that causes prolonged recession may permanently raise $\bar{u}$.