ECON 1550 — Problem Set 1 Answer Key

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Submission: Canvas or Gradescope

1. Multiple Choice

For each question, select the one correct answer.

(a) In the IS-LM-PC model, when the money supply is exogenous and the nominal interest rate is endogenous, the LM curve is

- ◯ (A) flat
- ✓ **(B) upward sloping**
- ◯ (C) downward sloping
- ◯ (D) vertical

Solution:

- (A) Do not select. A flat LM curve occurs when the interest rate is exogenous.
- **(B) Select.** When income increases, money demand increases. However, equilibrium requires that money demand remains equal to the unchanged exogenous money supply. The nominal interest rate must increase to reduce the money demand by an amount that exactly offsets the increase in money demand induced by the higher income.
- (C) Do not select. A downward sloping LM would imply that the interest rate goes down as income increases, which contradicts that money demand is increasing in income and decreasing in the interest rate.
- (D) Do not select. A vertical LM curve implies that any value for the interest rate is an equilibrium value. However, with an exogenous money supply and a money demand that is decreasing in the interest rate, there is always only one equilibrium value of the interest rate.

(b) In the IS-LM-PC model, when the money supply is endogenous and the nominal interest rate is exogenous, the LM curve is

✓ **(A) flat**

◯ (B) upward sloping

◯ (C) downward sloping

◯ (D) vertical

Solution: Any shape for the LM other than flat implies that the interest rate changes when output changes. However, when the interest rate is exogenous, it cannot change in response to changes in any of the variables of the model. Exogenous variables can only change if we assume they change for reasons outside the model.

- **(A) Select.**
- (B) Do not select.
- (C) Do not select.
- (D) Do not select.

(c) Assume the nominal interest rate is exogenous. An increase in this exogenous nominal interest rate

✓ **(A) keeps the IS curve unchanged**

◯ (B) shifts the IS curve to the right

◯ (C) shifts the IS curve to the left

◯ (D) cannot be determined without more information

Solution: The IS curve gives combinations of the interest rate r and output Y that are equilibria in the goods market. When the interest rate changes, the equilibrium value of output changes (through the effect of the interest rate on investment). Because the IS is plotted with output Y on the horizontal axis and the interest rate r on the vertical axis, simultaneous changes in r and Y that maintain goods market equilibrium correspond to movements along the IS curve.

- **(A) Select.**

- (B) Do not select.
- (C) Do not select.
- (D) Do not select.

(d) When inflation expectations are unanchored, if output exceeds potential output, the inflation rate over time

◯ (A) remains stable

◯ (B) spirals downward

✓ **(C) increases**

◯ (D) decreases

Solution: When inflation expectations are unanchored, expected inflation π_t^e equals inflation in the previous period π_{t-1} The Phillips curve in this case is $\pi_t - \pi_{t-1} = \alpha(Y_t - Y^n)$. If output exceeds potential output, the output gap $(Y_t - Y^n)$ is positive. The Phillips curve then gives $\pi_t > \pi_{t-1}$, that is, inflation is increasing over time.

- (A) Do not select.
- (B) Do not select.
- **(C) Select.**
- (D) Do not select.

(e) In the IS-LM-PC model with anchored inflation expectations, starting from a medium-run equilibrium, the government increases taxes. After the increase in taxes, the resulting medium-run equilibrium has

◯ (A) higher output than in the original medium-run equilibrium

◯ (B) a higher real interest rate than in the original medium-run equilibrium

✓ **(C) an IS curve that is to the left of the IS curve of the original medium-run equilibrium**

◯ (D) the answer depends on whether the LM curve is flat or upward sloping

Solution:

- (A) Do not select. In the resulting medium-run equilibrium, output equals potential just as in the initial medium-run equilibrium. Potential remains unchanged because taxes do not affect potential output.
- (B) Do not select. Taxes do not shift the LM. With an upward-sloping LM, the interest rate falls endogenously; with a flat LM, the central bank must lower the interest rate to bring output back to potential. In both cases, the medium-run real interest rate ends up below the initial medium-run equilibrium.
- **(C) Select.** Higher taxes reduce equilibrium output for any level of the interest rate, so the IS curve shifts to the left.
- (D) Do not select. Same explanation as in (B).

(f) In the Phillips curve, which of the following changes is associated with an increase in the current inflation rate (keeping everything else fixed)?

◯ (A) a decrease in the expected inflation rate

◯ (B) an increase in the unemployment rate

◯ (C) a lower natural rate of unemployment

✓ **(D) an increase in the markup**

Solution: We use that the Phillips curve is

$$\pi = \pi^e + m + z - \alpha u$$
$$= \pi^e - \alpha(u - u_n).$$

- (A) Do not select. Lower expected inflation directly lowers current inflation.
- (B) Do not select. Higher unemployment reduces the bargaining power of workers relative to employers, causing the equilibrium nominal wage to go down. A lower nominal wage means the nominal marginal cost of production is lower. To keep the markup (profit rate) unchanged, firms reduce the price of goods they sell and the price level goes down. A lower price level means lower inflation (the price level in the previous period cannot change in the current period, so changes in the price level correspond

directly to changes in inflation).

- (C) Do not select. A lower natural rate of unemployment is deflationary. For any given rate of unemployment, a lower natural rate of unemployment increases the unemployment gap. The amount of people unemployed relative to the stable-inflation medium-run level is now higher. Workers' bargaining power is therefore lower, pushing the nominal wage and inflation down.

- **(D) Select.** In the Phillips curve relation $\pi = \pi^e + m + z - \alpha u$, a higher markup m increases current inflation, holding π^e, z, α and u fixed. The intuition is that to earn a higher markup at any given level of the nominal wage, firms increase the price of the goods they sell.

(g) Assume that the Phillips curve is given by

$$\pi_t = \pi_t^e + m + z - \alpha u_t.$$

Which of the following causes a reduction in the natural rate of unemployment?

○ (A) an increase in m

○ (B) an increase in z

✓ **(C) an increase in α**

○ (D) an increase in π_t^e

Solution: The natural rate of unemployment is the medium-run equilibrium level of unemployment. Using the medium-run condition $\pi_t = \pi_t^e$ in the Phillips curve and solving for u gives the natural rate of unemployment $u_n = (m + z)/\alpha$.

- (A) Do not select. An increase in m raises u_n.

- (B) Do not select. An increase in z raises u_n.

- **(C) Select.** An increase in α reduces u_n.

- (D) Do not select. π_t^e does not appear in the expression for u_n, so it has no effect on the natural rate.

(h) The price setting equation is $P = (1 + m)W$. When there is perfect competition, we know that

◯ (A) $m > 0$

✓ **(B)** $m = 0$

◯ (C) $m < 0$

◯ (D) the price setting equation does not hold

Solution: The markup m gives the profit rate of firms.

- (A) Do not select. A positive markup occurs under imperfect (monopolistic) competition, when firms use their monopoly power to earn positive profits.
- **(B) Select.** Under perfect competition, firms earn zero profits.
- (C) Do not select. A negative markup would mean firms sell below cost, which leads to bankruptcy and exit from the market.
- (D) Do not select. The price setting equation always holds; under perfect competition it simplifies to $P = W$.

(i) The natural rate of unemployment is the rate of unemployment that occurs when

◯ (A) the money market is in equilibrium

◯ (B) the markup is zero

✓ **(C) the economy is in a medium-run equilibrium**

◯ (D) none of the above

Solution: The natural rate of unemployment is defined as the medium-run equilibrium level of unemployment.

- (A) Do not select.
- (B) Do not select.
- **(C) Select.**
- (D) Do not select.

2. **True, False, or Uncertain**

For each statement below, answer true, false, or uncertain. Explain your answer. Use graphs or equations if useful.

(a) In the accounting identity $Y = C + I + G$, a simultaneous 1% increase in all three variables Y, C, and I can occur while $G > 0$ remains unchanged.

Solution: False. Writing the accounting identity $Y = C + I + G$ as

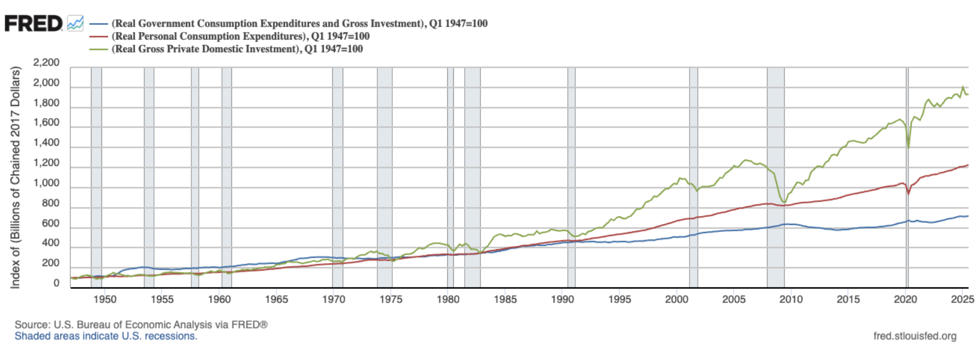
$$1 = \frac{C}{Y} + \frac{I}{Y} + \frac{G}{Y}$$

shows that a 1% increase in Y, C, and I leaves C/Y and I/Y unchanged. Therefore, for the identity to hold, G/Y must also remain unchanged. However, if $G > 0$, a fixed G and a higher Y imply a lower G/Y.

(b) In U.S. postwar data, real investment is substantially more volatile than real consumption and real government purchases.

<u>Hint</u>: Consult your intermediate macro textbook or plot the data using FRED.

Solution: True. Volatility here refers to cyclical fluctuations; investment has visibly larger cyclical swings. The plot below shows the evolution of real consumption, investment, and government purchases for the United States between 1947-Q1 and 2025-Q2 (index, 1947=100).



Source: `https://fred.stlouisfed.org/graph/?g=1QUNW`.

(c) In the IS-LM model, an increase in government spending raises output in the short run.

Solution: True. Higher government spending increases demand in the goods market at any given level of the interest rate. Higher demand, in equilibrium, is associated with higher output.

(d) Assume that investment is a function of output and the real interest rate. In the IS-LM model with an exogenous money supply, a decrease in government spending lowers investment.

Solution: Uncertain. Lower government spending reduces demand for goods. Equilibrium in the goods market then requires lower output for any given interest rate, so the IS shifts to the left. Lower output implies lower income. The decrease in income reduces the demand for money. But with an unchanged exogenous money supply, equilibrium in the money market requires money demand to also remain unchanged. The interest rate decreases so that money demand increases by an amount that exactly offsets the decrease caused by the lower income. The lower interest rate causes an increase in investment.
The overall effect on investment depends on the relative magnitude of the decline in investment caused by the initial drop in demand and the increase in investment caused by the lower interest rate. Without knowing the exact way in which investment responds to output and the interest rate, it is not possible to determine which of the two effects is stronger, making the behavior of equilibrium investment uncertain.

3. **A War Scare in the Short-Run IS-LM**

Consider the following closed-economy IS-LM model. The goods market equilibrium condition is

$$Y = C + I + \bar{G},$$

where Y is output, C is consumption, I is investment, and $\bar{G}$ is government spending. The behavioral equations for consumption and investment are

$$C = c_0 + c_1(Y - \bar{T}), \qquad I = b_0 - b_1 i,$$

where $\bar{T}$ denotes taxes, i is the nominal interest rate, and $c_0 > 0$, $0 < c_1 < 1$, $b_0 > 0$, and $b_1 > 0$ are parameters. Assume expected inflation is constant (so changes in the nominal interest rate i correspond one-for-one to changes in the real interest rate). The money market equilibrium condition is

$$\bar{M}^s = m_0 + m_1 Y - m_2 i,$$

where $\bar{M}^s$ is real money supply (we normalize the price level $P = 1$ so $\bar{M}^s/P = \bar{M}^s$), and $m_0 > 0$, $m_1 > 0$, and $m_2 > 0$ are parameters. The exogenous variables are $\bar{G}$, $\bar{T}$, $\bar{M}^s$, and the model parameters. The endogenous variables are Y, C, I, and i.

(a) Derive the IS curve and its slope.

> **Solution:** The IS curve represents the combinations of interest rates and output that are consistent with equilibrium in the goods market. Using the behavioral equations for consumption and investment in the goods market equilibrium condition gives the IS relation:
>
> $$\begin{aligned} Y &= C + I + \bar{G}, \\ &= c_0 + c_1(Y - \bar{T}) + b_0 - b_1 i + G. \end{aligned}$$
>
> Solving for i gives the IS curve
>
> $$i = \frac{c_0 + b_0 + \bar{G} - c_1\bar{T}}{b_1} - \left(\frac{1 - c_1}{b_1}\right) Y,$$
>
> which is the equation of a line (when plotting i as a function of Y) with slope
>
> $$\text{slope of IS curve} = -\frac{1 - c_1}{b_1}.$$

(b) Derive the LM curve and its slope.

> **Solution:** The LM curve represents the combinations of interest rates and output that are consistent with equilibrium in the money market.
> Solving of i in the money market equilibrium condition gives the LM curve:
>
> $$i = \frac{m_0 - \bar{M}^s}{m_2} + \left(\frac{m_1}{m_2}\right) Y,$$

which is the equation of a line (when plotting i as a function of Y) with slope

$$\text{slope of LM curve} = \frac{m_1}{m_2}.$$

(c) Solve for equilibrium output Y^* and the equilibrium interest rate i^*.

Solution: To make the algebra easier, write the IS from part (a) and the LM from part (b) as

$$\text{IS: } i = p - fY,$$
$$\text{LM: } i = q + gY,$$

where we have created the new auxiliary variables

$$p = \frac{c_0 + b_0 + \bar{G} - c_1\bar{T}}{b_1}, \qquad q = \frac{m_0 - \bar{M}^s}{m_2},$$
$$f = \frac{1 - c_1}{b_1}, \qquad g = \frac{m_1}{m_2}.$$

The IS and the LM are a system of two equations in the two unknowns Y and i. Solving the system gives

$$Y^* = \frac{p - q}{f + g},$$

and

$$i^* = \frac{gp + qf}{f + g},$$

or, in terms of the original variables

$$Y^* = \frac{m_2(c_0 + b_0 + \bar{G} - c_1\bar{T}) + b_1(\bar{M}^s - m_0)}{m_1 b_1 + m_2(1 - c_1)},$$

and

$$i^* = \frac{m_1(c_0 + b_0 + \bar{G} - c_1\bar{T}) + (1 - c_1)(m_0 - \bar{M}^s)}{m_1 b_1 + m_2(1 - c_1)}.$$

(d) Consider an increase in the money supply $\bar{M}^s$. What happens to Y^* and i^*? Explain using the IS-LM diagram.

Solution: Y^* goes up and i^* goes down. An increase in the money supply means a larger $\bar{M}^s$. For money markets to be in equilibrium, money demand must also increase. For people to have a higher money demand for a given level of income, the interest rate must go down so that bonds become less attractive, and people decide to sell bonds and hold more money. The LM curve shifts down.

The fall in the interest rate makes investment increase, pushing up the equilibrium level of output. The economy moves along the IS curve toward the new equilibrium with higher Y^* and lower i^*.

(e) Suppose a "war scare" raises precautionary demand for money, increasing m_0 to $m_0 + \Delta m_0$, where $\Delta m_0 > 0$. Find the new equilibrium level of output Y^{W}.

Solution: The new level of output Y^{W} can be found by replacing m_0 by $m_0 + \Delta m_0$ in the expression for Y^* from part (c):

$$Y^{\text{W}} = Y^* - \frac{\Delta m_0}{m_2(f+g)},$$

with f and g defined as before.

(f) Under the war scare described in (e), how do the IS and LM curves shift? Explain the resulting movement in equilibrium Y and i.

Solution: The increase in money demand caused by the war scare makes the interest rate rise for any given level of output. The LM shifts up. The IS curve is unchanged, as are the slopes of both curves.

As people move away from bonds and toward money, the interest rate increases. A higher interest rate leads to lower investment and lower output. The fall in investment makes equilibrium output fall due to the war scare.

(g) Now suppose fiscal policy follows the rule

$$G = \bar{G} + g_1(Y - Y^*),$$

where Y^* is the original equilibrium output from (c). How does this rule affect the IS curve relative to the constant-$\bar{G}$ case?

Solution: Replace $\bar{G}$ by $\bar{G} + g_1(Y - Y^*)$ in the IS from part (a) to get

$$i = \frac{c_0 + b_0 + \bar{G} + g_1(Y - Y^*) - c_1\bar{T}}{b_1} - \left(\frac{1 - c_1}{b_1}\right) Y,$$

Using the same notation as in (c), we can rewrite this new IS as

$$i = p - \frac{g_1 Y^*}{b_1} - \left(f - \frac{g_1}{b_1}\right) Y.$$

The new intercept is

$$\text{new intercept of IS} = p - \frac{g_1 Y^*}{b_1},$$

and the new slope is

$$\text{new slope of IS} = -\left(f - \frac{g_1}{b_1}\right) = -\frac{1 - c_1 - g_1}{b_1}.$$

Compared to the IS from part (a), the new intercept is

- higher when $g_1 < 0$,
- the same when $g_1 = 0$,
- lower when $g_1 > 0$.

The new slope goes from negative to zero for values of g_1 increasing from negative to $(1 - c_1)$. When g_1 is higher than $(1 - c_1)$, the new slope is positive. Putting together the simultaneous changes in the intercept and slope, the effect of the fiscal rule is to rotate the IS around the equilibrium (Y^*, i^*) from (c).

(h) Using an IS-LM diagram, assess whether the fiscal policy rule in (g) stabilizes the economy after the war scare.

Solution: The war scare shifts the LM only, while the fiscal rule changes the IS only. In the figure below, the LM curve is shown in green and labeled LM^{W} (the W is for "war scare"). This is the LM curve after the war scare; it is unaffected by the fiscal rule since government spending does not enter the money market equilibrium.

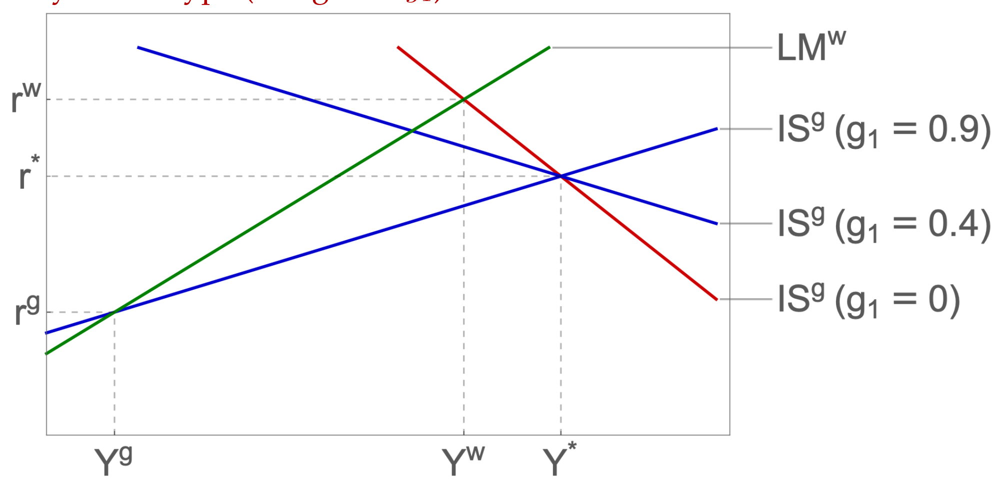
The red line, labeled $IS^g(g_1 = 0)$, is the IS curve before the war scare and also after the war scare. This red IS line is also the IS that would result from the government following the rule $G = \bar{G} + g_1(Y - Y^*)$ with $g_1 = 0$, which is equivalent to the policy $G = \bar{G}$ used in parts (a) through (f).

The two blue lines are two examples of IS curves that result for two different values of $g_1 > 0$. As g_1 increases from zero (the case of the red line) to positive values, it rotates counter-clockwise around (Y^*, i^*). For any positive values of g_1, equilibrium output is even further below the original equilibrium Y^* than it was under the war scare alone. The higher the g_1, the lower the levels of equilibrium output and the interest rate. For the case labeled $IS^g(g_1 = 0.9)$, we have equilibrium values (Y^g, i^g).

We conclude that when $g_1 > 0$, the fiscal policy pursued does not help stabilize the economy. On the contrary, it reduces output even below Y^W. The intuition is that with a positive g_1, when output goes down, government spending also goes down. The reduction in government spending reduces demand, which in turn reduces output. The policy amplifies the decline in Y.

A much better policy is to have a negative g_1 so that government spending increases as output decreases. The same analysis as before but with signs for g_1 reversed shows that fiscal policy makes the decline in output due to the war scare be smaller in magnitude than when G stays constant at $\bar{G}$.

A policy of this type (a negative g_1) is called an automatic stabilizer.



4. **An Endogenous Initial Price Level**

Consider a closed economy described by the following equations. The goods market is in equilibrium when

$$Y_t = C(Y_t - \bar{T}) + I(R_t) + \bar{G},$$

where Y_t is output, $C(\cdot)$ is the consumption function, $\bar{T}$ denotes taxes, $I(\cdot)$ is the investment function, R_t is the real interest rate, and $\bar{G}$ denotes government spending. Note that investment depends only on the interest rate R_t and does not depend on output Y_t. The money market is in equilibrium when

$$\frac{\bar{M}^s}{P_t} = \mathcal{L}(i_t, Y_t),$$

where $\bar{M}^s$ is the nominal money supply, P_t is the price level, $\mathcal{L}(\cdot,\cdot)$ is the real money demand function, and i_t is the nominal interest rate. The Fisher equation is

$$R_t = i_t - \pi^e,$$

where π^e is expected inflation. The labor market implies an aggregate supply relation of the form

$$P_t = (1+m)P_t^e F\left(1 - \frac{Y_t}{L}, z\right),$$

where m is the markup, P_t^e is the expected price level, L is the labor force, $u_t = 1 - \frac{Y_t}{L}$ is the unemployment rate, z is a catch-all variable for factors affecting the nominal wage other than P_t^e and u_t, and $F(\cdot,\cdot)$ is a function decreasing in its first argument and increasing in its second one. Assume the functional forms

$$C(Y - \bar{T}) = 1 + \frac{1}{2}(Y - \bar{T}),$$

$$I(R) = 2 - R,$$

$$\mathcal{L}(i, Y) = 2 + Y - 0.2i,$$

$$F(u, z) = 1 - \alpha u + z,$$

where $\alpha > 0$ is a parameter.

(a) Is the consumption function $C(\cdot)$ increasing or decreasing in its argument? Provide economic intuition.

Solution: The consumption function $C(\cdot)$ is increasing in disposable income $Y_D \equiv Y - \bar{T}$. Intuition: When households have higher disposable income, they consume more. This is a fundamental behavioral assumption: as people earn more (after taxes), they spend more on goods and services.

(b) Is the investment function $I(\cdot)$ increasing or decreasing in its argument? Provide economic intuition.

Solution: The investment function $I(\cdot)$ is decreasing in the real interest rate R_t. Intuition: The real interest rate represents the cost of borrowing for firms. When the real interest rate rises, it becomes more expensive for firms to finance investment projects, so they invest less. Equivalently, a higher real interest rate raises the required return on investment projects, making fewer projects profitable.

(c) Is the money demand function $\mathcal{L}(\cdot,\cdot)$ increasing or decreasing in each of its arguments? Provide economic intuition.

Solution: The money demand function $\mathcal{L}(i, Y)$ is decreasing in the nominal interest rate i and increasing in income Y. Intuition: When i goes up, people prefer to hold less money and more bonds, so money demand falls. The variable Y in this context plays the role of aggregate income. Higher income makes people want to buy more goods, which requires more transactions. To be able to conduct more transactions, people must hold more money.

(d) Derive the IS curve (when plotted with the nominal interest rate i_t on the vertical axis and output Y_t on the horizontal axis).

Solution: Substituting the functional forms into the goods market equilibrium:

$$Y_t = 1 + \frac{1}{2}(Y_t - \bar{T}) + 2 - R_t + \bar{G} = 1 + \frac{1}{2}(Y_t - \bar{T}) + 2 - (i_t - \pi^e) + \bar{G}.$$

Solving for i_t:

$$i_t = 3 - \frac{1}{2}\bar{T} + \bar{G} + \pi^e - \frac{1}{2}Y_t.$$

(e) Derive the LM curve (when plotted with the nominal interest rate i_t on the vertical axis and output Y_t on the horizontal axis).

Solution: From the money market equilibrium:

$$\frac{\bar{M}^s}{P_t} = 2 + Y_t - 0.2 i_t.$$

Solving for i_t:

$$i_t = 5\left(2 + Y_t - \frac{\bar{M}^s}{P_t}\right) = 10 - 5\frac{\bar{M}^s}{P_t} + 5Y_t.$$

(f) Combine the IS and LM relations to eliminate i_t and obtain an aggregate demand relation of the form

$$Y_t = AD\left(\frac{\bar{M}^s}{P_t}, \bar{T}, \bar{G}, \pi^e\right),$$

where AD is a function increasing in $\bar{M}^s/P_t$, $\bar{G}$, and π^e, and decreasing in $\bar{T}$.

Hint: Your final expression should be linear in $\bar{M}^s/P_t$, $\bar{T}$, $\bar{G}$, and π^e, i.e., AD is a linear function.

Solution: Equating the i_t implied by the IS from part (d) to the i_t implied by the LM from part (e) gives

$$3 - \frac{1}{2}\bar{T} + \bar{G} + \pi^e - \frac{1}{2}Y_t = 10 - 5\frac{\bar{M}^s}{P_t} + 5Y_t.$$

Solving for Y_t:

$$Y_t = -\frac{14}{11} - \frac{1}{11}\bar{T} + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e + \frac{10}{11}\frac{\bar{M}^s}{P_t}.$$

(g) Find potential output, denoted Y^n, as a function of m, z, α, and L.

Solution: With $P_t^e = P_t$, the aggregate supply relation becomes:

$$P_t = (1+m)P_t F\left(1 - \frac{Y^n}{L}, z\right).$$

This simplifies to:

$$1 = (1+m)\left(1-\alpha\left(1-\frac{Y^n}{L}\right)+z\right).$$

Solving for Y^n:

$$Y^n = \left(1-\frac{1}{\alpha}\left(1-\frac{1}{1+m}+z\right)\right)L = \left(1-\frac{m+z(1+m)}{\alpha(1+m)}\right)L.$$

(h) Explain briefly why, in this model, potential output Y^n does not depend on monetary and fiscal policy variables such as $\bar{M}^s$, $\bar{T}$, and $\bar{G}$.

Solution: Y^n does not depend on $\bar{M}^s, \bar{T}, \bar{G}$ because in the medium run, the labor market determines output through the wage and price setting process. Monetary and fiscal policy can only affect output in the short run when prices are sticky; in the medium run, output is determined by real factors (technology, labor force, markup, labor market conditions).

(i) Assume the economy is in a medium-run equilibrium at $t = 0$, so $Y_0 = Y^n$ and $P_0^e = P_0$. Use the aggregate demand relation from (f) and the condition $Y_0 = Y^n$ to solve for the initial price level P_0 as a function of $\bar{M}^s$, $\bar{T}$, $\bar{G}$, π^e and the parameters m, z, α, and L.

Solution: Using the AD relation at time $t = 0$ and with $Y_0 = Y^n$:

$$Y^n = -\frac{14}{11} - \frac{1}{11}\bar{T} + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e + \frac{10}{11}\frac{\bar{M}^s}{P_0}.$$

Solving for P_0:

$$P_0 = \frac{10\bar{M}^s}{11Y^n + \bar{T} - 2\bar{G} - 2\pi^e + 14}.$$

Substituting $Y^n = \left(1 - \frac{m+z(1+m)}{\alpha(1+m)}\right)L$ from (g):

$$P_0 = \frac{10\bar{M}^s}{11\left(1 - \frac{m+z(1+m)}{\alpha(1+m)}L\right) + \bar{T} - 2\bar{G} - 2\pi^e + 14}.$$

(j) At time $t = 1$ the government announces an unexpected increase in taxes from $\bar{T}$ to $\bar{T} + \Delta T$, where $\Delta T > 0$. Assume that, in the short run, the price level is fixed at $P_1 = P_0$. Compute the short run equilibrium values of output Y_1 and the interest rate i_1. Express your answers in terms of $\bar{M}^s$, P_0, $\bar{T}$, $\bar{G}$, π^e, and ΔT.

Solution: Using the AD relation with $T_1 = \bar{T} + \Delta T$ and $P_1 = P_0$:

$$Y_1 = -\frac{14}{11} - \frac{1}{11}(\bar{T} + \Delta T) + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e + \frac{10}{11}\frac{\bar{M}^s}{P_0} = Y^n - \frac{1}{11}\Delta T,$$

where the second equality follows by using the expression for Y^n from (i). For i_1, use the LM relation:

$$i_1 = 10 + 5Y_1 - 5\frac{\bar{M}^s}{P_0} = 10 + 5Y^n - \frac{5}{11}\Delta T - 5\frac{\bar{M}^s}{P_0}.$$

(k) Assume the tax increase is permanent. Assume the economy eventually returns to a medium-run equilibrium with $Y = Y^n$ and $P^e = P$. Compute the new medium-run price level P_{MR} and compare it to P_0.

Solution: In the new medium run with $Y = Y^n$ and taxes at $\bar{T} + \Delta T$:

$$Y^n = \frac{10}{11}\frac{\bar{M}^s}{P_{\text{MR}}} - \frac{1}{11}(\bar{T} + \Delta T) + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e - \frac{14}{11}.$$

Solving for P_{MR}:

$$P_{\text{MR}} = \frac{10\bar{M}^s}{11Y^n + (\bar{T} + \Delta T) - 2\bar{G} - 2\pi^e + 14}.$$

Since $\bar{T} + \Delta T > \bar{T}$, the denominator is larger, so $P_{\text{MR}} < P_0$. The permanent tax increase leads to a lower price level in the medium run.

ECON 1550 — Problem Set 2 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

Chapter 2: National Income Accounting and the Balance of Payments

1. Import Restrictions Effects on the Current Account

Please answer Question 2 from Chapter 2 of the textbook, reproduced here for convenience:

> "Equation (2-2) tells us[1] that to reduce a current account deficit, a country must increase its private saving, reduce domestic investment, or cut its government budget deficit. Nowadays, some people recommend restrictions on imports from China (and other countries) to reduce the American current account deficit. How would higher U.S. barriers to imports affect its private saving, domestic investment, and government deficit? Do you agree that import restrictions would necessarily reduce a U.S. current account deficit?"

Solution: It is possible to tell stories in which the effect on the current account goes either way. There are many valid answers. Here, we focus on investment (as discussed in class), which empirically is often the key factor in determining whether the current account improves. Public and private saving can, of course, also change.
One direct channel through which investment can increase is through an increase in demand. When imported goods become more expensive or less available, consumers may switch to domestic substitutes. Another channel is through profits. If domestic producers' monopoly power increases because of the reduced competition from abroad, profits can increase. If profitability is expected to be persistent, it can induce domestic firms to invest to increase future production.

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[1] Equation (2-2) is

$$S^p = I + CA - S^g = I + CA - (T - G) = I + CA + (G - T),$$

where S^p is private savings, I is investment, CA is the current account, S^g is government savings, T are taxes and G is government spending.

On the other hand, investment might fall in industries that face higher costs of imported intermediate goods, or higher costs of domestic substitutes.
Equation (2-2) is a powerful accounting identity: it must hold at all times and is therefore sufficient to rule out many common claims about the current account. In particular, it makes clear that tariffs affect the current account insofar as they also change private saving, domestic investment, or the government budget balance.
At the same time, the accounting identity alone cannot generate predictions about the direction or magnitude of specific variables, as evidenced by the examples above. Making such predictions requires additional assumptions—an explicit model with behavioral equations.
We will introduce and study those models later in the course.

2. **New Dynamics for American Primary Income**

Question 10 from Chapter 2 of the textbook states:

> "If you go to the BEA website for "U.S. International Transactions", table 1.1, you will find that in 2015, U.S. income receipts on its foreign assets were $ 775.85 billion (line 6), while the country's payments on liabilities to foreigners were $ 582.47 billion (line 14). Yet we saw in this chapter that the United States is a substantial net debtor to foreigners. How, then, is it possible that the United States received more foreign asset income than it paid out?"

In this question, we work through an updated version. There have been some interesting developments since 2015!

Go to FRED (Federal Reserve Economic Data) at `https://fred.stlouisfed.org` and plot the series "Balance on primary income" with series ID IEABCPI. Then answer the following:

(a) Give one concrete example that would contribute to the time series positively (make the balance on primary income larger) and one that would contribute negatively (make it smaller).

Solution: Here are a few examples (you only need one that contributes positively and one negatively for full credit).
Contribute positively:

- Wages paid to Prof. Duarte for teaching in France.

- Profits earned by Nike's subsidiary in Vietnam.
- Dividends received by a U.S. resident on shares of the Japanese firm Toyota.
- Interest received by U.S. residents on bonds they own that were issued by the Government of Mexico.
- Interest received by the Federal Reserve from the Banco Central do Brasil on dollars provided through a currency swap line during the Covid pandemic.

Contribute negatively:

- Dividends paid to a U.K. resident on shares of the U.S. company NVIDIA.
- Interest paid by Bank of America to an Australian resident on U.S. dollar deposits.
- Interest paid by the U.S. Treasury to the People's Bank of China on its holdings of U.S. Treasury securities.

(b) List all quarters in which the balance on primary income is negative.

Solution: There are only seven negative quarters in the entire dataset:

- Q3 2001: –$620 million
- Q4 2023: –$297 million
- Q1 2024: –$10,219 million
- Q2 2024: –$11,210 million
- Q3 2024: –$21,225 million
- Q1 2025: –$2,596 million
- Q2 2025: –$5,772 million

Additional information (not needed for full credit):
Here is the plot for the entire series, obtained from `https://fred.stlouisfed.org/series/IEABCPI`. The balance on primary income for each quarter is shown in the figure below. Quarters with negative values are marked with red dots.

(c) The United States is a substantial net debtor to foreigners. How, then, is it possible that the United States received more foreign asset income than it paid out?

Solution: Assets is a stock variable, while income is a flow variable[2]. That the value of foreign assets owned by the U.S. is less than the value of American assets owned by foreign countries (the U.S. is a net debtor) is a comparison between two stock variables. On any given quarter, the income flow generated by the smaller stock of foreign assets owned by the U.S. can be larger than the income flow generated by the larger stock of American assets owned by foreign countries. If bucket A has less water than bucket B, you can still pour more water out of bucket A than out of bucket B.

Income over one quarter equals assets at the beginning of the quarter multiplied by the return on those assets. Historically, the U.S. received a substantially higher rate of return on its foreign assets than other countries did on their U.S. assets. Key reasons include:

- U.S. foreign direct investment tends to earn higher returns than portfolio investment
- A substantial amount of foreign-held U.S. assets are Treasury securities, which have relatively low returns
- U.S. multinational corporations book profits in low-tax jurisdictions, inflating measured returns on foreign assets

The 2024 reversal suggests these advantages are no longer sufficient to offset the growing interest payments on the U.S.'s large net debtor position at the current relatively high level of interest rates.

[2]Stock: a variable that can be expressed as a quantity at a point in time (such as physical capital). Flow: a variable that can be expressed as a quantity per unit of time (such as investment).

(d) Go to the BEA website at `https://www.bea.gov/itable/` and find Table 1.1 U.S. International Transactions. For the year 2024, report the values of primary income receipts (line 6) and primary income payments (line 14). Compute the annual balance on primary income by subtracting payments from receipts. Compare this annual balance to the sum of the four quarterly values from the FRED series for 2024. Do they match? Are they expected to match?

Hint: Finding the numbers should take, at most, 5 minutes. The need to poke around a bit (rather than giving you the exact link) is built into this problem intentionally so that you gain some familiarity with international account statistics.

Solution: From BEA Table 1.1 for the year 2024:

- Line 6 (Primary income receipts): $1,451,065 million
- Line 14 (Primary income payments): $1,492,104 million
- Balance (Line 6 – Line 14): $1,451,065 – $1,492,104 = –$41,039 million

Sum of quarterly IEABCPI values for 2024:

$$\begin{aligned} &\text{Q1 2024} + \text{Q2 2024} + \text{Q3 2024} + \text{Q4 2024} \\ &\quad = (-10{,}219) + (-11{,}210) + (-21{,}225) + 1{,}615 \\ &\quad = -41,039 \text{ million.} \end{aligned}$$

The two values match exactly. The quarterly series comes from BEA Table 1.2 (Expanded Detail), while Table 1.1 is the summary table—but both contain the same primary income balance data.

(e) If you had taken this course in 2023, the textbook's 2015 framing would still have applied, with over two decades of positive values for the time series. The magnitude of the 2024-Q3 value (a deficit of $21 billion) is particularly noteworthy. Do some research and try to pinpoint the causes behind this large deficit. Keep it short and concrete. This question will be graded on effort rather than correctness.

Solution: The textbook's assumption that the U.S. receives more on its foreign assets than it pays on its liabilities held true for over two decades but reversed starting in Q4 2023. Q4 2023 marked the first quarterly deficit since Q3 2001, and Q1–Q3 2024 plus Q1–Q2 2025 all had deficits (Q4 2024 was positive), with Q3 2024 being the largest at $-\$21.2$ billion.

In Q3 2024 specifically, primary income receipts (earnings from overseas investments) fell by $15.5 billion, or 4.3%, primarily driven by declining direct investment earnings, while primary income payments decreased only slightly (BEA Survey of Current Business, January 2025). The deterioration was broad-based, with declining balances across all three major categories: direct investment, portfolio investment, and other investment earnings.

This structural shift reflects several factors:

- Rising interest rates increased payments on U.S. debt held by foreigners (much of it in Treasury securities). Net external interest payments now reach 1.3% of GDP.
- The "low-for-long" era of near-zero interest rates ended, so the U.S. can no longer borrow as cheaply while earning high returns abroad. When this profit-shifting is excluded, the income advantage largely disappears.
- Returns on American assets, dominated by AI-related industries, became relatively more profitable than U.S. investments overseas, further eroding the traditional return differential.

Review of Intermediate Macro

3. **The Labor Market and Phillips Curve**

Consider the following model of the labor market:

Labor force	L
Employment	N
Wage setting	$W = P^e(1-u)$
Price setting	$P = (1+\mu)W(1+\tau)$
Production function	$Y = N$

In the equations above, W is the nominal wage, P^e is the expected price level, u is the unemployment rate, P is the price level, μ is the markup, τ is a labor tax, and Y is output.

The labor tax τ is paid by firms that hire workers. If firms hire workers for a nominal wage W, they must pay τW to the government.

In the short run, the exogenous variables are L, μ, τ, P^e, and Y, while the endogenous variables are N, W, u, P.

In the medium run, the exogenous variables are L, P, μ, and τ, while the endogenous variables are N, W, u, P^e, and Y. In the medium run, the expected price level P^e is determined by $P^e = P$.

(a) Write an equation for the unemployment rate, u, in terms of the labor force L and employment N. Is this equation an identity, a behavioral equation, or an equilibrium condition?

Solution: The unemployment rate is

$$u \equiv \frac{L - N}{L}.$$

This is an identity so we use $\equiv$ instead of $=$.

(b) Solve the model in the short run.

Hint: Recall that "solving the model" means to write all endogenous variables in terms of exogenous variables only.

Solution: The short-run solution is:

$$\begin{aligned} N &= Y \\ W &= P^e \frac{Y}{L} \\ u &= 1 - \frac{Y}{L} \\ P &= P^e (1+\mu) \frac{Y}{L} (1+\tau). \end{aligned}$$

We now show how to derive this answer. The production function gives the solution for N:

$$N = Y.$$

Using the answer from a) and $N = Y$, we get the solution for u:

$$u = \frac{L - N}{L} = \frac{L - Y}{L} = 1 - \frac{Y}{L}.$$

Combine the wage and price setting relationships:

$$P = P^e(1+\mu)(1-u)(1+\tau).$$

Using the solution for u gives the solution for P:

$$\begin{aligned} P &= P^e(1+\mu)(1-u)(1+\tau) \\ &= P^e(1+\mu)\left(1 - \left(1 - \frac{Y}{L}\right)\right)(1+\tau) \\ &= P^e(1+\mu)\frac{Y}{L}(1+\tau). \end{aligned}$$

Plugging the solution for P into the price setting relationship:

$$P^e(1+\mu)\frac{Y}{L}(1+\tau) = (1+\mu)W(1+\tau).$$

Simplifying and solving for W gives:

$$W = P^e\frac{Y}{L}.$$

(c) Solve the model in the medium run.

Solution: The medium-run solution is:

$$\begin{aligned} N &= \frac{L}{(1+\mu)(1+\tau)} \\ W &= \frac{P}{(1+\mu)(1+\tau)} \\ u &= 1 - \frac{1}{(1+\mu)(1+\tau)} \\ P^e &= P \\ Y &= \frac{L}{(1+\mu)(1+\tau)}. \end{aligned}$$

We now show how to derive this answer. First, we note that the equations that give the short-run solution obtained in part b) are valid equations in the medium run with $P = P^e$ (can you see why?). The short-run solution for P with $P = P^e$ gives:

$$1 = (1+\mu)\frac{Y}{L}(1+\tau).$$

Solving for Y gives:

$$Y = \frac{L}{(1+\mu)(1+\tau)}.$$

Plugging the last equation into the solutions for u and W from part b), and using $P = P^e$, we get:

$$u = 1 - \frac{Y}{L} = 1 - \frac{1}{(1+\mu)(1+\tau)},$$

$$W = \frac{P}{(1+\mu)(1+\tau)}.$$

(d) How do u, P, P^e, and Y respond to an increase in the labor tax τ in the short run? Give economic intuition for your answer.

Solution: Short run

Using the answers from part b), we can see that an increase in the labor tax τ leads to an increase in the price level P and no change in any of the other variables.

The intuition is as follows. Since output Y, the labor force L, and the expected price level P^e are exogenous, they are unchanged. To produce the same output as before the increase in tax, the production function implies that firms need to hire the same number of workers, so N remains unchanged. With N and L unchanged, the unemployment rate u also remains unchanged. The wage setting relation implies that the nominal wage W also stays the same: since the unemployment rate is unchanged, the bargaining power of workers and firms does not change, and since the expected price level is unchanged, the real standard of living that workers expect and the real wage bill that firms expect to pay both remain unchanged. By the price setting relation, higher labor taxes increase firms' marginal cost $W(1+\tau)$ even if wages have not changed. To keep earning the same markup μ as before the tax increase, firms increase the price

P at which they sell their goods.

(e) How do u, P, P^e, and Y respond to an increase in the labor tax τ in the medium run? Give economic intuition for your answer.

Solution: Medium run

Using the answers from part c), we can see that an increase in the labor tax τ leads to lower N, W and Y; higher u; and unchanged P^e.

The intuition is as follows. Since P did not change, the price that firms charge for the goods they sell is unchanged. By the price setting relation, to earn the same profit margin μ at the given price level P, firms keep the marginal cost $W(1+\tau)$ unchanged. For a given nominal wage W, the increase in tax τ makes marginal cost go up. To offset the increase in marginal cost caused by the higher tax rate, firms pay a lower nominal wage. In turn, a lower nominal wage W and an unchanged expected price level P^e leads to a lower expected real wage W/P^e. By the wage setting relation, the lower expected real wage leads to an increase in the unemployment rate u or, equivalently, a reduction in employment N, as workers' willingness to work declines. The production function then implies that the lower number of workers produce less output Y.

(f) We now introduce subscripts to keep track of the value of variables at different points in time. For a variable x, we denote its value at time t by x_t. For example, P_t is the price level at time t. We assume all variables can change over time (so we add time subscripts to all variables).

Inflation and expected inflation are defined by:

$$\pi_t \equiv \frac{P_t - P_{t-1}}{P_{t-1}},$$

$$\pi_t^e \equiv \frac{P_t^e - P_{t-1}}{P_{t-1}}.$$

The non-linear Phillips Curve. Using your answers from parts (a) and (b), give an expression for inflation π_t only as a function of π_t^e, μ_t, u_t, and τ_t.

Solution: In part b), we found that

$$P = P^e(1+\mu)\frac{Y}{L}(1+\tau).$$

Using the answer from part a), we can re-write the last equation as:

$$P = P^e(1+\mu)(1-u)(1+\tau).$$

Introducing time subscripts for all variables gives:

$$P_t = P_t^e\left(1+\mu_t\right)\left(1-u_t\right)\left(1+\tau_t\right).$$

Dividing both sides by P_{t-1}, we get:

$$\frac{P_t}{P_{t-1}} = \frac{P_t^e}{P_{t-1}}\left(1+\mu_t\right)\left(1-u_t\right)\left(1+\tau_t\right).$$

Using the definitions for inflation and expected inflation, we get:

$$1+\pi_t = \left(1+\pi_t^e\right)\left(1+\mu_t\right)\left(1-u_t\right)\left(1+\tau_t\right).$$

This is the *non-linear* Phillips curve (because inflation is not a linear function of π_t^e and u_t).

(g) Show that the expression you found in part (f) can be written as:

$$\frac{1+\pi_t}{1+\pi_t^e} = \frac{1-u_t}{1-u_t^n},$$

where u_t^n is the medium-run unemployment rate that you found in part (c), also called the natural rate of unemployment.

Solution: From c), we have that

$$u = 1 - \frac{1}{(1+\mu)(1+\tau)},$$

$$u_t^n = 1 - \frac{1}{\left(1+\mu_t\right)\left(1+\tau_t\right)}.$$

Substituting the last equation into the non-linear Phillips Curve from part f) and re-arranging, we find that

$$\frac{1+\pi_t}{1+\pi_t^e} = \frac{1-u_t}{1-u_t^n}.$$

(h) The Phillips Curve. Show that when π_t, π_t^e, u_t, and u_t^n are small enough, a good approximation to the expression given in part (g) is:

$$\pi_t = \pi_t^e - (u_t - u_t^n).$$

Hint: Use that when x and y are small enough,

$$\frac{1+x}{1+y} \approx 1 + x - y$$

is a good approximation.

Solution: Using the hint with $x = \pi_t$ and $y = \pi_t^e$ gives the approximation

$$\frac{1+\pi_t}{1+\pi_t^e} \approx 1 + \pi_t - \pi_t^e.$$

Using the hint with $x = -u_t$ and $y = -u_t^n$ gives the approximation

$$\frac{1-u_t}{1-u_t^n} \approx 1 - u_t + u_t^n.$$

Plugging the two approximations into the expression

$$\frac{1+\pi_t}{1+\pi_t^e} = \frac{1-u_t}{1-u_t^n}$$

found in part g) gives

$$1 + \pi_t - \pi_t^e = 1 - u_t + u_t^n.$$

Re-arranging, we get

$$\pi_t = \pi_t^e - (u_t - u_t^n).$$

This is the Phillips curve, which is a linear equation (inflation is a linear function of π_t^e and u_t).

(i) From now on, assume that the labor force is always $L = 1$.

Show that the Phillips Curve from part (h) can also be written as:

$$\pi_t = \pi_t^e + (Y_t - Y_t^n),$$

where Y_t^n is the medium-run level of output that you found in part (c), also called the natural level of output or potential output.

Solution: The answer from part a), the production function $Y = N$, and $L = 1$, imply

$$u = 1 - Y.$$

After adding time subscripts and the superscript n for the medium run, plugging the last equation into the Phillips Curve from part h) gives

$$\pi_t = \pi_t^e - ((1 - Y_t) - (1 - Y_t^n)).$$

Simplifying,

$$\pi_t = \pi_t^e + (Y_t - Y_t^n).$$

(j) Assume the economy is initially at its medium-run equilibrium with $P = 1$. Then, the government increases labor taxes from τ to τ^{new} (with $\tau < \tau^{new}$). Immediately after the increase in τ, the economy jumps to its short-run equilibrium. Keep assuming that $L = 1$ at all times. The variables μ, P^e, and Y that are exogenous in the short inherit their value from the initial medium-run equilibrium.

Is inflation π_t in the short-run equilibrium positive, negative, or zero? Give intuition for why.

Hint: Use your previous answers.

Solution: From part c), the initial medium-run equilibrium with $L = P = 1$ has

$$Y = Y^n = \frac{1}{(1+\mu)(1+\tau)},$$

$$P^e = P = 1.$$

The short-run solution from part b) with

$$L = 1,$$
$$Y = Y^n = \frac{1}{(1+\mu)(1+\tau)},$$
$$P^e = 1,$$

is

$$N = Y^n,$$
$$W = Y^n,$$
$$u = 1 - Y^n,$$
$$P = (1+\mu)\left(1+\tau^{new}\right)Y^n = \frac{1+\tau^{new}}{1+\tau} > 1.$$

Inflation in the short-run equilibrium is positive

$$\pi_t = \frac{\frac{1+\tau^{new}}{1+\tau} - 1}{1} = \frac{\tau^{new} - \tau}{1+\tau} > 0.$$

(k) Find expected inflation π_t^e in the short-run equilibrium. Is expected inflation positive, negative, or zero? Give intuition for why.

Hint: Use the Phillips Curve.

Solution: The new medium-run natural level of output after taxes increase from τ to τ^{new} is

$$Y^{n,new} = \frac{1}{(1+\mu)\left(1+\tau^{new}\right)}.$$

Plugging this $Y^{n,new}$ and the expressions for Y^n and π_t from part j) into the Phillips Curve

$$\pi_t = \pi_t^e + \left(Y^n - Y^{n,new}\right)$$

gives

$$\frac{\tau^{new} - \tau}{1+\tau} = \pi_t^e + \left(\frac{1}{(1+\mu)(1+\tau)} - \frac{1}{(1+\mu)\left(1+\tau^{new}\right)}\right).$$

Solving for π_t^e and simplifying,

$$\begin{aligned}\pi_t^e &= \frac{\tau^{new} - \tau}{1+\tau} - \left(\frac{1}{(1+\mu)(1+\tau)} - \frac{1}{(1+\mu)\,(1+\tau^{new})}\right) \\ &= \frac{1}{(1+\mu)(1+\tau)}\left((\tau^{new}-\tau)(1+\mu) + \frac{1+\tau}{1+\tau^{new}} - 1\right).\end{aligned}$$

Expected inflation is positive:

$$\begin{aligned}&\Longrightarrow \pi_t^e > 0 \\ &\Longrightarrow \frac{1}{(1+\mu)(1+\tau)}\left((\tau^{new}-\tau)(1+\mu) + \frac{1+\tau}{1+\tau^{new}} - 1\right) > 0 \\ &\Longrightarrow (\tau^{new}-\tau)(1+\mu) + \frac{1+\tau}{1+\tau^{new}} - 1 > 0 \\ &\Longrightarrow (1+\mu)(1+\tau^{new}) > 1.\end{aligned}$$

Where I have used that μ, τ, and τ^{new} are positive and that $\tau^{new} > \tau$.

ECON 1550 — Problem Set 3 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

1. **Multiple Choice**

Select only one answer.

(a) The carry trade

- ◯ (A) has positive average returns because the uncovered interest parity condition holds.
- ◯ (B) has a non-zero risk premium only when covered interest parity holds.
- ◯ (C) is risky because the difference between domestic and foreign interest rates fluctuates over time.
- ✓ **(D) earns a zero average risk premium when the uncovered interest parity condition holds.**

Solution:

- (A) Do not select. The carry trade has positive average returns because the uncovered interest parity condition does *not* hold empirically.
- (B) Do not select. The carry trade risk premium is about whether *uncovered* interest parity holds, not *covered* interest parity.
- (C) Do not select. The carry trade is risky because exchange rates fluctuate, not because interest rate differentials fluctuate.
- **(D) Select.** When UIP holds, expected returns from investing in foreign versus domestic bonds are equal, implying a zero average risk premium.

(b) Running a current account deficit is equivalent to

- ✓ **(A) net borrowing from the rest of the world.**
- ◯ (B) net lending to the rest of the world.

○ (C) an increase in public savings.
○ (D) an increase in private savings.

Solution:

- **(A) Select.** A current account deficit means imports exceed exports, so the country must finance the difference by borrowing from abroad (or selling assets to foreigners).
- (B) Do not select. Lending to the rest of the world corresponds to a current account *surplus*, not a deficit.
- (C) Do not select. An increase in public savings (larger government budget surplus or smaller deficit) would tend to improve the current account, not cause a deficit.
- (D) Do not select. An increase in private savings would also tend to improve the current account, not cause a deficit.

(c) If the government has a $100 million budget deficit, private saving is equal to $500 million, private investment is equal to $300 million, what is the value of the current account?

✓ **(A) $100 million surplus.**
○ (B) $700 million surplus.
○ (C) $100 million deficit.
○ (D) $700 million deficit.

Solution:

- **(A) Select.** Using the identity $S^p + (T - G) = I + CA$, we have $500 + (-100) = 300 + CA$, so $CA = 100$ million surplus.
- (B) Do not select. This would require a different combination of savings, investment, and government balance.
- (C) Do not select. This has the wrong sign; the calculation yields a surplus, not a deficit.
- (D) Do not select. This has both the wrong sign and the wrong magnitude.

(d) Which of the following correctly shows the relationship between savings, the government budget balance, and the current account?

- ◯ (A) $S^p + CA = I + (T - G)$
- ◯ (B) $S^p + CA = I + (T + G)$
- ✓ **(C)** $S^p + (T - G) = I + CA$
- ◯ (D) $S^p + (T + G) = I + CA$

Solution:

- (A) Do not select. The terms are on the wrong sides of the equation.
- (B) Do not select. Both the placement and the sign of G are incorrect.
- **(C) Select.** This is the correct national income identity: private savings plus public savings (government budget balance $T - G$) equals investment plus the current account.
- (D) Do not select. The government budget balance should be $T - G$, not $T + G$.

(e) All else equal, if Canada raises its interest rates,

- ✓ **(A) the U.S. dollar depreciates.**
- ◯ (B) the U.S. demand for Canadian dollars decreases.
- ◯ (C) the Canadian supply of Canadian dollars increases.
- ◯ (D) the Canadian dollar will depreciate.

Solution:

- **(A) Select.** The symbol for the Canadian dollar is CAD. All else equal, higher Canadian interest rates increase demand for CAD-denominated bonds. To purchase these bonds, people need to use CAD, so demand for CAD increases. The CAD appreciates and the USD depreciates.
- (B) Do not select. U.S. demand for Canadian dollars *increases* as U.S. investors seek higher Canadian interest rates.
- (C) Do not select. Money supply does not enter UIP. Looking at the FX market in isolation says nothing about money supply. In the Canadian money

market, if money supply is exogenous, it does not change by assumption. If money supply is endogenous, higher Canadian interest rates lead to lower (not higher) money supply.

- (D) Do not select. The CAD appreciates (not depreciates). The explanation is the same as for choice (A).

2. **Chapter 3: Exchange Rates and the Foreign Exchange Market: An Asset Approach**

   (a) Please answer question 11 from Chapter 3 of the textbook, reproduced here for convenience:

   > "Suppose the dollar exchange rates of the euro and the yen are equally variable. The euro, however, tends to depreciate unexpectedly against the dollar when the return on the rest of your wealth is unexpectedly high, while the yen tends to appreciate unexpectedly in the same circumstances. As a U.S. resident, which currency, the euro or the yen, would you consider riskier?"

   Solution: The yen is riskier for you (equivalently, the euro is safer). When the return on the rest of your wealth is unexpectedly low, the euro tends to appreciate against the dollar, reducing your losses by giving you a relatively high payoff in terms of dollars. Conversely, losses on your euro assets tend to occur when they are least painful, that is, when the rest of your wealth is unexpectedly high. Holding the euro, therefore, reduces the variability of your total wealth, acting as a hedge (insurance) against bad outcomes (low wealth). The yen behaves in the opposite way and therefore is riskier.
   This logic showed up in lecture as one of the possible explanations for why the carry trade has a non-zero risk premium.

   (b) Consider our model of exchange rate determination through uncovered interest parity (UIP) for two time periods, t and $t+1$. Tables I and II summarize this two-period model. The behavioral equation for the expected exchange rate at $t+1$, E^e_{t+1}, is missing from Table II (the entry for that equation is '??'). Propose a reasonable behavioral equation for E^e_{t+1} such that an (exogenous) increase in E^e_t results in an increase in E_{t+1}. Explain the intuition for why E_{t+1} increases when E^e_t increases.

Hint: By reasonable, we mean reasonable to you. This is your own new model of exchange rate determination!

Table I: Exogenous variables

Variable	Description
R_t	Domestic interest rate at t
R_t^*	Foreign interest rate at t
E_t^e	Expected exchange rate at t
R_{t+1}	Domestic interest rate at $t+1$
R_{t+1}^*	Foreign interest rate at $t+1$

Table II: Endogenous Variables and Equations

Variable	Description	Equation	Type of equation
E_t	Exchange rate at t	$R_t = R_t^* + \frac{E_t^e - E_t}{E_t}$	Equilibrium condition
E_{t+1}	Exchange rate at $t+1$	$R_{t+1} = R_{t+1}^* + \frac{E_{t+1}^e - E_{t+1}}{E_{t+1}}$	Equilibrium condition
E_{t+1}^e	Expected exchange rate at $t+1$	??	Behavioral equation

Solution: We propose one particular answer, but of course there are many correct answers.

Irrespective of what equation we propose for E_{t+1}^e, the equilibrium at t looks like the standard equilibrium of the static (one-period) model we studied in class. For this standard model, we can solve the UIP condition for E_t to get

$$E_t = \frac{E_t^e}{1 + R_t - R_t^*}.$$

When E_t^e goes up, E_t goes up as well: at time t, the expectation of a future depreciation leads to an actual depreciation.

For E_{t+1} to also increase in response to the increase in E_t^e, we have to make E_{t+1}^e depend on E_t^e, E_t, or both. Let's try a behavioral equation for E_{t+1}^e given by:

$$E_{t+1}^e = E_t^e.$$

One way to justify this equation with economic intuition is to interpret the expected exchange rate for both t and $t+1$ as expectations for the value that the exchange rate will take "in the long run", many, many periods after t and $t+1$. To the extent that the long run looks the same from the perspectives of times t and $t+1$ (since one period is not a big difference when thinking about the far future), revisions in expectations about the long run at t should lead to an equal revision at $t+1$. The idea is that we will not change our mind about the long run in just one period.

$$E_{t+1} = \frac{E^e_{t+1}}{1 + R_{t+1} - R^*_{t+1}} = \frac{E^e_t}{1 + R_{t+1} - R^*_{t+1}}.$$

The expectation of a long-run depreciation at time t (E^e_t goes up) produces an equal expectation of a long run depreciation at $t+1$ (E^e_{t+1} goes up due to our behavioral equation $E^e_{t+1} = E^e_t$).

From here, the intuition is the one of the standard model.

Keeping the exchange rate E_{t+1} fixed at its initial value (before the change in E^e_t), an expected depreciation increases the domestic-currency return of investing in the foreign bond. After converting domestic currency into foreign currency at the given exchange rate E_{t+1} and earning the foreign interest rate R^*_{t+1}, the higher expected exchange rate E^e_{t+1} implies that the same amount of foreign currency earned by investing in the foreign bond is now exchanged into a larger amount of domestic currency.

The domestic-currency return of investing in the domestic bond, R_{t+1}, has not changed.

We have found that, at the initial exchange rate, the domestic-currency return on the foreign bond is higher than that of the domestic bond. But equilibrium requires that the two are equal.

To reduce the domestic-currency return of investing in the foreign bond, the exchange rate must depreciate today (E_{t+1} has to go up). When E_{t+1} goes up, the same amount of domestic currency results in a smaller amount of foreign currency that can be invested in the foreign bond. Even though the foreign-currency return on the foreign bond, R^*_{t+1}, has not changed, the smaller initial investment leads to a smaller payoff. When the reduction in payoff due to the higher exchange rate offsets the increase in payoff due to the higher expected exchange rate, equilibrium is reached.

(c) Question 18 from Chapter 3 of the textbook states:

"The interest rate on U.S. three-month Treasury bills dropped to very low levels at the end of 2008 and remained there for several years. Starting in January 2009 and ending in December 2019, find data on the three-month Treasury bill rate from Federal Reserve Economic Data (FRED) at the Federal Reserve Bank of St. Louis; find data on the exchange rate of the U.S. dollar against the Korean won from the Bank of Korea Economic Statistics System at http://ecos.bok.or.kr/flex/EasySearch_e.jsp; and from the same source, find data on the Korean 91-day Monetary Stabilization Bond interest rate. Imagine that you borrow dollars at the Treasury bill rate to invest in Korean stabilization bonds, thus doing a carry trade that exposes you to the risk of won/dollar exchange rate fluctuations. As in the Case Study in the text, calculate the total return on your carry trade for every month starting in February 2009 and ending in December 2019."

Please answer this question but end your analysis in July 2023 (rather than on the earlier date in the textbook's question). In addition to calculating the returns, please include a plot that shows the calculated total returns[1] (on the vertical axis) for each month (on the horizontal axis) assuming your initial investment was $100.

Note also that the link http://ecos.bok.or.kr/flex/EasySearch_e.jsp to find data from the Bank of Korea Economic Statistics System provided by the textbook is outdated and no longer works. The correct link is:

`https://ecos.bok.or.kr/#/SearchStat`

Be patient on the first load, it takes a while to load the page but works well after that.

Hint: You can review how to compute payoffs and returns for the carry trade in these lecture slides.

Solution: There are two steps to this question. The first step is getting the data, the second step is constructing the carry trade returns.

Step 1: Getting the data

- Bank of Korea

To get the Monetary Stabilization Bond (MSB) interest rate, go to:

[1]Total returns are the same as cumulative returns. For example, if your initial investment is $100 in January 2023 and the value of your portfolio is $120 in March 2023, then your total (cumulative) return is $120/100 - 1 = 0.2 = 20\%$. This 20% return can be achieved with different combinations of monthly (not cumulative) returns for the months of January, February, and March.

https://ecos.bok.or.kr/#/SearchStat

Then, in the Table Select pane, navigate to:

> 1. Monetary Financial Statistics > 1.3. Interest Rates > 1.3.2. Market Interest Rates > 1.3.2.2. Market Interest Rates (Monthly, Quarterly, Annual)

Once there, the Item Select pane will be populated with a list of rates. Turn off the Select All switch at the top of the pane, then from the list select Monetary stabilization bonds (91-day). At the bottom of the panel, click the Add to List button. Now the selected series appears on the Table Name pane.

To get the exchange rate, there are two equally correct options.

- Option 1. In the Table Select pane, navigate to:

  > 3. Exchange Rate/International Reserves and Trade > 3.1. Foreign Exchange Rate > 3.1.2 Average Period, End Period > 3.1.2.1. Arbitraged Rates of Major Currencies Against Won, Longer Frequency.

- Option 2. In the Table Select pane, navigate to:

  > 3. Exchange Rate/International Reserves and Trade > 3.1. Foreign Exchange Rate > 3.1.2 Average Period, End Period > 3.1.2.3. Exchange Rate of Won Against US Dollar, China Yuan Renminbi […].

The exchange rates from the two options are very close to each other[2]. Then follow the same steps as before to add Won per United States Dollar (Close) to the Table Name pane. You can use either the Closing Rate or the Average Rate for the Won per United States Dollar (Close) series. They are both equally good options and very close to each other. In this answer, we use the Closing Rate from Option 1 above.

Last, at the bottom of the Table Name pane, click View List. A new screen will appear. Check the box for Mon (for monthly series) and select 2009.01 as the start date and 2023.07 as the end date. After selecting the dates, you have to click Search, otherwise the dates will not be updated. Finally, customize the format if desired (e.g., vertical view rather than horizontal) and click on Original Data Download.

- FRED

The three-month Treasury bill rate from FRED has code “TB3MS”. However, the series “Market Yield on U.S. Treasury Securities at 3-Month Constant Maturity, Quoted on an Investment Basis” that has code “GS3M” is equally appropriate and gives essentially identical results. In this answer, we use “TB3MS”.

The original spreadsheets with the downloaded data from the Bank of Korea can be found here (or in PDF) and from FRED it can be found here (or in PDF).

Step 2: Constructing carry trade returns

- Formula for returns

The carry trade returns are the same whether we compute US dollar (USD) returns or Korean won (KRW) returns. We compute USD returns.
We use the following notation:

$$\begin{aligned} E_t &= \text{USD / KRW exchange rate (dollars per won) in month } t, \\ R_t &= \text{Interest rate for the USD-denominated U.S. Treasury bill that accrues} \\ &\quad \text{between months } t \text{ and } t+1, \\ R_t^* &= \text{Interest rate for the KRW-denominated Korean bond that accrues} \\ &\quad \text{between months } t \text{ and } t+1. \end{aligned}$$

If you exchange 1 USD into KRW at the end of month t and use the resulting $1/E_t$ KRW to buy the Korean bond, at the end of month $t+1$, you have an amount of KRW equal to:

$$(1+R_t^*)\frac{1}{E_t}.$$

Converting this KRW-denominated payoff into USD using the $t+1$ exchange rate gives the USD-denominated payoff:

$$(1+R_t^*)\frac{E_{t+1}}{E_t}.$$

Thus, the USD-denominated net return earned by investing in the Korean bond between t and $t+1$ is:

$$(1+R_t^*)\frac{E_{t+1}}{E_t}-1.$$

By *net* return we just mean subtracting 1, so 1.05 is a *gross* return and 0.05 is a net return.

The USD-denominated net return earned between months t and $t+1$ by borrowing in the American bond is:

$$-R_t.$$

The negative sign is there because we are borrowing (short-selling the bond) rather than lending (buying the bond).

The returns on the carry trade strategy are therefore:

$$\begin{aligned}\text{returns}_{t+1} &= \left[(1+R_t^*)\frac{E_{t+1}}{E_t} - 1\right] - R_t \\ &= (1+R_t^*)\frac{E_{t+1}}{E_t} - (1+R_t). \qquad (1)\end{aligned}$$

We can approximate to get an expression that looks the same as the formula for expected returns from lecture, but with E_{t+1} instead of E^e since we are constructing realized rather than expected returns. First, re-write the last equation as

$$\begin{aligned}\text{returns}_{t+1} &= (1+R_t^*)\frac{E_{t+1}}{E_t} - (1+R_t) \\ &= (1+R_t^*)\left(\frac{E_{t+1}}{E_t} - 1 + 1\right) - (1+R_t) \\ &= (1+R_t^*)\left[1 + \left(\frac{E_{t+1}}{E_t} - 1\right)\right] - (1+R_t) \\ &= (1+R_t^*) + (1+R_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right) - (1+R_t) \\ &= (1+R_t^*) + \left(\frac{E_{t+1}}{E_t} - 1\right) + R_t^*\left(\frac{E_{t+1}}{E_t} - 1\right) - (1+R_t) \\ &= R_t^* + \left(\frac{E_{t+1}}{E_t} - 1\right) + R_t^*\left(\frac{E_{t+1}}{E_t} - 1\right) - R_t.\end{aligned}$$

The cross term

$$R_t^*\left(\frac{E_{t+1}}{E_t} - 1\right)$$

is much smaller than the other terms, so we ignore it and get

$$\begin{aligned}\text{Approximate returns}_{t+1} &= R_t^* + \left(\frac{E_{t+1}}{E_t} - 1\right) - R_t \\ &= R_t^* - R_t + \left(\frac{E_{t+1}}{E_t} - 1\right). \end{aligned} \tag{2}$$

The term $R_t^* - R_t$ is the *interest rate differential* and the term $E_{t+1}/E_t - 1$ is the *realized depreciation rate* of the USD with respect to the KRW.
Both the exact and the approximate returns can now be computed using the data on R_t^* and E_t downloaded from the Bank of Korea and the data on R_t downloaded from FRED.

- From monthly returns to cumulative returns

To compute cumulative returns, we take January 2009 to be month $t = 0$ and set the initial value of cumulative returns to be 100:

$$\text{Cumulative returns}_0 = 100. \tag{3}$$

For $t > 0$, we compute cumulative returns using the recursive formula:

$$\text{Cumulative returns}_t = (1 + \text{returns}_t)\,\text{Cumulative returns}_{t-1}. \tag{4}$$

We can alternatively use Approximate returns$_t$ instead of returns$_t$, which gives essentially identical results.

- Converting to the correct units

The formulas above use non-annualized decimal returns for the interest rates R and R^*, and dollars per won for the exchange rate E. For example, if $R = 0.02$, this means 2% returns over one month. And if $E = 2$, this means that we need 2 dollars to buy one won.
We have to make sure our numbers are the correct units before we plug them into the formula.

For interest rates, there are three dimensions of the data:

– Maturity of the bond: 3 months for both bonds

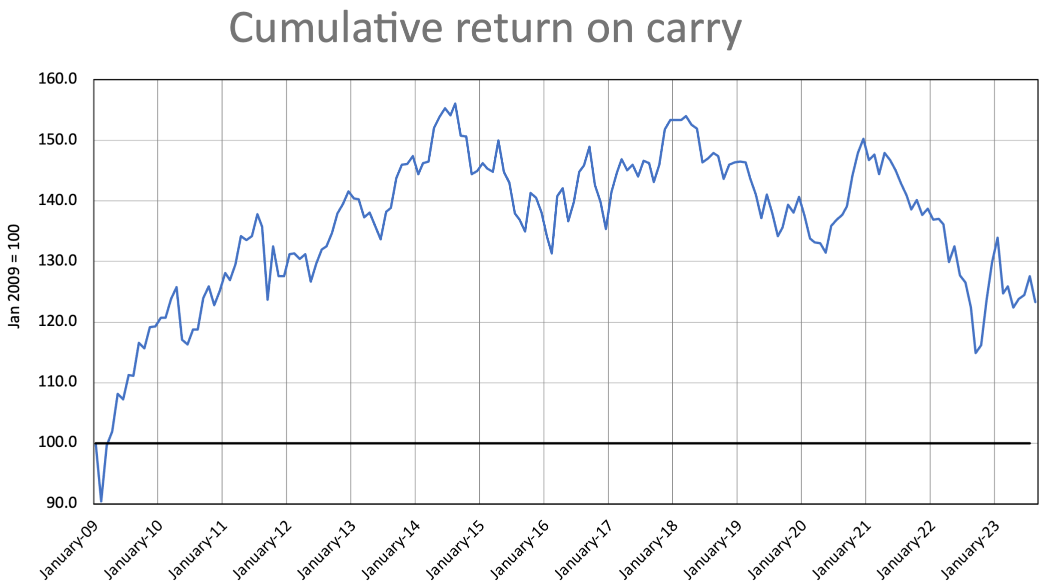
- Frequency of observation: monthly for both bonds
- Units: percent per annum for the Bank of Korea interest rate and decimal per annum for the FRED interest rate

Per annum here just means *annualized*. To convert to raw (non-annualized) values, we simply divide by 12 (because there are 12 months in a year). To convert percent to decimal, we divide by 100. For example, for January 2009, the Bank of Korea interest rate is reported as 2.26. This means that this bond provides a return of $2.26\%/12 = 0.1883\%$ over the next month or, in decimal, $0.1883/100 = 0.001883$. The FRED interest rate for the same month is reported as 0.13. Since FRED reports in annualized decimal units, the bond return over the next month is $0.13/12 = 0.01083$ in decimal, or 1.083%.

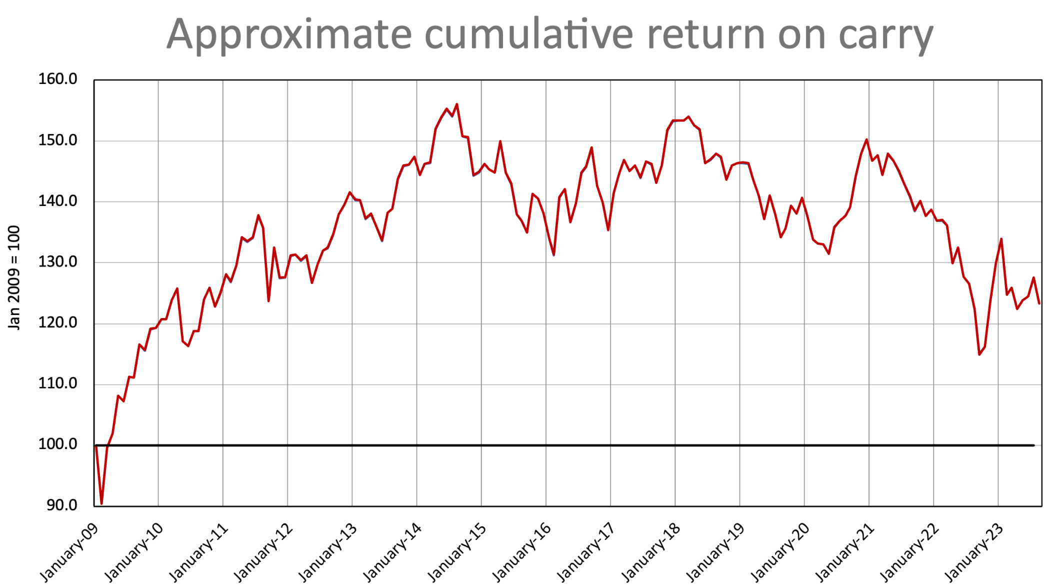
For the exchange rate, the Bank of Korea reports the KRW / USD (won per dollar) exchange rate. However, in our formulas E_t represents the USD / KRW exchange rate (dollars per won). Therefore, to convert the exchange rate we downloaded into E_t, we have to take its reciprocal. For example, for January 2009, the downloaded exchange rate value from the Bank of Kore is $1{,}368.5$ won per dollar. Then,

$$E_t = \frac{1}{1{,}368.5 \text{ KRW/USD}} = \frac{1}{1{,}368.5} \text{ USD/KRW} = 0.00073073 \text{ dollars per won.}$$

The plot below shows the time series of cumulative returns obtained by using equations (1), (3), and (4) with interest rates in non-annualized decimal units and the exchange rate in dollars per won. The cumulative returns in month t give the amount of money you would have in month t if you had invested \$100 in the carry trade strategy starting in January 2009.



If we use approximate returns in equation (2) rather than the exact returns from equation (1), we get essentially the same plot:



You can see all the calculations and plots in this Excel file.

[2] The exchange rate in Option 1 is the "basic exchange rate" and is determined as the transactions volume-weighted average of the rates applied in the previous business day's transactions between foreign exchange banks through brokers in an "over-the-counter" (OTC) market. The exchange rate in Option 2 is the closing-day exchange rate quoted in a trading exchange (a marketplace where prices are quoted openly).

ECON 1550 — Problem Set 4 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

1. **Chapter 4: Money, Interest Rates, and Exchange Rates**

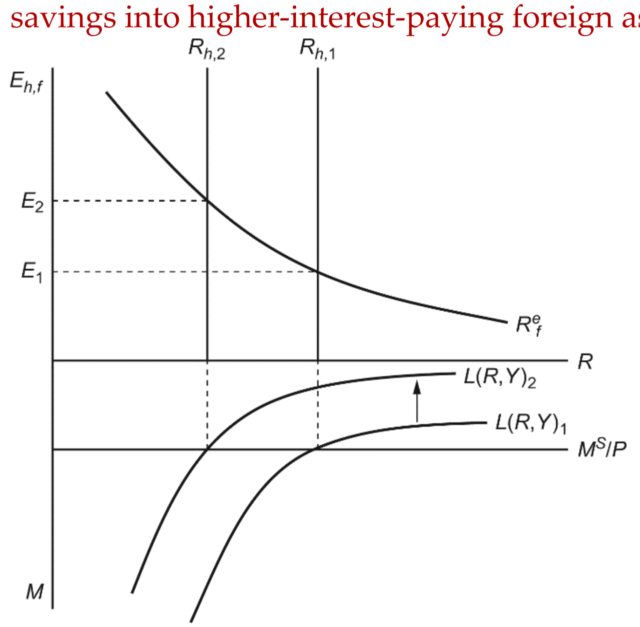
Answer the following questions about money, interest rates, and exchange rates from Chapter 4.

(a) Question 1 from Chapter 4 of the textbook is:

> "Suppose there is a reduction in aggregate real money demand, that is, a negative shift in the aggregate real money demand function. Trace the short- and long-run effects on the exchange rate, interest rate, and price level."

Answer this question **but only for the short run**. Treat the expected exchange rate and the price level as exogenous.

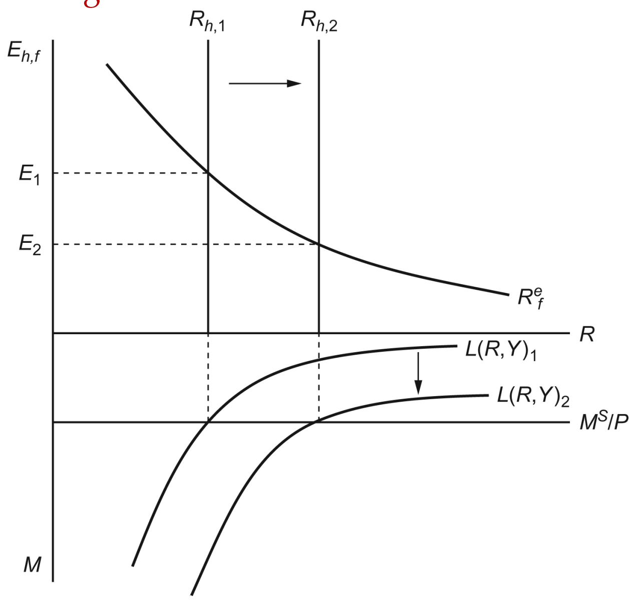
Solution: A reduction in the home money demand causes interest rates in the home country to fall from $R_{h,1}$ to $R_{h,2}$. With no change in expectations, there will be a depreciation of the home currency from E_1 to E_2 as investors shift their savings into higher-interest-paying foreign assets.



(b) Please answer question 4 from Chapter 4 of the textbook, reproduced here:

> What is the short-run effect on the exchange rate of an increase in domestic real GNP, given expectations about future exchange rates?

Solution: An increase in domestic real GNP will cause domestic real money demand to rise. This will cause domestic real interest rates to rise from $R_{h,1}$ to $R_{h,2}$ (see graph below). With no change in expectations, there will be an appreciation of the home currency from E_1 to E_2 as investors channel their savings into domestic assets.

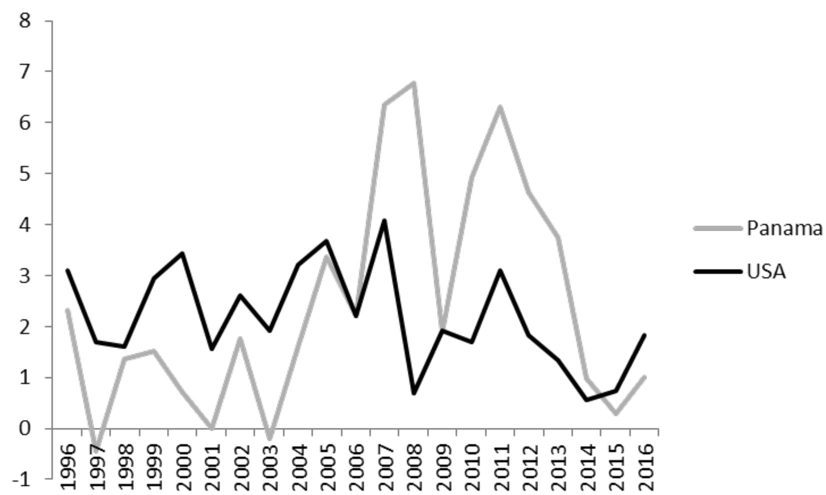


(c) Please answer question 13 from Chapter 4 of the textbook, reproduced here:

> "Since 1942, the small country of Panama has had no paper currency other than the U.S. dollar, which circulates freely internally. What would you expect to be true about the inflation rate in Panama compared to that in the United States, and why? Go to the International Monetary Fund's most recent World Economic Outlook database (accessible directly or through www.imf.org) and examine comparable consumer-price inflation rates for Panama and the United States. Do the inflation rates you see there conform to your earlier prediction? (After you have read Chapters 5 and 7, you should return to this question as you will then have a deeper understanding of the factors that determine the price level in a country like Panama.)"

Solution: Because Panama uses the US dollar as its currency, we would expect that, all else being equal, inflation in Panama and that in the United States should be identical. The chart below gives inflation rates in Panama and the United States over the past 20 years.

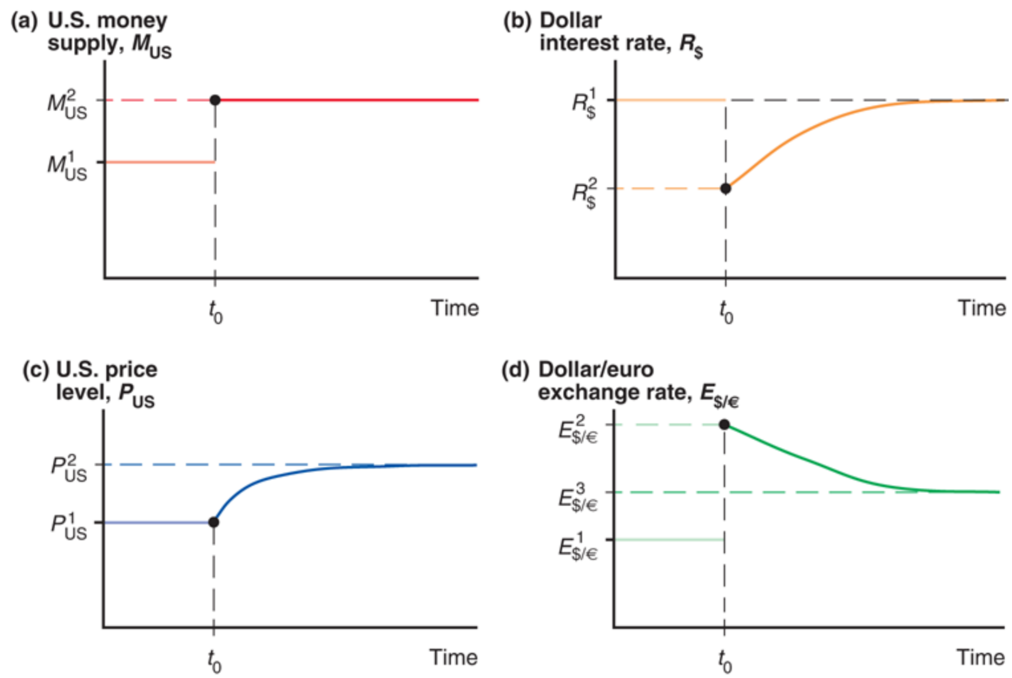
On the one hand, the inflation rates in the two countries tend to move together, as we would expect because they share the same money supply. That said, the inflation rates are not identical between the two countries. This is because prices (and thus inflation) are not determined by the money supply alone. Recall the long-run price level defined as $P = M^S/L(R,Y)$. Although Panama and the United States share the same money supply, the demand for money in each country may differ, allowing for differences in price levels.



2. **Overshooting and Carry Trade Returns**

Consider Figure 4-13 in Chapter 4 of the textbook:

Figure 4-13 Time Paths of U.S. Economic Variables after a Permanent Increase in the U.S. Money Supply



The figure was constructed under some specific assumptions explained in the textbook (the interest parity condition holds, $R_€ = R^1_\$$, expectations of exchange rates do not change during the adjustment of P_{US}, etc.). When you answer the questions below, please maintain the same assumptions made by the textbook.

(a) Plot the time-path of the expected exchange rate. What is its long-run value?

Solution: The textbook explained that the expected exchange rate jumps at t_0 and was assumed to remain constant at the new value after t_0.
To find the long-run value of E^e, we use that:

(i) $R_€ = R^1_\$$ (by assumption in the textbook)

(ii) The long-run value of $R_\$$ is $R^1_\$$

(iii) The long-run value of E is E^3

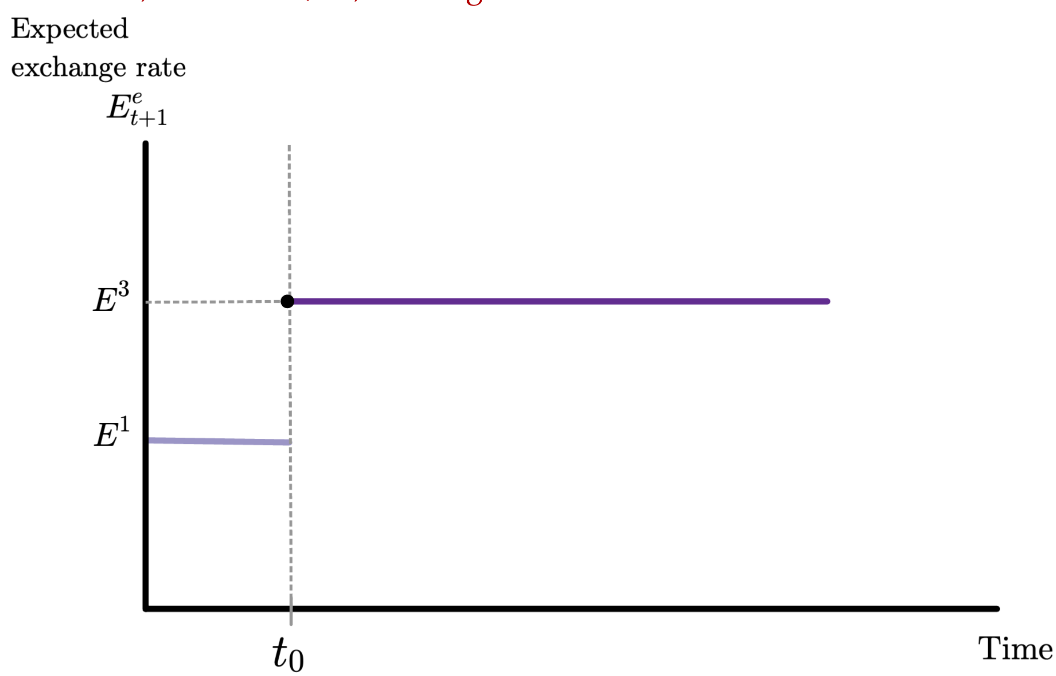
(iv) Since interest parity holds, in the long run:

$$0 = R_\$ - R_€ - \left(\frac{E^e}{E} - 1\right)$$

Using (i), (ii) and (iii) in the interest parity condition from (iv) we find that in the long run:

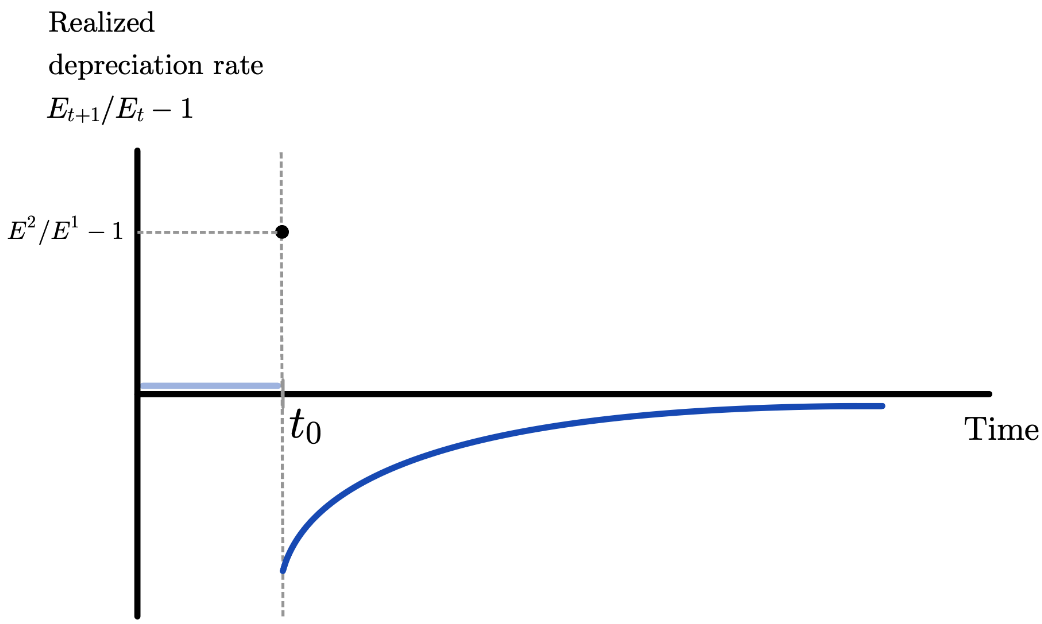
$$0 = R_\$ - R_€ - \left(\frac{E^e}{E} - 1\right) = R^1_\$ - R^1_\$ - \left(\frac{E^e}{E^3} - 1\right) = 1 - \frac{E^e}{E^3}$$

Therefore, $0 = 1 - E^e/E^3$, which gives $E^e = E^3$.



(b) Plot the time-path of the realized depreciation rate of the dollar with respect to the euro, $E_{t+1}/E_t - 1$ (where E is the number of dollars per euro).

Solution: The realized depreciation rate can be found by looking at the time-path of the exchange rate in panel (d) of the textbook's figure. At t_0, the exchange rate jumps from E^1 to E^2, so the initial depreciation rate is $E^2/E^1 - 1$. After t_0, the exchange rate decreases from E^2 to E^3, so the depreciation rate is negative. Eventually, the exchange rate converges, so the depreciation rate is zero in the long run.



Note that this solution requires the "Time" axis to be reported in terms of $t+1$ rather than t, i.e., $[\text{realized depreciation rate}]_{t+1} \equiv E_{t+1}/E_t - 1$. If we instead used $[\text{realized depreciation rate}]_t \equiv E_{t+1}/E_t - 1$, a depreciation at $t+1 = t_0$ would enter the realized depreciation rate at $t = t_0 - 1$, i.e., before the public had any knowledge of the coming money supply shock.

(c) Plot the time-path of realized returns for a carry trade that lends in dollars and borrows in euros. Give intuition for the behavior of the returns at t_0 and immediately after t_0.

Solution: We use R^* to denote the euro interest rate and R to denote the dollar interest rate. The realized carry trade returns are:

$$RET_{t+1} = R_t - \left[R_t^* + \left(\frac{E_{t+1}}{E_t} - 1\right)\right]$$

We will analyze the behavior of RET_{t+1} in three different stages: before t_0, exactly at t_0, and after t_0.

Before t_0

When $t+1 < t_0$, we have $RET_{t+1} = 0$ since E_{t+1} is constant and $R_t = R_t^*$.

Exactly at t_0

We found in part b) of this question that the realized depreciation rate $E_{t+1}/E_t - 1$ jumps up at $t+1 = t_0$, generating lower RET_{t+1}, so the carry trade returns go

down.
The dollar interest rate also drops to $R_{t_0} < R_{t_0-1}$, but this change isn't incorporated into returns realized at t_0: These returns depend only on interest rates set at $t_0 - 1$.
Since returns were zero before t_0, they are negative at exactly t_0.
<u>After</u> t_0
We start by analyzing what happens in the long run (as t grows to infinity).

- From part a) of this question, we know that in the long run, $R_t = R_t^*$.
- Additionally, panel (d) of the textbook's figure shows that the exchange rate eventually becomes constant and therefore, in the long run, $E_{t+1}/E_t - 1 = 0$.

Together, $R_t = R_t^*$ and $E_{t+1}/E_t - 1 = 0$ imply that, in the long run, we have $RET_{t+1} = 0$.
Now we show that $RET_{t+1} < 0$ between t_0 and the long run. First, note that for any $t + 1 > t_0$, we have:

$$E_{t+1} > E^3 \tag{1}$$

as can be directly seen in panel (d) of the textbook's figure. In addition, because the interest parity condition holds, we have $R_t - R_t^* = E_{t+1}^e/E_t - 1$.
Using the result from part b) that $E^e = E^3$ after t_0, we get:

$$R_t - R_t^* = \frac{E^3}{E_t} - 1 \tag{2}$$

Using equations (1) and (2),

$$RET_{t+1} = R_t - R_t^* - \left(\frac{E_{t+1}}{E_t} - 1\right) = \left(\frac{E^3}{E_t} - 1\right) - \left(\frac{E_{t+1}}{E_t} - 1\right) = \frac{E^3 - E_{t+1}}{E_t} < 0$$

Therefore, we know carry trade returns are always negative after t_0.
We now examine what happens *immediately* after t_0, i.e., at $t + 1 = t_0 + 1$.
From panel (d) of the textbook's figure, we see that depreciation maxes out at t_0; after that, the dollar only appreciates toward its long-run level. So, in $t_0 + 1$, realized depreciation contributes *positively* to returns: $E_{t_0+1} < E_{t_0}$, so $-(E_{t_0+1}/E_{t_0} - 1) > 0$.

But RET_{t_0+1} also depends on the dollar interest rate realized in t_0. From panel (b) in the textbook's figure, we know the dollar interest rate drops abruptly at t_0: $R_{t_0} < R_{t<t_0}$ contributes *negatively* to returns.

Combining these two pieces and drawing on our discussion of RET_{t+1} over the long run allows us to state $\Delta R_{t_0} < RET_{t_0+1} < 0$. But how does RET_{t_0+1} compare to RET_{t_0}?

Since $E_{t+1}/E_t = 1$ and $R_{t_0-1} = R^*_{t_0-1} \quad \forall t+1 < t_0$ in the long-run equilibrium preceding t_0, RET_{t_0} can be expressed in terms of E_{t_0}, the one variable that changes, as $-\Delta E_{t_0}/E_{t_0-1}$. Recalling our UIP condition

$$E_t = \frac{E^e}{1 + R_t - R^*_t}$$

lets us study ΔE_{t_0} in terms of $\Delta E^e_{t_0}$ and ΔR_{t_0} by evaluating the **total derivative** of E at t_0:

$$\begin{aligned}
\Delta E_{t_0} &= \frac{\partial E_{t_0-1}}{\partial E^e_{t_0-1}} \cdot \Delta E^e_{t_0} + \frac{\partial E_{t_0-1}}{\partial R_{t_0-1}} \cdot \Delta R_{t_0} \\
&= \frac{\Delta E^e_{t_0}}{1 + R_{t_0-1} - R^*_{t_0-1}} - \frac{E^e_{t_0-1} \cdot \Delta R_{t_0}}{(1 + R_{t_0-1} - R^*_{t_0-1})^2} \\
&= \Delta E^e_{t_0} - E^e_{t_0-1} \cdot \Delta R_{t_0}
\end{aligned}$$

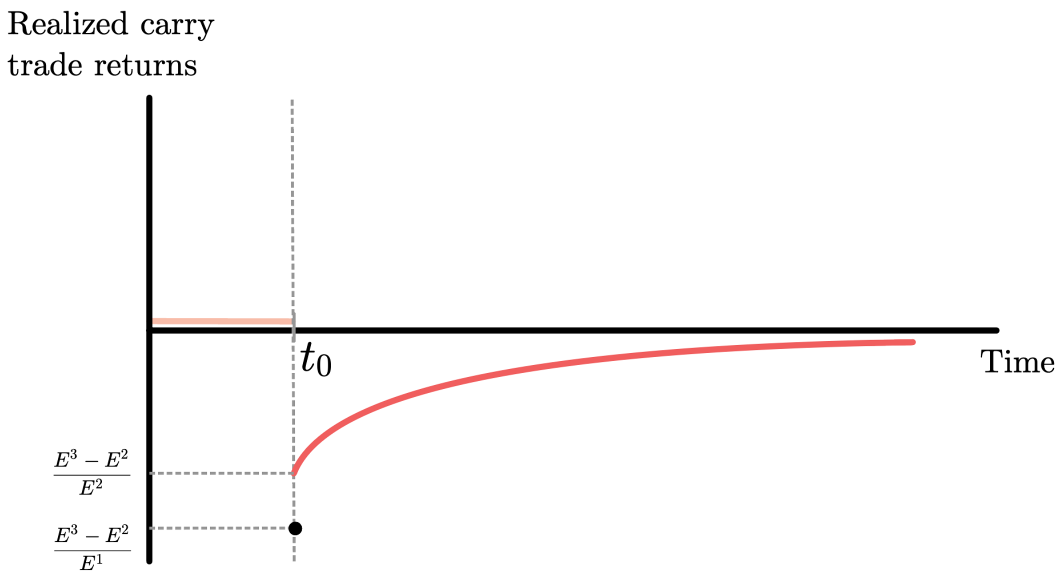
We therefore have

$$RET_{t_0} = -\frac{\Delta E^e_{t_0} - E^e_{t_0-1} \cdot \Delta R_{t_0}}{E_{t_0-1}} = -\frac{\Delta E^e_{t_0}}{E_{t_0-1}} + \frac{E^e_{t_0-1} \cdot \Delta R_{t_0}}{E_{t_0-1}}$$

The second term on the right-hand side simplifies to ΔR_{t_0} because $E^e_{t_0-1} = E_{t_0-1}$ in the long-run equilibrium that prevailed at $t_0 - 1$. The first term is negative because $\Delta E^e_{t_0}$ is positive: The expected exchange rate is permanently higher after the money supply shock at t_0. This gives us

$$RET_{t_0} = -\frac{\Delta E^e_{t_0}}{E_{t_0-1}} + \Delta R_{t_0} < \Delta R_{t_0} < RET_{t_0+1}$$

The reasoning above gives the following time path for realized carry trade returns:



The graph shows that carry trade returns jump up between t_0 and the instant immediately after t_0. This is a consequence of exchange rate overshooting, which induced a positive depreciation rate at t_0 but a negative one immediately after t_0, and of the interest parity condition, which guaranteed that the change in R did not perfectly offset the movements in returns caused by the exchange rate.

ECON 1550 **Problem Set 5 Answer Key**

Spring 2026

Instructor: Fernando Duarte
Head TA: Leo Zucker
Undergraduate TAs: Eric Kim, Raisa Axenie, Nathalie Peña
Submission: Canvas or Gradescope

1. **The Big Mac Index, Purchasing Power Parity, and the Exchange Rate**

The Big Mac index was invented by The Economist in 1986 as a lighthearted guide to whether currencies are at their "correct" level. Read the article about the Big Mac index (attached at the end of this problem set or online at `https://www.economist.com/interactive/big-mac-index`), and the box "Some Meaty Evidence on the Law of One Price" in Chapter 5 of the textbook, then please answer the following questions:

(a) How is Purchasing Power Parity (PPP) defined in the article from The Economist?

Solution: According to the article from The Economist, purchasing-power parity (PPP) is:

> "the notion that in the long run exchange rates should move towards the rate that would equalise the prices of an identical basket of goods and services (in this case, a burger) in any two countries."

(b) How is Purchasing Power Parity (PPP) defined in Chapter 5 of the textbook (and in class)?

Solution: From Chapter 5 of the textbook:

> "The theory of purchasing power parity states that the exchange rate between two countries' currencies equals the ratio of the countries' price levels."

Additional information (not part of the answer): This definition, correct as it is, fails to emphasize that the price levels for the two countries must be the prices of the *same* basket of goods.

We can also use a formula. If E is the exchange rate, P the domestic price (in units of domestic currency) of some reference basket of goods, and P^* the foreign price (in units of foreign currency) of the same reference basket of goods, then PPP holds if

$$E = \frac{P}{P^*}$$

Last, in the textbook and in class, PPP is a long-run theory, which means that the relation $E = P/P^*$ is only supposed to hold in the long-run. Throughout this question, we use current values rather than long-run values as a simplified approximation.

(c) Measures of exchange rates and PPP for many countries can be downloaded from the OECD at this link. Observations are annual.

Data for the Big Mac index can be found at `https://github.com/TheEconomist/big-mac-data`. For this problem set, use the pinned file `big-mac-source-data-v2-pinned.csv`, which is based on the corresponding Economist source file. For some years, observations are annual. For other years, observations are semi-annual. When comparing Big Mac index data to OECD data, transform semi-annual data to annual by taking the average of the two semi-annual observations.

Explain how the OECD PPP measure relates to our definition of PPP from the textbook (and from class).

Hint: The OECD database links to this explanation of how their measure of PPP is constructed.

Solution: Question 1 in the link provided in the hint to the question explains that:

> "PPPs are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. PPPs are also calculated for product groups and for each of the various levels of aggregation up to and including GDP."

Therefore, in their "simplest form", the PPP measure from the OECD is the analog to the term P/P^* in the equation $E = P/P^*$, where P is in units of national currency and P^* is in US dollars.

(d) Pick any two countries that have data for 2024 or later in both the Big Mac index data and the OECD data. Using these two countries:

For the latest year available, construct P/P^* using the Big Mac data and the OECD data. Which of the two is closest to E? Do the two P/P^* measures agree on which of the two currencies is over/under-valued?

Solution: Using Argentina as the home country and the United States as the foreign country, the solution proceeds as follows. Results for a selection of other countries can be found here.

For Argentina, there are two semi-annual observations in 2024. The local price of a Big Mac in local currency (variable local_price) in Jan-2024 is 3,150 ARS and in Jul-2024 is 6,100 ARS, where ARS are Argentinean. We create a single annual observation for 2024 by taking the average of the two prices, which is 4,625.00 ARS.

For the United States, there are also two semi-annual observations for the local_price variable, but they are both the same and equal to 5.69 USD, so we use that value as the single annual observation for 2024.

The ratio of the two prices is:

$$\frac{\text{BigMac } P}{\text{BigMac } P^*} = \frac{4{,}625.00}{5.69} = 812.83$$

The OECD's PPP measure for Argentina in 2024 is 419.90. The PPP for the U.S. is 1 (as it is the reference currency). The ratio of the two PPP measures is:

$$\frac{P}{P^*} = \frac{419.90}{1} = 419.90$$

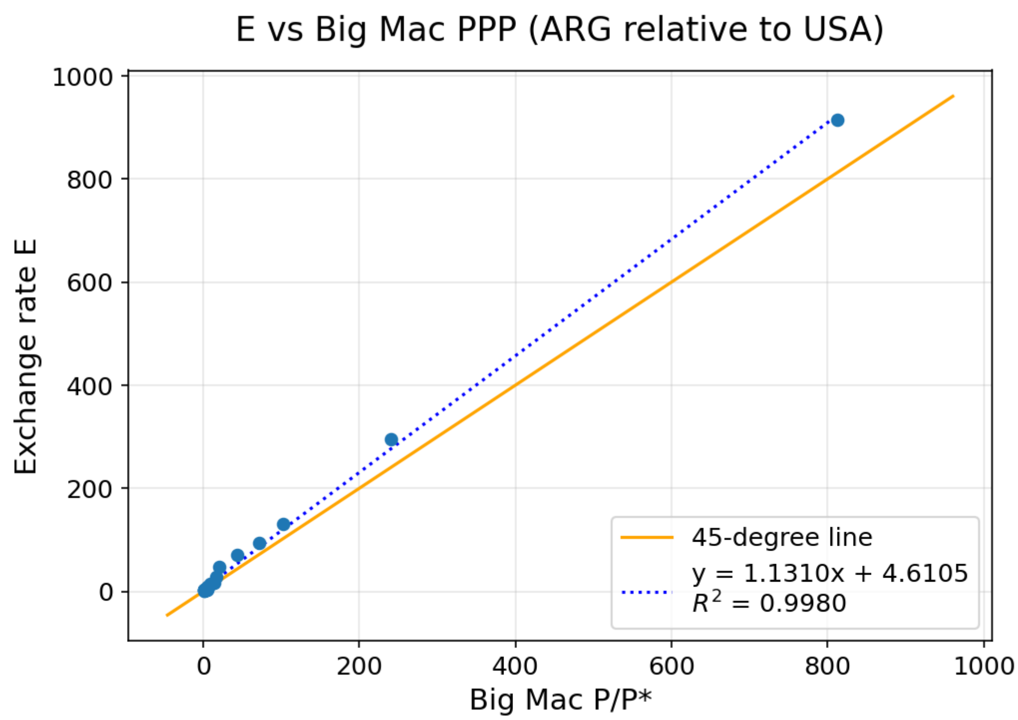
The exchange rate from the OECD data is:

$$E = 914.69 ARS/USD$$

The exchange rate predicted by the theory of PPP is $E_{\text{PPP}} = P/P^*$. The $E_{\text{PPP}} = 812.83$ using the Big Mac data is closer to the actual exchange rate $E = 914.69$ ARS/USD than the $E_{\text{PPP}} = 419.90$ using the OECD data. Both E_{PPP} measures are below E, so they agree in signaling an undervalued ARS. If the theory of PPP were true, then we would expect ARS to appreciate as time goes by, and to eventually reach E_{PPP} in the long run.

(e) Using all the years available, make a scatter plot of E against the Big Mac data's P/P^*. What should the scatter plot look like if PPP holds? What features of the scatter plot support the hypothesis that PPP holds? What features suggest the hypothesis that PPP holds is not true?

Solution: PPP holds when $E = P/P^*$. Therefore, if we plot E on one axis and P/P^* on the other, PPP holds exactly when the observations are on the line that goes through the origin and has a slope of 1, i.e., the 45-degree line that goes through the point (0,0).
A scatter plot using data between 2000 and 2024 gives:



The exchange rate E is on the vertical axis, and the PPP-implied measure of the exchange rate, $E_{\text{PPP}} = P/P^*$, is on the horizontal axis. Each dot represents the pair $(P/P^*, E)$ for a particular year, constructed exactly as in part (d). The orange line is the 45-degree line through the origin.
Features of the plot that support the theory of PPP are:

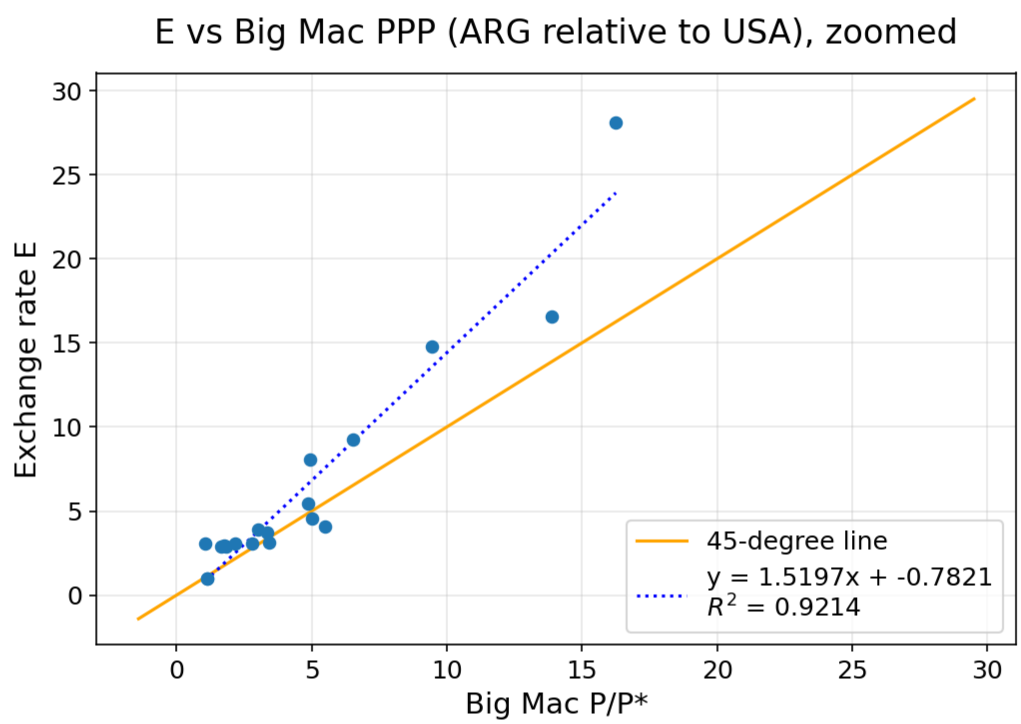
- The points align along a line (rather than along some other shape of curve)
- The slope of a line fitted to the points has a slope of 1.1310, which is close to the slope of 1 predicted by PPP.

Features of the plot against the theory of PPP are:

- The observations with high values of E are systematically above the 45-degree line. The fitted intercept of 4.6105 is small relative to the data range, but this systematic pattern shows that the deviations from PPP are not random.

- Even though the slope of 1.1310 is close to 1, the points fit the line with slope 1.1310 very well (with an R^2 of 0.9980). This tight fit means the slope is estimated precisely, so the deviation from the slope of 1 predicted by PPP is likely a genuine feature of the data rather than noise.

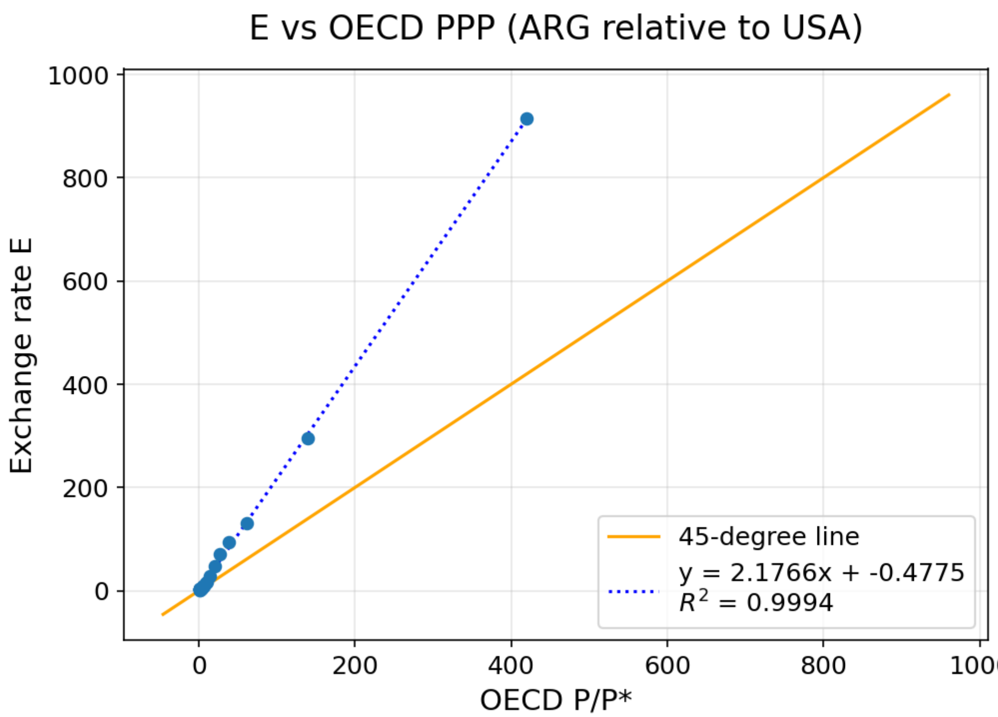
- The points with low E seem to fit the 45-degree line better, but it is hard to see in the figure above. The next figure zooms into lower values of E:



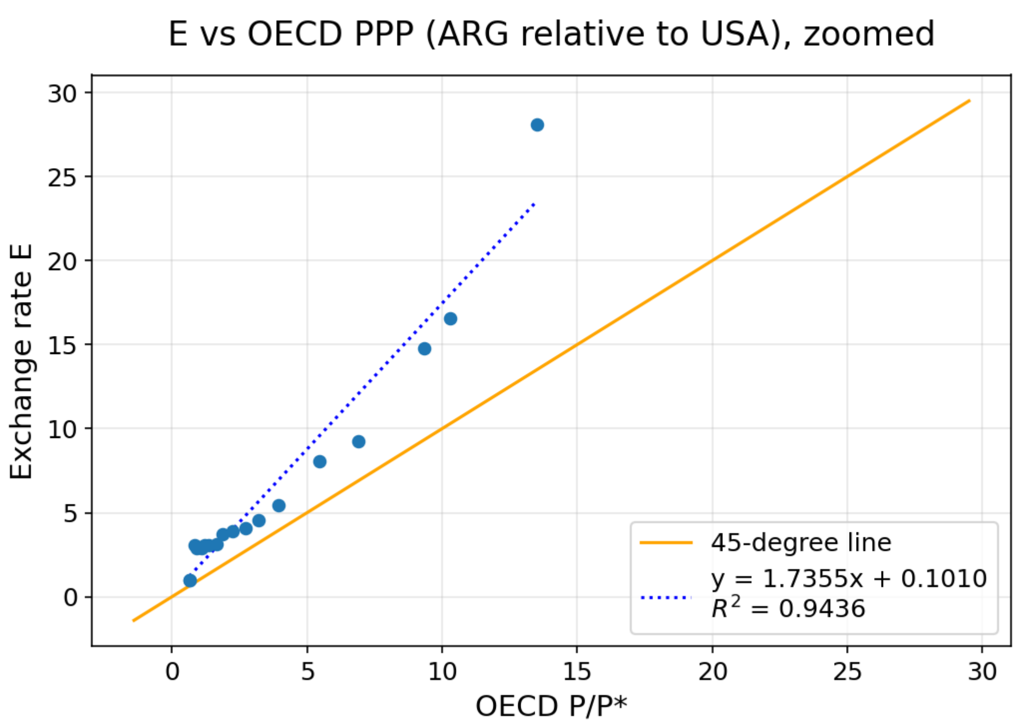
In this zoomed plot, the fitted line has slope 1.5197 and intercept -0.7821. We can more clearly see now that the low-E observations do not line up all that well with the 45-degree line.

(f) Answer the last question once again, but using OECD data to construct P/P^*.

Solution: The plot using the OECD data is:



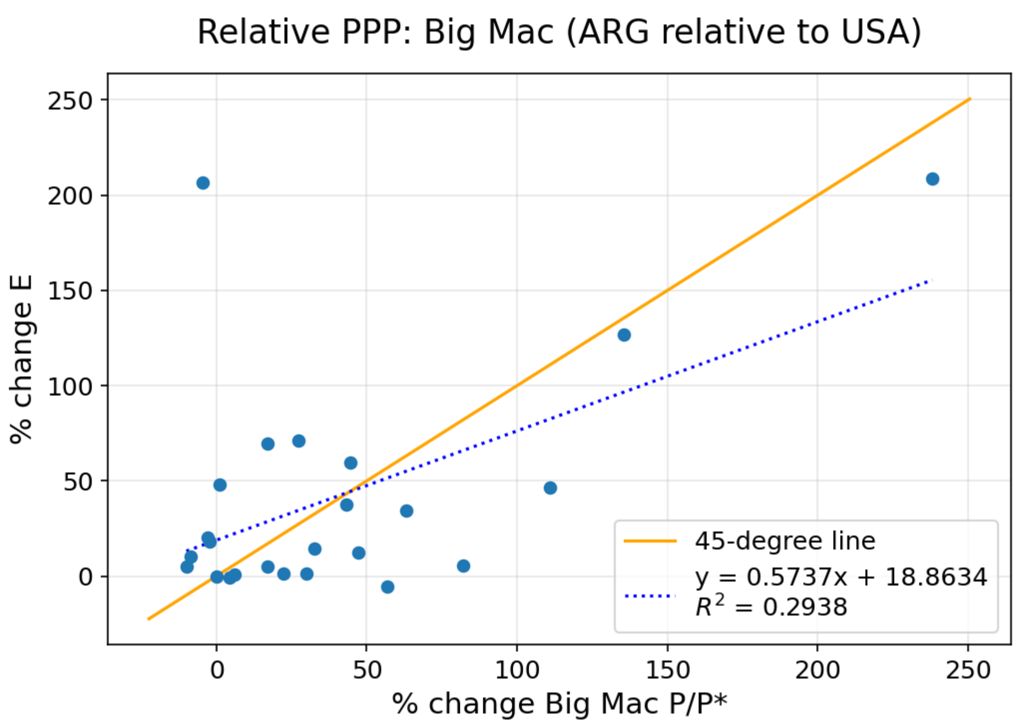
Zooming into small values:



In the full sample, the fitted line has slope 2.1766, intercept -0.4775, and $R^2 = 0.9994$. In the zoomed plot, the fitted line has slope 1.7355, intercept 0.1010, and $R^2 = 0.9436$. Similar to the Big Mac case from part (e), the points fit a line quite well when using the full sample (all the years), and not as well for low values of E. We conclude that the OECD-based PPP measure is strongly related to the exchange rate, but the relationship is still noticeably steeper than the 45-degree line predicted by PPP, has some noticeable deviations from being linear, and has an intercept different from zero.

(g) Repeat parts (e) and (f) but now assess relative PPP rather than absolute PPP.

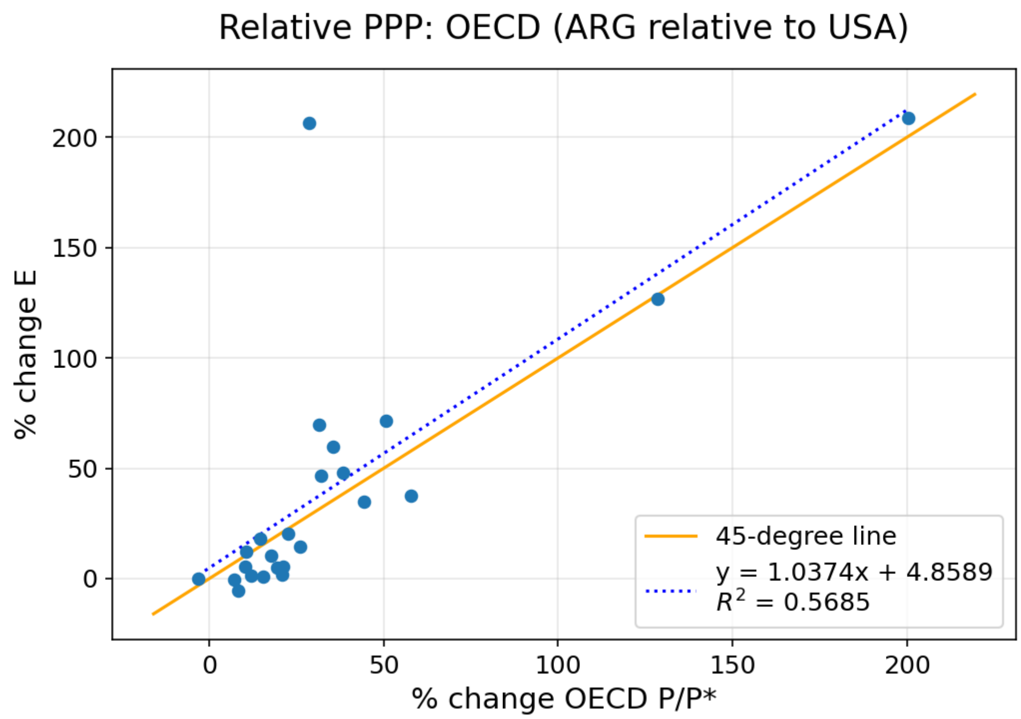
Solution: To assess relative PPP, we plot percentage changes in PPP and E rather than levels. For the Big Mac data, the plot is:



The scatterplot that uses the Big Mac data offers little support for relative PPP. The points are not neatly in a line, and the fitted line has slope 0.5737 with $R^2 = 0.2938$. In addition, the percentage change in E is often smaller than the percentage change in PPP. The outlier point labeled 2002 corresponds to the year 2002, when Argentina had its most severe financial crisis in its more than

200-year history.

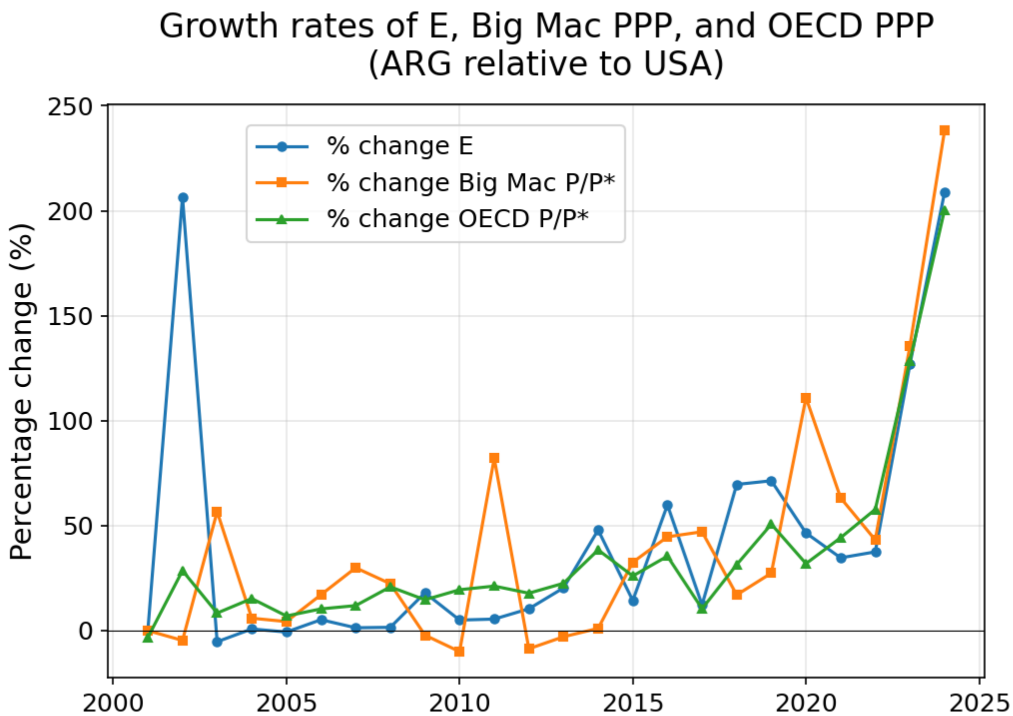
For the OECD data, we get:



The scatterplot that uses the OECD data offers more support for relative PPP than the Big Mac data. The fitted line has slope 1.0374, which is close to the slope of 1 predicted by relative PPP. Against the theory of PPP, the points do show noticeable dispersion and the R^2 is only 0.5685. The point corresponding to the 2002 financial crisis remains a clear outlier.

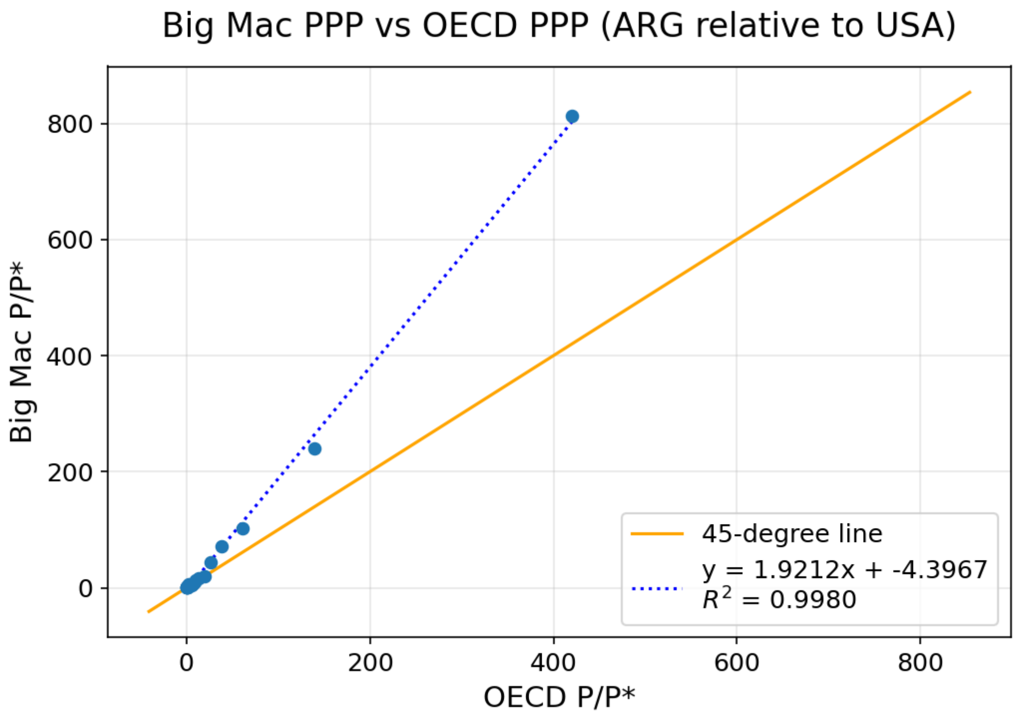
(h) In a single plot, show the time series of the growth rate of the two PPP measures and the growth rate of the exchange rate (that is, plot the year in the horizontal axis and the growth rates of the three variables on the vertical axis). Do the series move together over time? Describe one feature of the plot that provides evidence in favor and one feature that provides evidence against the hypothesis that relative PPP holds.

Solution: The series do move roughly together, although not in every year. If relative PPP held exactly, the exchange rate series E should lie exactly on top of the PPP series P/P^*. One feature in favor of relative PPP is that in 2023 and 2024, all three series jump sharply together, showing strong co-movement even if the exact magnitudes differ. A feature against relative PPP is in 2002, when the exchange rate depreciated more than what is implied by either of the two PPP measures.

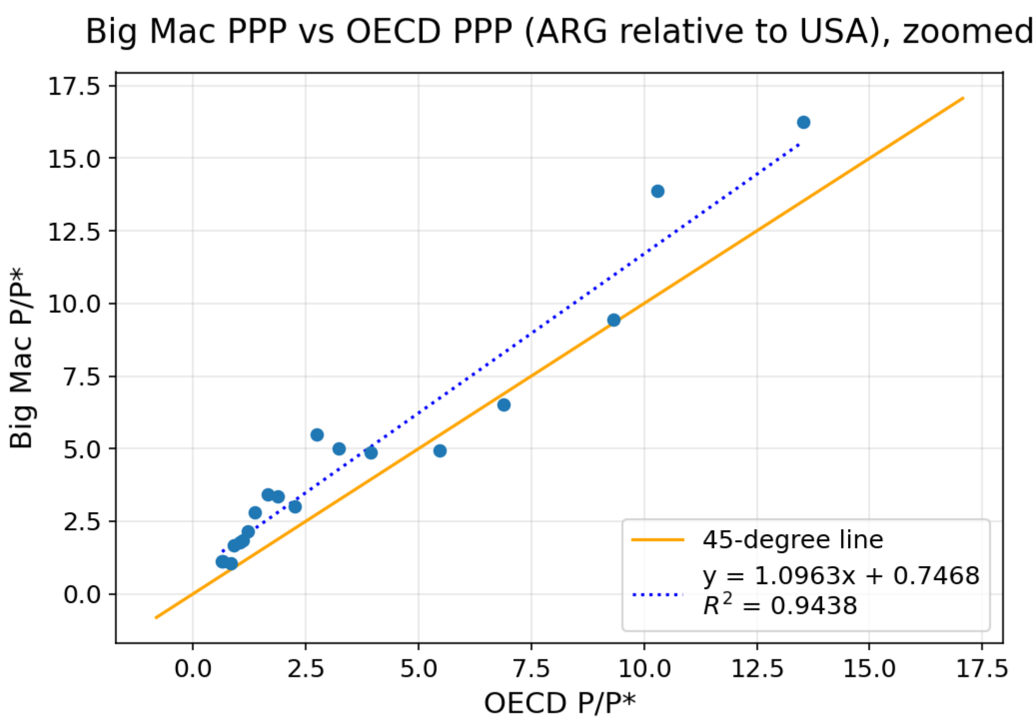


(i) Is the PPP implied by the Big Mac data close to the PPP from the OECD data? Give two reasons for why they are not supposed to perfectly agree.

Solution: The two PPP measures comove closely over time, with a correlation of 99.9%. A scatterplot of the two measures also shows relatively good agreement:



Zooming into smaller values,



Despite their closeness, they are far from identical. One reason is that the Big

Mac PPP measure uses an essentially identical basket of goods in Argentina and the U.S. (the Big Mac), while the GDP-based basket of goods for the OECD PPP measure is quite different for the two countries. In addition, the Big Mac itself has a composition of goods that is quite different from the GDP-based basket of goods of both Argentina and the U.S. The timing of when prices are measured within the year can also lead to noticeable differences, especially for prices in Argentina, which can be quite volatile in certain years.

(j) There are many criticisms of the Big Mac index as a measure of PPP. The Economist itself points out it is not meant to be a precise measure of PPP or currency valuation. On the other hand, there must be some advantages of the Big Mac index. List three advantages of the Big Mac index.

Solution: There are many correct answers. Only three are needed for full credit. We list four examples below, and many other answers would also be acceptable.

- Despite some local differences, the Big Mac is an incredibly uniform product across the world. It is likely much more uniform than any two representative or reference baskets of goods we can construct for two different countries.
- The concept of a Big Mac is much more tangible and easier to grasp than the more abstract concept of a "reference basket of goods" or a "representative basket of goods".
- There are likely many fewer data measurement errors than indices that rely on surveys or that must compile prices for thousands of goods.
- The Big Mac is not only uniform across countries, it is also remarkably uniform across time.

The Economist

Our Big Mac index shows how burger prices differ across borders

Using patty-power parity to think about exchange rates

Last updated on January 29th 2026

Raw index (January 2026)

Base currency: US dollar

Country	Currency	% Under/Over valued
Switzerland	Franc	+48.4
Uruguay	Peso	+43.1
Norway	Krone	+22.8
Sweden	Krona	+18.6
Denmark	Krone	+16.7
Britain	Pound	+15.7
Euro area	Euro	+15.3
Israel	Shekel	+4.0
Poland	Zloty	+2.2
Colombia	Peso	+1.5
Mexico	Peso	+0.8
United States	US$	*BASE*
Costa Rica	Colón	−1.3
Turkey	Lira	−3.5
Singapore	S$	−5.5
Australia	A$	−7.0

Country	Currency	% Under/Over valued
Canada	C$	−9.4
Argentina	Peso	−9.6
Czech Rep.	Koruna	−10.2
Chile	Peso	−11.4
Lebanon	Pound	−12.4
UAE	Dirham	−15.5
Saudi Arabia	Riyal	−17.2
Honduras	Lempira	−17.3
Peru	Sol	−17.8
Hungary	Forint	−18.4
New Zealand	NZ$	−19.3
Bahrain	Dinar	−22.0
Nicaragua	Córdoba	−22.4
Qatar	Riyal	−23.7
Kuwait	Dinar	−25.8
Brazil	Real	−27.3
Guatemala	Quetzal	−29.7
Thailand	Baht	−29.7
Moldova	Leu	−33.2
Venezuela	Bolívar	−33.9
Romania	Leu	−35.0
Oman	Rial	−35.1
Azerbaijan	Manat	−36.2
Pakistan	Rupee	−36.9
South Korea	Won	−38.9
China	Yuan	−40.2
Jordan	Dinar	−42.3

Country	Currency	% Under/Over valued
Malaysia	Ringgit	−44.6
South Africa	Rand	−45.1
Hong Kong	HK$	−47.6
Ukraine	Hryvnia	−47.8
Japan	Yen	−50.5
Vietnam	Dong	−52.7
Philippines	Peso	−53.6
Egypt	Pound	−56.8
Indonesia	Rupiah	−58.9
India	Rupee	−58.9
Taiwan	NT$	−59.6

Example: The British pound is 15.7% overvalued against the US dollar

A Big Mac costs £5.29 in Britain and US$6.12 in the United States. The implied exchange rate is 0.86. The difference between this and the actual exchange rate, 0.75, suggests the British pound is 15.7% overvalued.

About the Big Mac index

The Big Mac index was invented by *The Economist* in 1986 as a lighthearted guide to whether currencies are at their “correct” level. It is based on the theory of purchasing-power parity (PPP), the notion that in the long run exchange rates should move towards the rate that would equalise the prices of an identical basket of goods and services (in this case, a burger) in any two countries.

Burgernomics was never intended as a precise gauge of currency misalignment, merely a tool to make exchange-rate theory more digestible. Yet the Big Mac index has become a global standard, included in several economic textbooks and the subject of dozens of academic studies.

GDP-adjusted index

The GDP-adjusted index addresses the criticism that you would expect average burger prices to be cheaper in poor countries than in rich ones because labour costs are lower. PPP signals where exchange rates should be heading in the long run, as a country like China gets richer, but it says little about today's equilibrium rate. The relationship between prices and GDP per person may be a better guide to the current fair value of a currency.

Methodology note

In July 2022 we updated the Big Mac index to use a McDonald's-provided price for the United States. We also changed our methodology for how we calculate the GDP-adjusted index, the full history of which will now be adjusted whenever the IMF's historical GDP series are updated. The previously published versions of both indices are available in our archive.

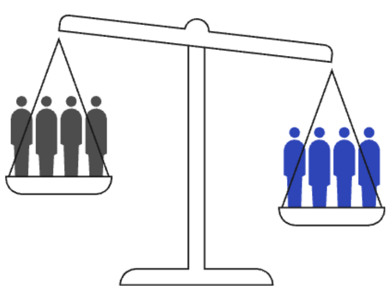
Note: All prices include tax.

Sources: McDonald's; LSEG Workspace; IMF; Eurostat; LebaneseLira.org; Banque du Liban; *The Economist*.

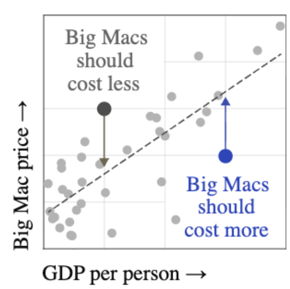
How it works

Raw index | GDP-adjusted

Varying labour costs and barriers to migration and trade may undermine purchasing-power parity



To control for this, our adjusted index predicts what Big Mac prices should be given a country's GDP per person



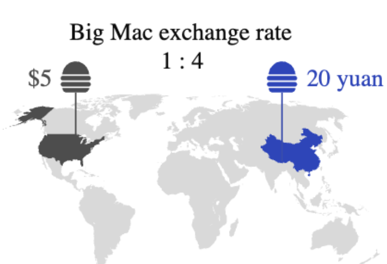
The difference between the predicted and the market price is an alternative measure of currency valuation

How it works

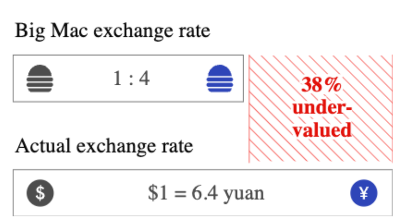
Raw index | GDP-adjusted

Purchasing-power parity implies that exchange rates are determined by the value of goods that currencies can buy

Differences in local prices – in our case, for Big Macs – can suggest what the exchange rate should be



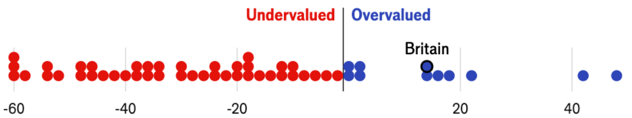
Using burgernomics, we can estimate how much one currency is under- or over-valued relative to another



ADJUST TO ACCOUNT FOR GDP PER PERSON

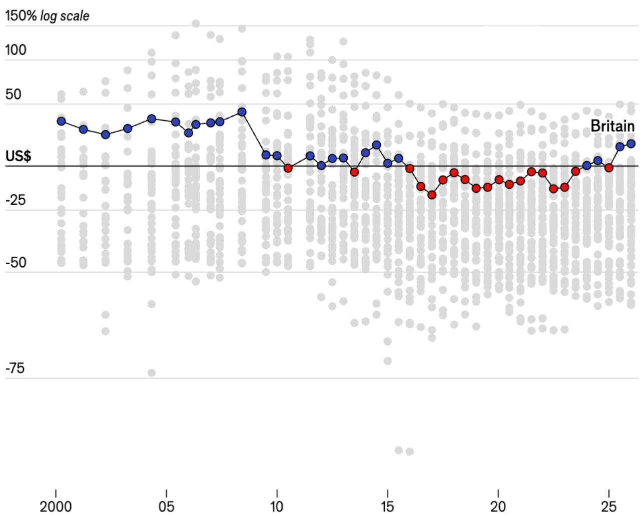
Raw index | GDP-adjusted

Jan 2026 | The British pound is 15.7% overvalued against the US dollar



A Big Mac costs **£5.29** in Britain and **US$6.12** in **the United States**. The implied exchange rate is **0.86**. The difference between this and the actual exchange rate, **0.75**, suggests the British pound is **15.7% overvalued**.

2000-2025

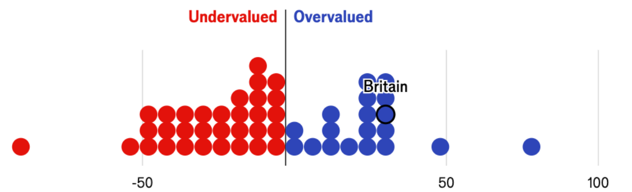


Sources: McDonald's; LSEG Workspace; IMF; Eurostat; LebaneseLira.org; Banque du Liban; *The Economist*

ADJUST TO ACCOUNT FOR GDP PER PERSON

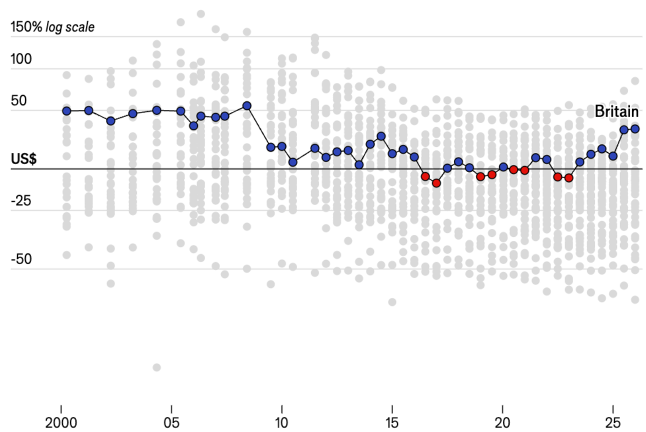
Raw index | GDP-adjusted

Jan 2026 | The British pound is 31.9% overvalued against the US dollar



A Big Mac costs **15.7% more** in **Britain** (**US$7.08**) than in **the United States** (**US$6.12**) at market exchange rates. Based on differences in GDP per person, a Big Mac should cost **12.3% less**. This suggests the British pound is **31.9% overvalued**.

2000-2025



Sources: McDonald's; LSEG Workspace; IMF; Eurostat; LebaneseLira.org; Banque du Liban; *The Economist*

ECON 1550 **Problem Set 6 Answer Key**

Spring 2026

Instructor:	Fernando Duarte
Head TA:	Leo Zucker
Undergraduate TAs:	Eric Kim, Raisa Axenie, Nathalie Peña
Submission:	Canvas or Gradescope

1. A Conditional Carry Trade

(a) Consider the price level in the United States at time t, $P_{\text{US},t}$, the price level in Korea at time t, $P_{\text{Korea},t}$, and the U.S. Dollar (USD) per Korean Won (KRW) exchange rate at time t, E_t. Write the equation for relative PPP between the United States and Korea.

Solution: As shown in equation (5-2) in the textbook, relative PPP between the United States and Korea is

$$\frac{E_t - E_{t-1}}{E_{t-1}} = \pi_{\text{US},t} - \pi_{\text{Korea},t}$$

where $\pi_{\text{US},t}$ is U.S. inflation and $\pi_{\text{Korea},t}$ is Korean inflation.

(b) When

$$\frac{P_{\text{US},t}}{P_{\text{Korea},t}} - E_t > 0,$$

the theory of absolute PPP suggests that USD is overvalued compared to KRW. Write an analogous condition that suggests that USD is overvalued compared to KRW according to *relative* PPP.

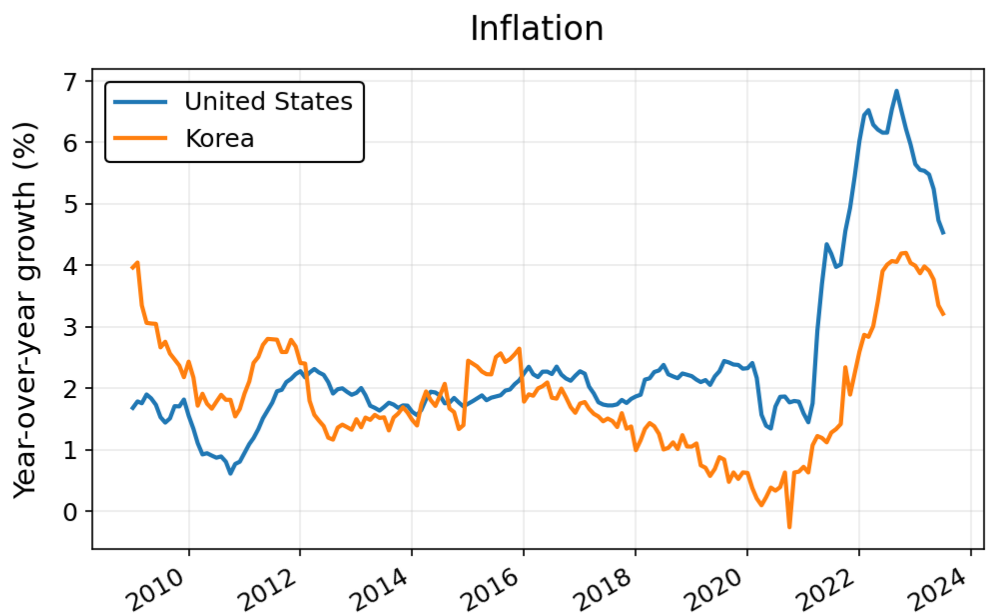
Solution: The condition using relative PPP is

$$\pi_{\text{US},t} - \pi_{\text{Korea},t} - \left(\frac{E_t - E_{t-1}}{E_{t-1}}\right) > 0$$

(c) Download the inflation rate for the United States and the inflation rate for Korea from FRED for all months between February 2009 and July 2023 and show both series in a single plot that has time on the horizontal axis and the inflation rates on the vertical axis.

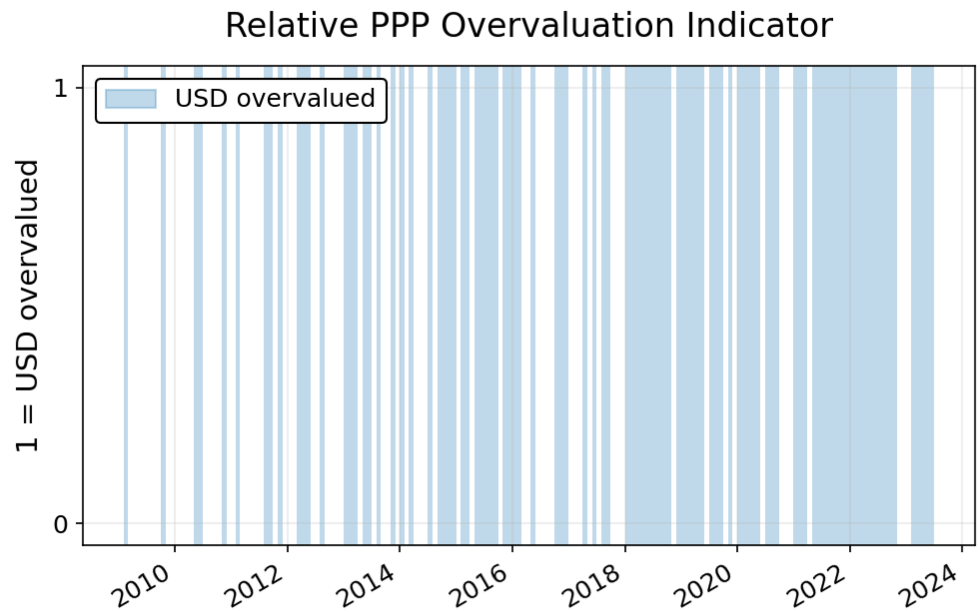
Hint: The links should already display the correct dates, but double check and adjust them if needed. Likewise, the link should already show the consumer price index in units of "Growth rate same period previous year", but make sure it is the case before downloading.

Solution: The plot with both inflation rates is:



(d) Combine the data from (c) with the carry trade data you constructed in Problem Set 3, question 2, part (c), and compute the relative PPP overvaluation condition from part (b). Now construct an indicator variable that is equal to 1 when the overvaluation condition is true, and equal to zero otherwise. Plot this indicator variable with time on the horizontal axis and the indicator on the vertical axis.

Solution: The plot for the indicator variable is:

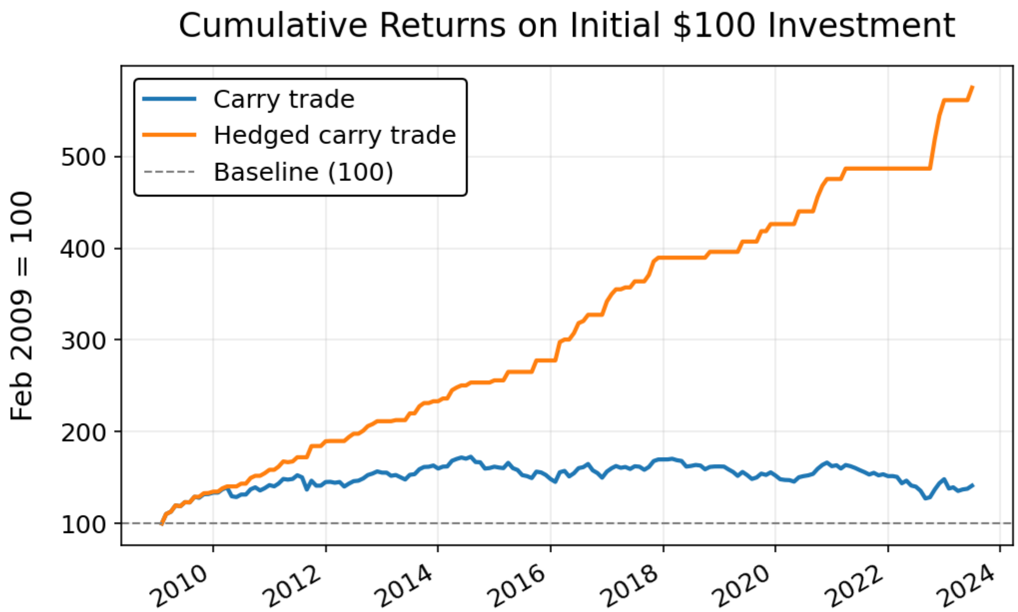


The *hedged carry trade* is a trading strategy where, for each month, you check if the relative PPP overvaluation condition you constructed in (d) signals an overvalued USD. If the signal is for an overvalued USD, invest nothing for that month and earn a monthly return of zero. If the signal is not for an overvalued USD, invest in the standard carry trade and earn the same monthly return that you computed in Problem Set 3, question 2c.

(e) Show the cumulative returns for the hedged carry trade and the standard carry trade together in one plot, with time on the horizontal axis and the cumulative returns on the vertical axis.

By the end of the sample, which strategy has higher cumulative returns? Is the difference in cumulative returns between the two strategies evidence in favor or against the idea that relative PPP holds in the long run?

Solution: The plot with cumulative returns for both strategies is:



By the end of the sample, the hedged carry trade has cumulative returns that are more than eleven times larger than the standard carry trade. This difference does provide some support to the idea that PPP holds in the long run. When relative PPP signals an overvalued dollar, the standard carry tends to have negative returns over the long run. The hedged carry trade has zero returns on those months. Since the standard carry trade borrows in dollars, the negative returns following the overvaluation signal suggest that the dollar depreciates in those periods, at least on average over our relatively long sample.

On the other hand, it could be possible that the negative returns are not due to a depreciation of the dollar but due to a reduction in the dollar-won interest rate differential. Whether the reduction in interest rate differential is evidence in favor or against relative PPP depends on how interest rates interact with inflation.

A spreadsheet with the data, calculations, and plots can be downloaded here.

2. **Long-Run Theories of the Exchange Rate Determination**

Consider the model of the long run given by:

$(PPP):$	$E = P/P^*$
$(MS = MD):$	$M^s/P = \text{L}(R, Y)$
$(MS^* = MD^*):$	$M^{s*}/P^* = \text{L}(R^*, Y^*)$

In class, we referred to this model as "Model 1".

(a) Explain the name of the equations PPP, $MS = MD$, and $MS^* = MD^*$.

> **Solution:** PPP means purchasing power parity. $MS = MD$ and $MS^* = MD^*$ mean (real) money supply equal to (real) money demand in the domestic and foreign countries, respectively.

(b) Identify the exogenous and endogenous variables.

Hint: Consult these slides if you need a reminder.

> **Solution:** The exogenous variables are: $R, Y, M^s, R^*, Y^*, M^{s*}$. The endogenous variables are: E, P, P^*.

(c) Assume that the function $\text{L}(\cdot,\cdot)$ is given by $\text{L}(R, Y) = Y/R$ and $\text{L}(R^*, Y^*) = Y^*/R^*$. Solve for the endogenous variables as a function of the exogenous variables.

> **Solution:** Solve for P and P^* in the domestic and foreign money market equations to get: $P = M^sR/Y$ $P^* = M^{s*}R^*/Y^*$. Plugging into the PPP equation we get
>
> $$E = \frac{\frac{M^sR}{Y}}{\frac{M^{s*}R^*}{Y^*}} = \frac{M^s}{M^{s*}}\frac{R}{R^*}\frac{Y^*}{Y}$$

(d) Consider a one-time permanent increase in M^s. Explain how all endogenous variables respond immediately when the change in M^s occurs and in the long run.

> **Solution:** After a one-time permanent increase in M^s, P goes up, P^* remains unchanged and E goes up (there is a nominal depreciation). The changes in the short run and long run are identical, that is, immediately after the change in M^s we have a one-time permanent increase in P and E.

To the above monetary model, we add the following equations:

Relative output demand:	$Y/Y^* = q$
Relative output supply:	$Y/Y^* = \bar{Y}$
Definition of real exchange rate:	$q \equiv EP^*/P$

The exogenous variables are the same as before and, in addition, $\bar{Y}$. Assume $\bar{Y} = 1$. The endogenous variables are the same as before and, in addition, q and Y/Y^*.

The first equation, labeled Relative output demand, is a behavioral equation that captures the idea that if domestic goods become cheaper relative to foreign goods (q goes up, a real depreciation), then demand for domestic goods will increase relative to demand for foreign goods (the "relative output demand" Y/Y^* goes up).

The second equation, labeled Relative output supply, says that the relative supply of domestic and foreign goods, Y/Y^*, is equal to an exogenous variable $\bar{Y}$.

The third equation is the definition of the real exchange rate q.

In equilibrium, relative output supply must equal relative output demand.

(e) Consider a one-time permanent increase in M^s. Explain how all endogenous variables respond to the change in M^s in the short run (immediately after the change in M^s) and in the long run.

Hint: If you need help understanding the model, Section 5.6 of Chapter 5 of the textbook has a longer discussion.

Solution: From (d), we know that P^* remains unchanged. We also found that P and E increase permanently in the short run and remain at their new levels in the long run.
In equilibrium, relative output demand equals relative output supply and hence $Y/Y^* = q = \bar{Y}$. Because PPP is imposed in Model 1, $q = EP^*/P = 1$; therefore equilibrium in the added block requires $\bar{Y} = 1$ in levels. The key comparative-static result is that Y/Y^* and the real exchange rate q remain unchanged after the increase in M^s.

ECON 1550	**Problem Set 7 Answer Key**
Spring 2026	

Instructor:	Fernando Duarte
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Submission:	Canvas or Gradescope

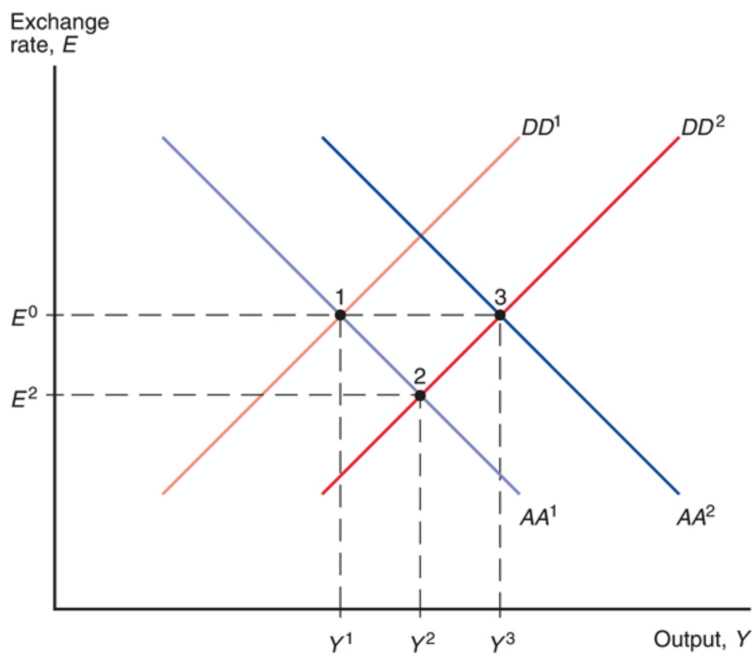
1. **Chapter 6: Output and the Exchange Rate in the Short Run**

The following questions analyze fiscal and monetary policy using the AA-DD model.

(a) If a government initially has a balanced budget but then cuts taxes, it is running a deficit. Suppose the government finances its deficit by printing the extra money it now needs to cover its expenditures, that is, by increasing the money supply enough to finance the deficit. Assume that the tax cuts and the increase in the money supply are both temporary and occur at the same time. According to the AA-DD model, how does the nominal exchange rate respond to this simultaneous change in taxes and money supply in the short run?

Solution: A temporary tax cut raises disposable income and consumption, so the DD curve shifts to the right. A temporary increase in the money supply shifts the AA curve to the right. Because both policies are expansionary, output rises unambiguously.

The initial equilibrium is point 1. The tax cut alone shifts the DD curve from DD^1 to DD^2, with the equilibrium moving from point 1 to point 2. Adding the temporary monetary expansion shifts the AA curve from AA^1 to AA^2, moving the equilibrium from point 2 to point 3.



In the figure, the shifts in AA and DD are such that the exchange rate at point 1 is the same as the exchange rate at point 3. In general, however, the effect on the exchange rate is ambiguous. If the DD shift is relatively large, the new equilibrium can have a lower exchange rate than E^0. If the AA shift is relatively large, the new equilibrium can have a higher exchange rate than E^0. Summing up, the combined temporary tax cut and temporary monetary expansion raise output, while the effect on the exchange rate is ambiguous.

(b) A new government is elected and announces that once it is inaugurated, it will permanently increase the money supply. Use the AA-DD model to study the economy's response at the moment the announcement is made. Do not analyze what happens later, when the new government is inaugurated and the policy is implemented.

Solution: The expansionary money supply announcement causes a depreciation in the expected exchange rate and shifts the AA curve to the right. This leads to an immediate increase in output and an immediate currency depreciation. The effects of the anticipated policy action thus precede the policy's actual implementation.

During the last few years, and especially after the COVID-19 pandemic, there have been many calls to "buy American". Imagine the government implements a "buy American" program in which any new government spending is constrained to only purchase domestic goods. Use the AA-DD model to answer the following questions:

(c) Does a *permanent* increase in U.S. government spending constrained by "buy American" restrictions have a bigger effect on U.S. output than unconstrained U.S. government spending? Why or why not? Make sure you consider both the short and long run effects on output.

> **Solution:** A "buy American" provision results in a larger permanent rightward shift in the DD curve than an unconstrained increase in government spending because there is a greater demand for U.S. goods than if some imported goods are purchased with the stimulus funds.
>
> In both cases, the short-run expected exchange rate declines, shifting the AA curve down so that it intersects the DD curve at the point where output equals its full-employment level, that is, $Y = Y^f$. Since the short-run equilibrium has $Y = Y^f$, the AA and DD curves do not shift after the short run, so the long-run equilibrium coincides with the short-run equilibrium.
>
> We conclude that the buy American provision and the unconstrained government spending case result in the same $Y = Y^f$ level of output in the short run and in the long run.
>
> Because the buy American provision shifts the DD more than the unconstrained spending, the shift in the AA required to have $Y = Y^f$ is also larger for the buy American provision, and the currency appreciates more.
>
> Additional information (not part of the answer): Because the buy American provision shifts the DD curve farther to the right than unconstrained government spending, keeping equilibrium at $Y = Y^f$ requires a larger downward shift in the AA curve. As a result, the domestic currency appreciates more under the buy American provision than under unconstrained government spending.

(d) Now assume the government spending is temporary. Do "buy American" restrictions have a bigger effect on U.S. output than unconstrained U.S. government spending? Why or why not? Make sure you consider both the short and long run effects on output.

> **Solution:** When spending is temporary, a "buy American" provision has a larger effect on output in the short run, since the AA curve does not shift because

exchange rate expectations remain unchanged.
In the long run, the economy returns to $Y = Y^f$ in both cases, making the long-run effect on output the same with and without "buy American" provisions.

2. **Import Tariffs in the AA-DD Model**

Use the standard AA-DD model from class and from the textbook, with the following functional forms:

$$C(Y-T) = \frac{1}{2}(Y-T),$$
$$EX(q, Y^*) = \frac{1}{4} + \frac{1}{10}q + \frac{1}{10}(Y^* - 1),$$
$$IM(q, Y-T) = \frac{5 + 2(Y-T)}{20} - \frac{1}{10}q,$$
$$L(R, Y) = \frac{Y}{1+R}.$$

Throughout this question, use

$$T = 0, \quad I = \frac{1}{5}, \quad G = \frac{1}{5}, \quad M^s = 1, \quad P^* = 1, \quad R^* = 0, \quad Y^* = 1.$$

It will also be useful to write imports as

$$IM(q, Y-T) = qV(q, Y-T),$$

where
$$V(q, Y-T) = \frac{5 + 2(Y-T)}{20q} - \frac{1}{10}$$
is the volume of imports measured in units of foreign goods.

(a) Explain the price effect and the volume effect of an increase in q on imports. Then, using the functional forms and values given above, verify that the volume effect dominates.

Solution: Write imports as

$$IM(q, Y-T) = qV(q, Y-T).$$

The price effect is that when q rises, each imported unit costs more in terms of domestic goods, which tends to raise IM for a given import volume. The volume effect is that when q rises, domestic residents buy fewer imported units, which tends to lower IM.

In this model,

$$V(q, Y-T) = \frac{5+2(Y-T)}{20q} - \frac{1}{10}.$$

Holding $Y-T$ fixed, a rise in q lowers the term $\frac{5+2(Y-T)}{20q}$, so import volume is decreasing in q.

Imports (expressed in units of domestic goods) are:

$$IM(q, Y-T) = q\left(\frac{5+2(Y-T)}{20q} - \frac{1}{10}\right) = \frac{5+2(Y-T)}{20} - \frac{q}{10}.$$

Since IM is decreasing in q, the fall in import volume more than offsets the higher price per imported unit. In this model, the volume effect dominates the price effect.

(b) Derive the DD curve explicitly. Explain what points on the DD curve represent. In a graph with E on the vertical axis and Y on the horizontal axis, is the DD curve increasing or decreasing? Give intuition.

Solution: From part (a),

$$IM = \frac{5+2Y}{20} - \frac{q}{10} = \frac{1}{4} + \frac{Y}{10} - \frac{q}{10},$$

because $T=0$, so $Y-T=Y$.

Exports are

$$EX = \frac{1}{4} + \frac{q}{10},$$

because $Y^* = 1$.

So the current account is

$$CA = EX - IM = \left(\frac{1}{4} + \frac{q}{10}\right) - \left(\frac{1}{4} + \frac{Y}{10} - \frac{q}{10}\right) = \frac{q}{5} - \frac{Y}{10}.$$

Aggregate demand for domestic goods is

$$D = C + I + G + CA = \frac{1}{2}Y + \frac{1}{5} + \frac{1}{5} + \frac{q}{5} - \frac{Y}{10} = \frac{2}{5}Y + \frac{2}{5} + \frac{q}{5}.$$

Goods-market equilibrium requires $Y = D$, so

$$Y = \frac{2}{5}Y + \frac{2}{5} + \frac{q}{5}.$$

Re-arranging,

$$\frac{3}{5}Y = \frac{2}{5} + \frac{q}{5},$$

so

$$q = 3Y - 2.$$

Because $q = EP^*/P$ and $P^* = 1$, the DD curve is

$$E = P(3Y - 2).$$

Points on the DD curve are pairs (E, Y) that are consistent with equilibrium in the market for domestic goods.
In this version of the model, DD is a straight line. Its slope is $3P$, and its vertical intercept is $-2P$.
The DD curve is increasing. A higher level of output raises disposable income, consumption, and imports. To keep the market for domestic goods in equilibrium, the real exchange rate must depreciate (higher q) so that exports rise and imports fall enough to offset the increase in domestic absorption. With P and P^* fixed, a higher q requires a higher nominal exchange rate E.

(c) Repeat part (b) for the AA curve.

Solution: The money market is

$$\frac{1}{P} = \frac{Y}{1 + R},$$

because $M^s = 1$.
So

$$1 + R = PY,$$

and therefore

$$R = PY - 1.$$

Uncovered interest parity is

$$R = \frac{E^e}{E} - 1,$$

because $R^* = 0$.

Substitute the money-market expression for R into uncovered interest parity:

$$PY - 1 = \frac{E^e}{E} - 1.$$

So

$$PY = \frac{E^e}{E},$$

which implies

$$E = \frac{E^e}{PY}.$$

This is the AA curve.

Points on the AA curve are pairs (E, Y) that are consistent with asset-market equilibrium, meaning equilibrium in the money market together with equilibrium in the foreign-exchange market.

The AA curve is decreasing. If Y rises, people want to hold more money. With the money supply fixed, the interest rate must rise to make people willing to hold the available money. A higher domestic interest rate makes domestic bonds more attractive. For uncovered interest parity to continue to hold, the domestic currency must be more appreciated today, which means a lower E.

For the remaining parts of the question, add a Phillips curve:

$$\pi = \pi^e + \alpha(Y - Y^f),$$

where π is inflation, π^e is expected inflation, α is the slope, and Y^f is full-employment output. Set $\pi^e = 0$, $\alpha = 1$, and $Y^f = 1$.

(d) Solve for the initial long-run equilibrium.

Solution: With the given parameter values, the Phillips curve becomes

$$\pi = Y - 1.$$

In the long run, output equals full-employment output:

$$Y_0 = Y^f = 1.$$

So inflation is

$$\pi_0 = Y_0 - 1 = 0.$$

In the long run, expected and actual exchange rates are equal:

$$E_0^e = E_0.$$

Uncovered interest parity then gives

$$R_0 = R_0^* + \frac{E_0^e}{E_0} - 1 = 0 + 1 - 1 = 0.$$

The money market gives

$$\frac{1}{P_0} = \frac{Y_0}{1 + R_0} = \frac{1}{1},$$

so

$$P_0 = 1.$$

The DD relation from part (b) is

$$q = 3Y - 2.$$

At $Y_0 = 1$,

$$q_0 = 1.$$

Since $q_0 = E_0/P_0$ and $P_0 = 1$,

$$E_0 = 1.$$

Therefore

$$E_0^e = 1.$$

The remaining endogenous variables are

$$Y_0 - T = 1, \quad C_0 = \frac{1}{2}, \quad EX_0 = \frac{7}{20},$$

$$IM_0 = \frac{1}{4}, \quad CA_0 = \frac{1}{10}, \quad D_0 = 1.$$

So the initial long-run equilibrium is

$$Y_0 = 1, \quad E_0 = 1, \quad q_0 = 1, \quad R_0 = 0, \quad P_0 = 1, \quad \pi_0 = 0.$$

Now add an exogenous *ad valorem* (proportional) import tariff τ. The tariff raises the domestic-currency price of imported goods from q to $(1+\tau)q$ in the volume of imports:

$$IM(q, \tau, Y - T) = qV((1+\tau)q, Y - T).$$

Treat tariff revenue as negligible so that T and G remain unchanged.

(e) Keeping the real exchange rate, output, and taxes fixed, does a higher tariff lead to a higher or a lower current account? Explain why.

Solution: With the tariff,

$$V((1+\tau)q, Y) = \frac{5+2Y}{20(1+\tau)q} - \frac{1}{10},$$

because $T = 0$, so $Y - T = Y$.
Imports are therefore

$$IM(q, \tau, Y) = qV((1+\tau)q, Y) = q\left(\frac{5+2Y}{20(1+\tau)q} - \frac{1}{10}\right) = \frac{5+2Y}{20(1+\tau)} - \frac{q}{10}.$$

So the current account is

$$CA(q, \tau, Y) = \left(\frac{1}{4} + \frac{q}{10}\right) - \left(\frac{5+2Y}{20(1+\tau)} - \frac{q}{10}\right).$$

Holding q and Y fixed, a higher tariff makes the term $\frac{5+2Y}{20(1+\tau)}$ smaller. So imports fall and the current account rises.
The intuition is simple. At a fixed real exchange rate and a fixed level of output, the tariff makes imported goods more expensive for domestic buyers. Domestic

residents therefore buy fewer imports, and that improves the current account.

(f) Find the DD curve when the tariff is present. How do tariffs change the DD curve? Comment on both the slope and the intercept. Give intuition.

Solution: From part (e),

$$IM = \frac{5+2Y}{20(1+\tau)} - \frac{q}{10}.$$

Exports are unchanged by the home import tariff:

$$EX = \frac{1}{4} + \frac{q}{10}.$$

So the current account is

$$CA = EX - IM = \frac{1}{4} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

Aggregate demand for domestic goods is

$$D = \frac{1}{2}Y + \frac{1}{5} + \frac{1}{5} + \frac{1}{4} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

So

$$D = \frac{1}{2}Y + \frac{13}{20} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

Set $Y = D$:

$$Y = \frac{1}{2}Y + \frac{13}{20} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

Move the Y-terms to the left:

$$\left(\frac{1}{2} + \frac{1}{10(1+\tau)}\right)Y = \frac{13}{20} - \frac{1}{4(1+\tau)} + \frac{q}{5}.$$

So

$$\frac{6+5\tau}{10(1+\tau)}Y = \frac{8+13\tau}{20(1+\tau)} + \frac{q}{5}.$$

Solving for q,

$$q = \frac{(12+10\tau)Y - 8 - 13\tau}{4(1+\tau)}.$$

Because $q = EP^*/P$ and $P^* = 1$, the DD curve with tariffs is

$$E = P\left[\frac{12+10\tau}{4(1+\tau)}Y - \frac{8+13\tau}{4(1+\tau)}\right].$$

This is again a straight line. Its slope is

$$m_{DD}(\tau) = P\frac{12+10\tau}{4(1+\tau)} = P\frac{6+5\tau}{2(1+\tau)},$$

and its vertical intercept is

$$b_{DD}(\tau) = -P\frac{8+13\tau}{4(1+\tau)}.$$

Without tariffs, the slope is $3P$ and the intercept is $-2P$. With a positive tariff, the slope is smaller because

$$\frac{6+5\tau}{2(1+\tau)} < 3,$$

and the intercept is lower because

$$\frac{8+13\tau}{4(1+\tau)} > 2.$$

So in an E-against-Y graph, the tariff DD curve is flatter and lies below the no-tariff DD curve. That is the same as saying DD shifts to the right.
If you solve instead for Y as a function of E, you get

$$Y = \frac{2(1+\tau)}{P(6+5\tau)}E + \frac{8+13\tau}{2(6+5\tau)}.$$

Both the slope and the intercept in that version are higher than in the no-tariff case, which makes the rightward shift especially easy to see.
The intuition is that the tariff already reduces imports. Because domestic demand is redirected away from foreign goods and toward domestic goods, the economy needs less depreciation to keep the market for domestic goods in equilibrium.

(g) Find the AA curve. How do tariffs change the AA curve? Give intuition.

<u>Hint</u>: The AA curve is not a straight line, so you don't need to talk about its slope and intercept. A qualitative explanation, or a sketch of the AA curve before and after

the tariff is imposed, is enough.

Solution: The tariff does not enter the money market or uncovered interest parity. So the AA curve is the same as before:

$$E = \frac{E^e}{PY}.$$

AA is not a straight line. So it does not have one constant slope or a finite vertical intercept.
If a tariff change leaves E^e unchanged, then AA is unchanged. That means the curve keeps exactly the same shape.
This is what happens for a temporary tariff increase. In that case, the long-run exchange rate is unchanged, so E^e is unchanged, and the whole AA curve stays where it was.
A permanent tariff increase is different. It changes the long-run exchange rate, so it changes E^e. Here the permanent tariff lowers the long-run exchange rate. So every point on

$$E = \frac{E^e}{PY}$$

is multiplied by a smaller number. The whole AA curve shifts down, but its downward shape is unchanged.
The intuition is that the AA curve comes from equilibrium in asset markets. Current tariffs work through the goods market, not directly through money demand or interest parity. AA moves only if the tariff changes the expected future exchange rate.

(h) Consider a temporary increase in the tariff from 0 to $1/3$ in the short run, and a return to zero tariffs $\tau = 0$ immediately after and in the long run. Sketch in an AA-DD diagram the initial equilibrium, the short-run equilibrium, the long-run equilibrium, and the transition from the short run back to the long run. A qualitatively correct sketch is enough. Explain in words how and why the curves shift, or do not shift, at each point in time.

Solution: Since the shock is transitory, the long-run equilibrium after the temporary tariff shock is the initial long-run equilibrium:

$$Y_{LR} = 1, \quad E_{LR} = 1, \quad q_{LR} = 1, \quad P_{LR} = 1.$$

So on impact,

$$E^e_{SR} = E_{LR} = 1.$$

The short-run price level is fixed at the initial value:

$$P_{SR} = P_0 = 1.$$

On impact, AA is unchanged because the shock is temporary and E^e is unchanged:

$$AA_{SR}: \quad E = \frac{1}{Y}.$$

The DD curve shifts to the right. With $\tau = 1/3$ and $P = 1$, the tariff DD curve is

$$DD_{SR}: \quad E = \frac{46Y - 37}{16}.$$

The short-run equilibrium solves

$$\frac{46Y_{SR} - 37}{16} = \frac{1}{Y_{SR}},$$

so

$$46Y_{SR}^2 - 37Y_{SR} - 16 = 0.$$

The positive solution is

$$Y_{SR} = 1.116.$$

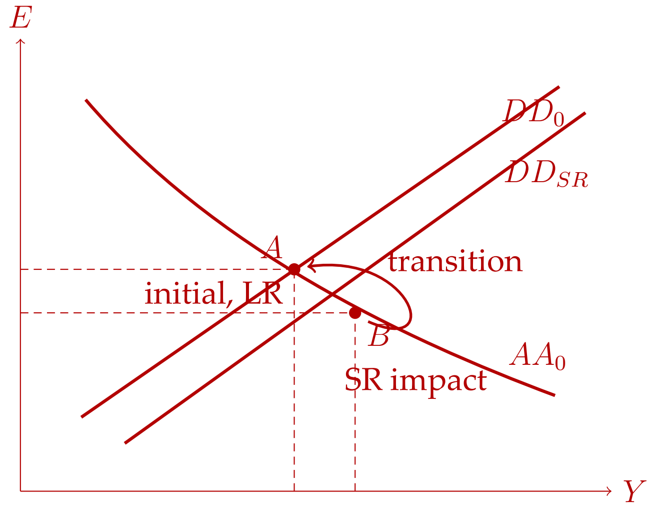
Therefore

$$E_{SR} = \frac{1}{Y_{SR}} = 0.896, \quad q_{SR} = \frac{E_{SR}}{P_{SR}} = 0.896.$$

So on impact the economy moves from the initial point A to the short-run point B, with higher Y and lower E. The tariff shifts spending toward domestic goods. That raises output and the exchange rate appreciates.
Because $Y_{SR} > Y^f = 1$, short-run inflation is positive:

$$\pi_{SR} = Y_{SR} - 1 = 0.116.$$

Immediately after the impact, the tariff returns to zero. So the economy begins to transition back toward the original long-run equilibrium. Because this temporary tariff affects the economy only at the impact instant, the short-run shift in the DD immediately reverses after the short run. The equilibrium at all times after the short run is the same as the initial long-run equilibrium. A qualitatively correct sketch therefore shows the original equilibrium A, the short-run impact point B, and a return from B back to A.



(i) Plot the time paths of E, q, Y, P, π, CA, EX, and IM for the temporary tariff increase. A qualitatively correct path is enough.

Solution: At the initial long-run equilibrium,

$$E_0 = 1, \quad q_0 = 1, \quad Y_0 = 1, \quad P_0 = 1,$$
$$\pi_0 = 0, \quad CA_0 = \frac{1}{10}, \quad EX_0 = \frac{7}{20}, \quad IM_0 = \frac{1}{4}.$$

At the short-run equilibrium from part (h),

$$Y_{SR} = 1.116, \quad E_{SR} = 0.896, \quad q_{SR} = 0.896, \quad P_{SR} = 1, \quad \pi_{SR} = 0.116.$$

The external variables at SR are

$$EX_{SR} = \frac{1}{4} + \frac{1}{10}q_{SR} = 0.340,$$

$$IM_{SR} = \frac{5 + 2Y_{SR}}{20(1 + 1/3)} - \frac{q_{SR}}{10} = 0.182,$$
$$CA_{SR} = EX_{SR} - IM_{SR} = 0.158.$$

In the long run, the temporary tariff is gone and the economy returns to the initial long-run equilibrium:

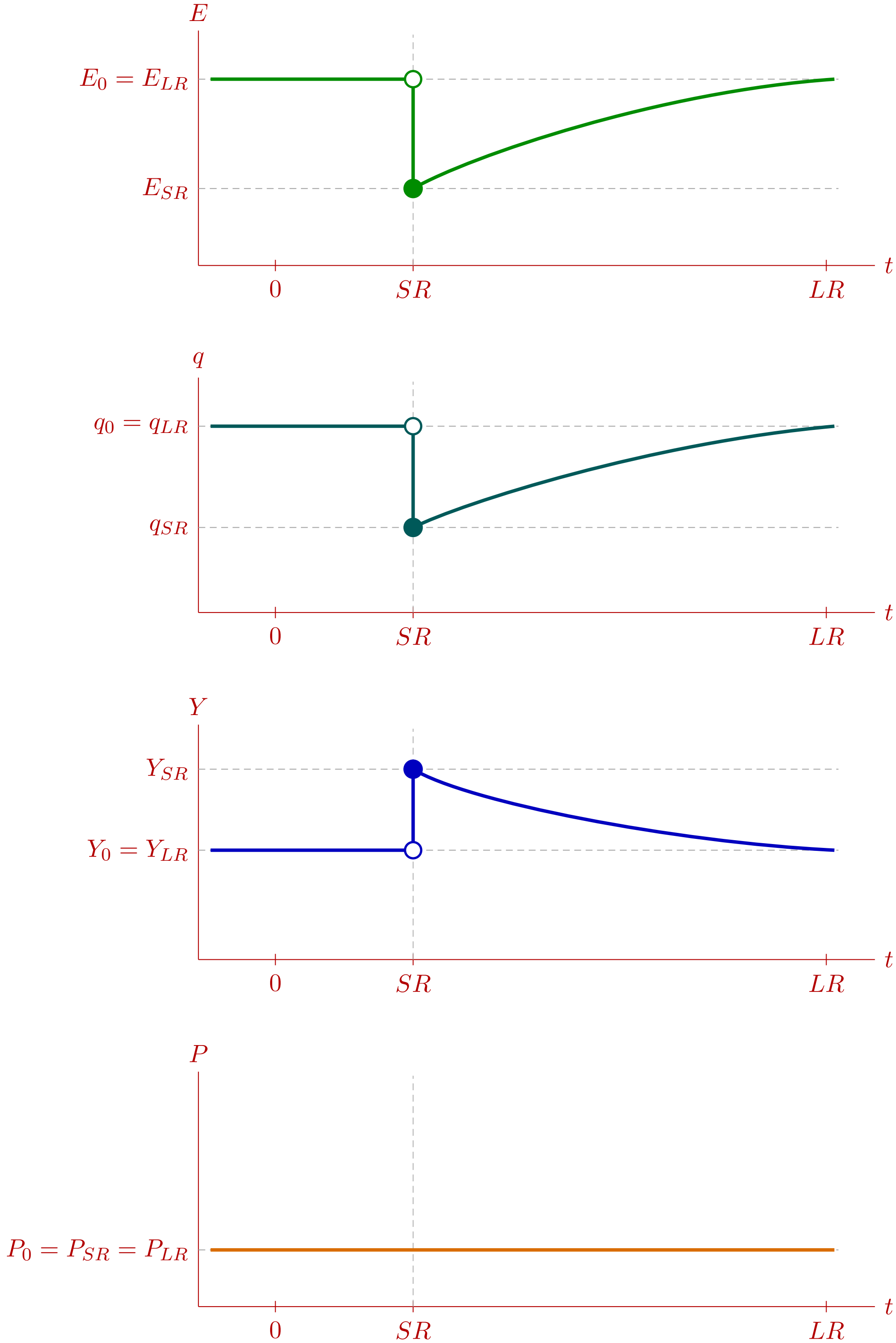
$$E_{LR} = 1, \quad q_{LR} = 1, \quad Y_{LR} = 1, \quad P_{LR} = 1,$$
$$\pi_{LR} = 0, \quad CA_{LR} = \frac{1}{10}, \quad EX_{LR} = \frac{7}{20}, \quad IM_{LR} = \frac{1}{4}.$$

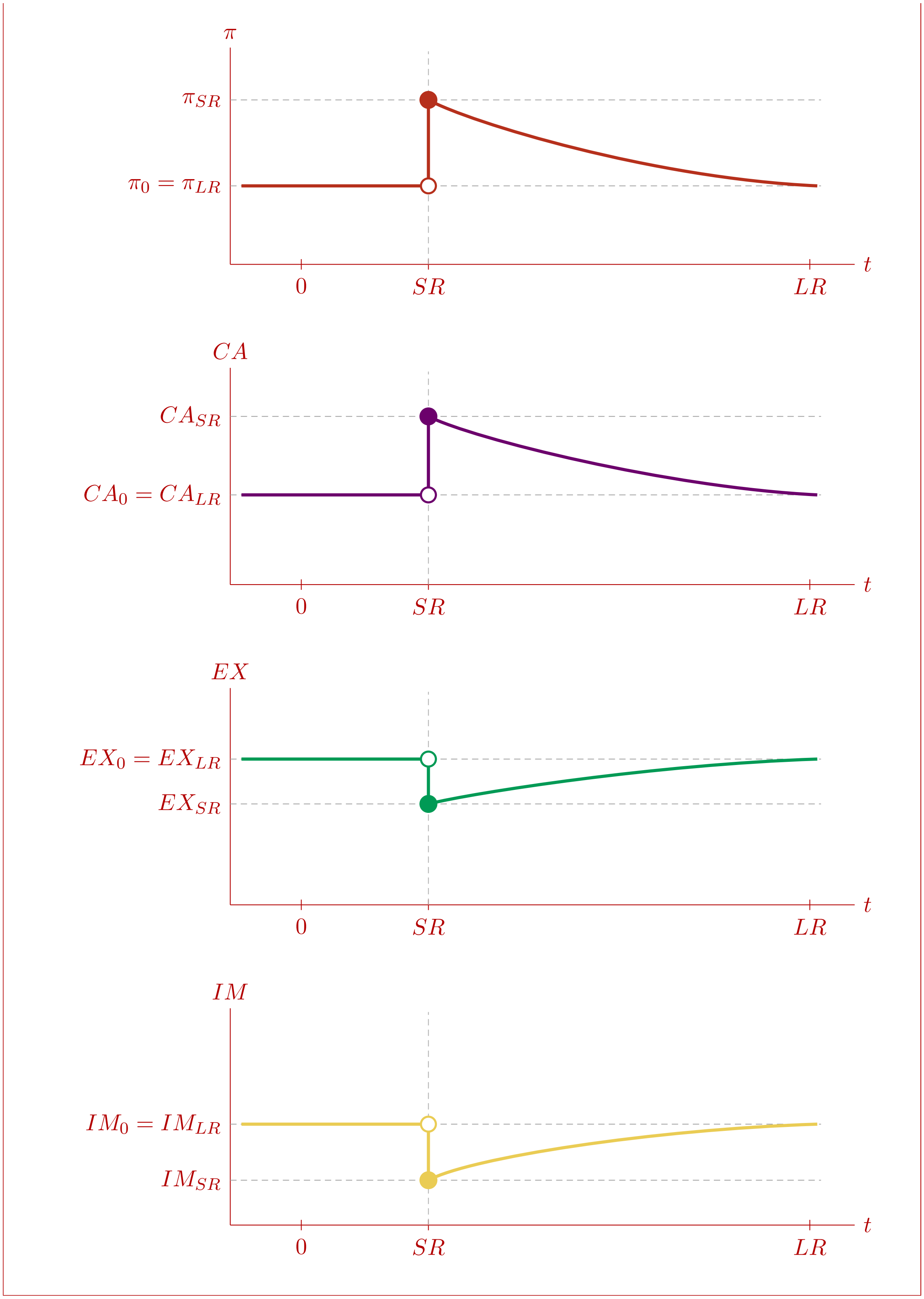
A convenient summary table for the values at 0, SR, and LR is

Variable	0	SR	LR
E	1.000	0.896	1.000
q	1.000	0.896	1.000
Y	1.000	1.116	1.000
P	1.000	1.000	1.000
π	0.000	0.116	0.000
CA	0.100	0.158	0.100
EX	0.350	0.340	0.350
IM	0.250	0.182	0.250

Because the temporary tariff is treated as a short-run impact only, each variable jumps to its impact value at SR and then jumps back to the initial equilibrium's value immediately after. So E and q jump down and then rise back, Y jumps up and then falls back, P is unchanged at the impact instant and stays at its original level, π jumps up and then falls back to zero, CA jumps up and then falls back, and both EX and IM jump down and then rise back to their original values.

One set of qualitatively correct paths is shown below.


E
$E_0 = E_{LR}$
E_{SR}
t
0
SR
LR
q
$q_0 = q_{LR}$
q_{SR}
t
0
SR
LR
Y
Y_{SR}
$Y_0 = Y_{LR}$
t
0
SR
LR
P
$P_0 = P_{SR} = P_{LR}$
t
0
SR
LR



(j) Repeat part (h) for a permanent increase in the tariff that changes it from 0 to $1/3$ in the short run, the long run, and the transition between the short run and the long run.

Solution: Now the tariff stays at $1/3$ in both the short run and the long run:

$$\tau_{SR} = \tau_{LR} = \frac{1}{3}.$$

In the long run, output is still at full employment:

$$Y_{LR} = 1.$$

The money supply, foreign interest rate, and full-employment output are unchanged, so the long-run money market still gives

$$P_{LR} = 1, \quad R_{LR} = 0.$$

Use the tariff DD relation from part (f):

$$q = \frac{(12 + 10\tau)Y - 8 - 13\tau}{4(1 + \tau)}.$$

At $Y = 1$ and $\tau = 1/3$,

$$q_{LR} = \frac{46 - 37}{16} = \frac{9}{16}.$$

Since $P_{LR} = 1$, the long-run exchange rate is

$$E_{LR} = q_{LR} = \frac{9}{16}.$$

So on impact,

$$E^e_{SR} = E_{LR} = \frac{9}{16}.$$

The short-run price level is still fixed at

$$P_{SR} = P_0 = 1.$$

With $\tau = 1/3$, the DD curve on impact is

$$DD_{SR}: \quad E = \frac{46Y - 37}{16}.$$

The AA curve on impact is

$$AA_{SR}: \quad E = \frac{9}{16Y}.$$

Solve for the short-run equilibrium:

$$\frac{46Y_{SR} - 37}{16} = \frac{9}{16Y_{SR}}.$$

So

$$46Y_{SR}^2 - 37Y_{SR} - 9 = 0.$$

This factors as

$$(Y_{SR} - 1)(46Y_{SR} + 9) = 0.$$

The positive solution is

$$Y_{SR} = 1.$$

Therefore

$$E_{SR} = \frac{9}{16}, \quad q_{SR} = \frac{9}{16}, \quad R_{SR} = 0.$$

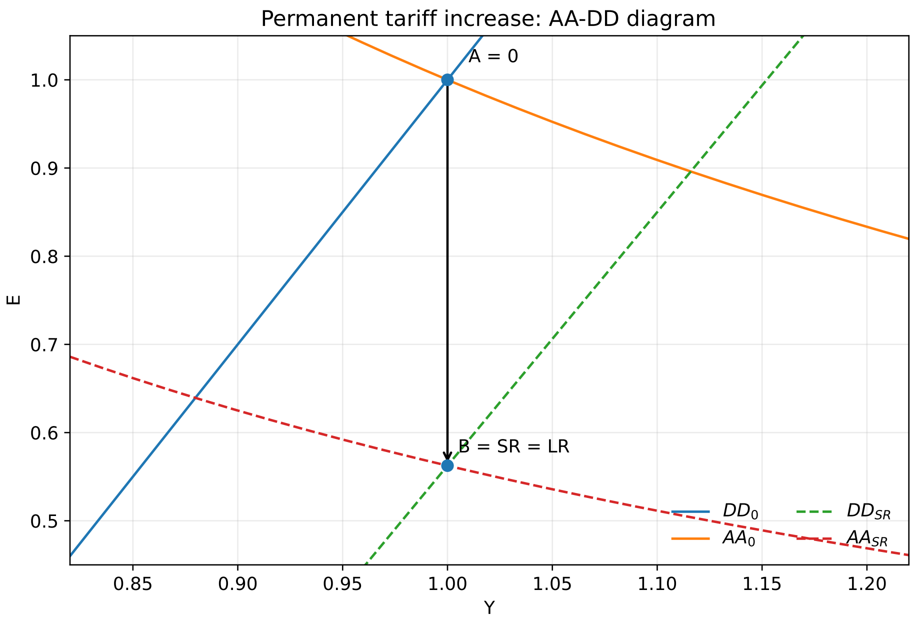
Because $Y_{SR} = Y^f = 1$, inflation is zero:

$$\pi_{SR} = 0.$$

So the price level does not change and the short-run equilibrium is already the long-run equilibrium.

In words, DD shifts to the right because the tariff reduces imports. AA shifts down because the permanent tariff lowers the expected future exchange rate. Those two shifts exactly offset each other in terms of output. The new equilibrium has the same Y as before, but a lower E.

The figure below shows one correct diagram.



(k) Repeat part (i) for the permanent tariff increase.

Solution: From part (j), the short-run and long-run equilibria are the same:

$$Y_{SR} = Y_{LR} = 1, \quad P_{SR} = P_{LR} = 1,$$
$$E_{SR} = E_{LR} = \frac{9}{16}, \quad q_{SR} = q_{LR} = \frac{9}{16}, \quad \pi_{SR} = \pi_{LR} = 0.$$

Exports and imports are

$$EX_{SR} = EX_{LR} = \frac{1}{4} + \frac{1}{10}\frac{9}{16} = \frac{49}{160} = 0.306,$$

$$IM_{SR} = IM_{LR} = \frac{5+2}{20(1+1/3)} - \frac{1}{10}\frac{9}{16} = \frac{33}{160} = 0.206.$$

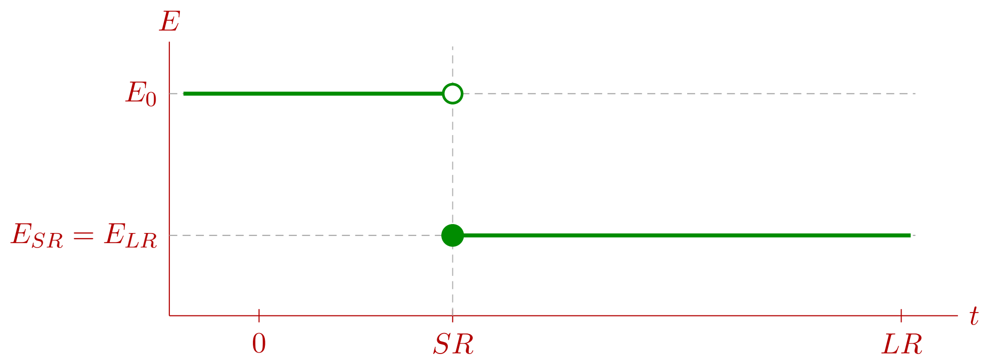
So

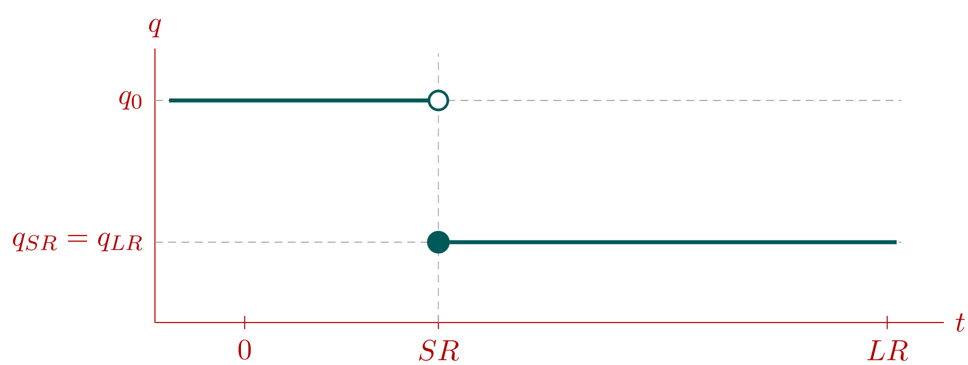
$$CA_{SR} = CA_{LR} = EX_{SR} - IM_{SR} = \frac{1}{10} = 0.100.$$

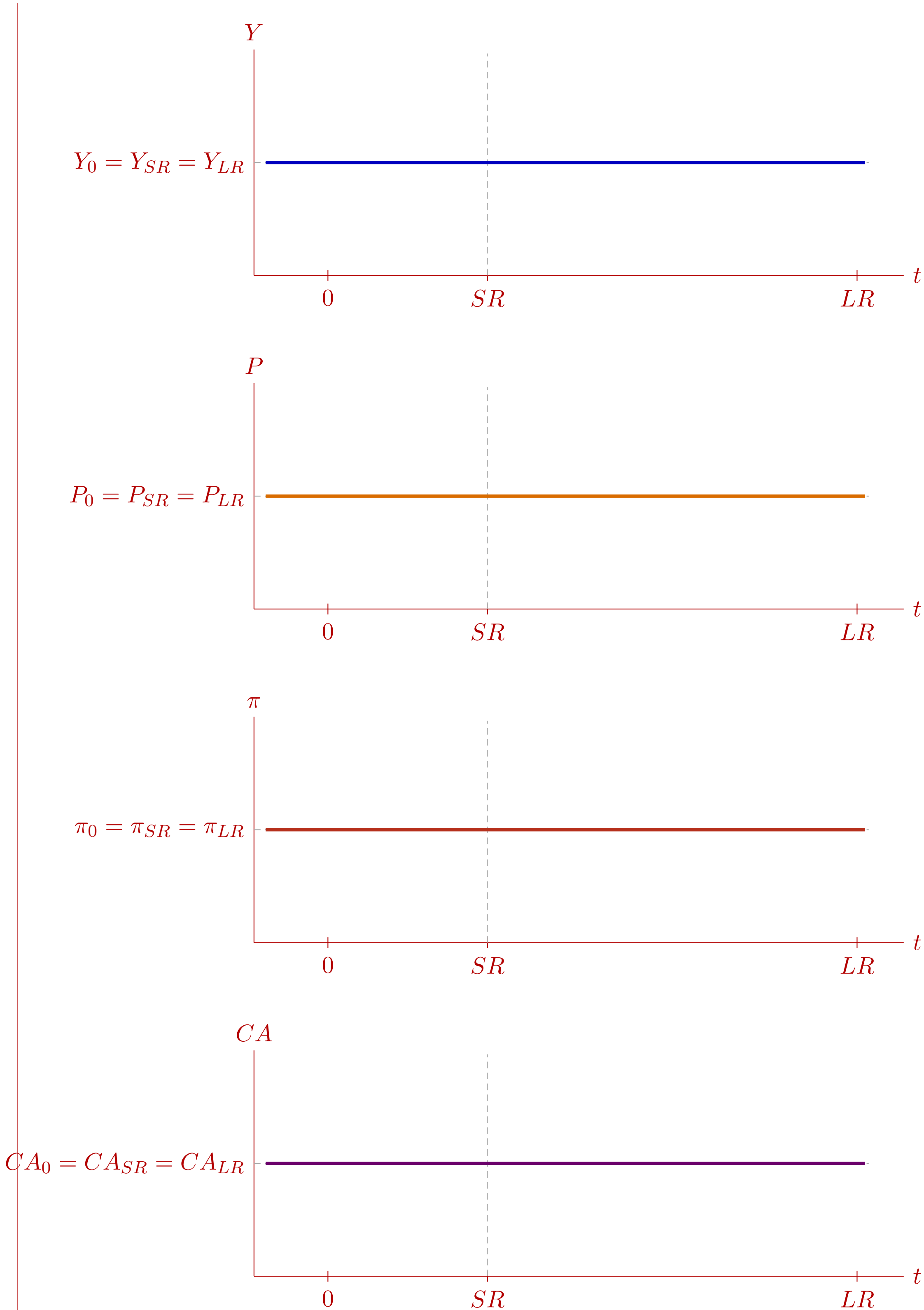
A convenient summary table is

Variable	0	SR	LR
E	1.000	0.5625	0.5625
q	1.000	0.5625	0.5625
Y	1.000	1.000	1.000
P	1.000	1.000	1.000
π	0.000	0.000	0.000
CA	0.100	0.100	0.100
EX	0.350	0.306	0.306
IM	0.250	0.206	0.206

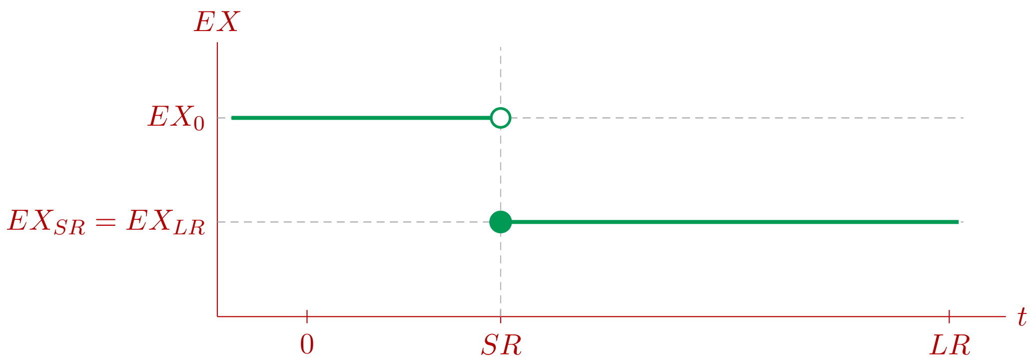
A correct set of time paths is shown below. Because the permanent tariff moves the economy directly to the new long-run equilibrium, every path is flat after the impact jump at SR.

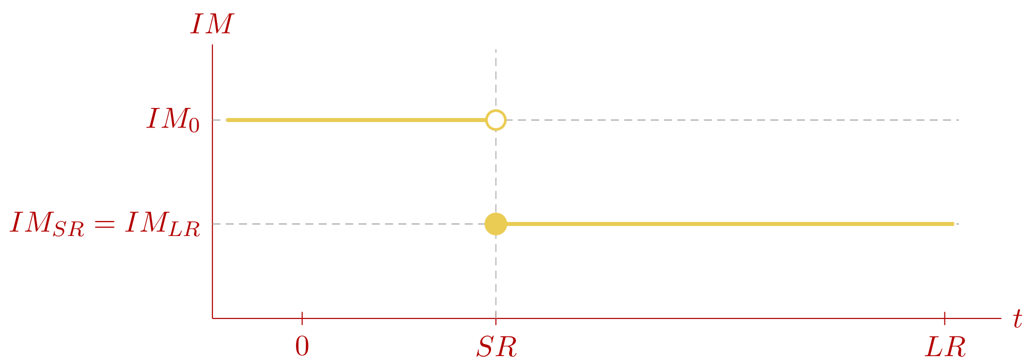






Y
$Y_0 = Y_{SR} = Y_{LR}$
t
0
SR
LR
P
$P_0 = P_{SR} = P_{LR}$
t
0
SR
LR
π
$\pi_0 = \pi_{SR} = \pi_{LR}$
t
0
SR
LR
CA
$CA_0 = CA_{SR} = CA_{LR}$
t
0
SR
LR





The reason CA does not change is that the permanent appreciation offsets the expenditure-switching effect of the tariff. The tariff reduces imports, but the appreciation also reduces exports by exactly enough to leave the current account unchanged in this numerical example.