PROBLEM SET #5 solutions

1. (1 point)

The Phillips Curve equation can be described by the equation $\pi = \pi^e - \beta(u - u^*) + ss$

A. (½ point) Suppose the expected inflation rate is 2 percent, β = 0.5, the natural rate of unemployment is 5 percent, and there are no supply shocks. When the unemployment rate is 5 percent, what is the inflation rate? When the unemployment rate is 4 percent, what is the inflation rate?

$$\pi = \pi^e - \beta(u - u^*) + ss$$
$$\pi = 0.02 - 0.5(u - 0.05) + 0$$
$$\pi = 0.02 - 0.5u + 0.025$$
$$\pi = 0.045 - 0.5u$$

When u = 0.05, $\pi = 0.045 - 0.5(0.05) = 0.02$. *Didn't really need to calculate that. We know that when* $u = u^*, then\ \pi = \pi^e$.

When u = 0.04, $\pi = 0.045 - 0.5(0.04) = 0.045 - 0.02 = 0.025$. *That makes sense; when the unemployment rate falls from 5 to 4 percent, the inflation rate rises from 2 to 2.5 percent.*

B. (½ point) Explain why the inflation rate increases when the unemployment rate decreases.

So, <u>why</u> does that make sense? When output increases and thus labor demand increases and thus (assuming no change in labor force) the unemployment rate decreases, firms will need to offer higher wages in order to entice workers to work for them. These higher wages that result from the lower unemployment rate are then passed on to consumers in the form of higher prices in all types of goods and services. By definition, an aggregate increase in price levels means an increase in the inflation rate.

FYI: We are using a linear Phillips Curve to make the math easier. Most estimates of the Phillips curve are nonlinear, with a steeper PC at very low unemployment and a relatively flat PC at very high unemployment. To see why it is usually non-linear (but not for us, just to keep the math easier), think about how much wages change when unemployment is either extremely high or extremely low. When unemployment is extremely high, firms can hire workers without offering higher wages – indeed, if unemployment is very, very high, firms can probably hire workers at wages that are lower than what the firm is currently paying. Workers may feel lucky to simply have a job, and are unlikely to be picky about the wages that are offered. Conversely, when the availability of workers is relatively low because unemployment is low, firms that want to hire additional workers will need to offer much higher wages in order to lure newly hired workers away from their existing jobs. Again, the changes in wage costs are passed on to customers in the form of higher prices.

2. (1 point)

The Taylor rule can be described by the equation $= r_0 + r_\pi(\pi - \pi^t)$. Suppose the Fed's "normal" baseline value of the real interest rate is 2 percent, r_π = 0.8, and the Fed's target inflation rate is 3 percent.

a. (½ point) If the actual inflation rate is 3 percent, what real interest rate will the Fed set? If instead the actual inflation rate is 5 percent, what real interest rate will the Fed set?

$$r = r_0 + r_\pi(\pi - \pi^t)$$
$$r = 0.02 + 0.8(\pi - 0.03)$$
$$r = 0.02 + 0.8\pi - 0.024$$
$$r = -0.004 + 0.8\pi$$

When $\pi = 0.03, r = -0.004 + 0.8(0.03) = -0.004 + 0.024 = 0.02$. *Didn't really need to calculate that. We know that when* $\pi = \pi^t, r = r_0$.

When $\pi = 0.05, r = -0.004 + 0.8(0.05) = -0.004 + 0.04 = 0.036$*. That makes sense. When the inflation rate rises from 3 to 5 percent, the central bank will increase interest rates from 2 to 3.6 percent.*

b. (½ point) Explain why the Fed would increase the real interest rate if the inflation rate rose.

The Fed does understands the connection between inflation and unemployment (that you explained in #1B). The Fed knows that the way to combat inflation is to raise the unemployment rate, reducing pressure on wages and prices. By raising the real interest rate, the Fed can lower output (via the IS curve) and thus raise unemployment (via Okun's law).

3. (2 points)

a. (1/2 point) What is the connection between the long-run flexible price model and long-term interest rates? (Re-asking this from MT2 because so many people got it wrong on the midterm and it's important.)

A long-term interest rate is the rate you would pay today to borrow over a long term (5, 10, 20, 30 years). Long-term interest rates are equal to the average of current and future expected short-term rates plus term & risk premia. A "future expected short-term rate" is what you or I answer today to the question "What do you think the 3-month borrowing rate will be in 2026? In 2035? In 2040?"

Our predictions today about interest rates in the future come from our long-run analysis of the determinants of interest rates, that is from the long-run flexible price model. For example, if we look toward the future and anticipate rising government deficits and therefore falling government saving, we therefore will expect future short-term rates will be higher than they are today.

BCD were eliminated; see email on 4/23/19

b. (1/2 point) What is the federal funds rate? What is the interest rate on excess reserves? Are these nominal or real interest rates?

FFR is rate banks pay to borrow overnight from other banks or from government-sponsored enterprises (GSEs) such as Ginnie Mae. IOER is the rate the Fed pays to banks on their excess reserves. These are nominal rates.

c. (1/2 point) What is the "zero lower bound"? Why does the concept apply only to nominal interest rates? What is the minimum possible value for the <oops, lost a word here: real> interest rate?

ZLB refers to the idea that nominal rates can't go below 0, that 0 is the minimum or lower-bound value for nominal interest rates. It applies only to nominal rates. There is no minimum possible value for real interest rates.

d. (1/2 point) Suppose the central bank had reached the ZLB. How could they then continue to lower the real interest rate?

Because the real rate is the nominal rate – expected inflation rate, if the nominal rate is 0 the central bank can continue to lower the real rate by taking actions that raise the expected inflation rate.

4. (2 points)

A. (1 point) Starting from these 3 relationships, derive the equation for the monetary policy reaction function: $u = u_0 + \phi(\pi - \pi^t)$. Be sure to show the full expression for ϕ.

- Taylor rule: $r = r_0 + r_\pi(\pi - \pi^t)$
- IS equation: $Y = \frac{A_0}{1-MPE} - \left(\frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE}\right) r$
- Okun's Law: $u = u^* - 0.4\left(\frac{Y-Y^*}{Y^*}\right) = u^* + 0.4\left(\frac{Y^*-Y}{Y^*}\right)$

Deriving the monetary policy reaction function (MPRF) is straightforward, but a bit messy.

Step (1): Plug the Taylor rule into the IS curve.

$$Y = \frac{A_0}{1-MPE} - \frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE}[r_0 + r_\pi(\pi - \pi^t)]$$

$$Y = \left[\frac{A_0}{1-MPE} - \frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE} r_0\right] - \frac{(I_r + X_\varepsilon \varepsilon_r) r_\pi}{1-MPE}(\pi - \pi^t)$$

Step (2): Plug the equation for Y from step (1) into Okun's law and we have the MPRF

$$u = u^* + \frac{0.4}{Y^*}\left[Y^* - \left(\left(\frac{A_0}{1-MPE} - \frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE} r_0\right) - \frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE} r_\pi(\pi - \pi^t)\right)\right]$$

$$u = \left[u^* + \frac{0.4}{Y^*}\left(Y^* - \frac{A_0}{1-MPE} + \frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE} r_0\right)\right] + \frac{0.4}{Y^*}\left(\frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE}\right) r_\pi(\pi - \pi^t)$$

$Therefore, u = u_0 + \phi(\pi - \pi^t), where$

$$u_0 = \left[u^* + \frac{0.4}{Y^*}\left(Y^* - \frac{A_0}{1-MPE} + \frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE} r_0\right)\right] and\ \phi = \frac{0.4}{Y^*}\left(\frac{I_r + X_\varepsilon \varepsilon_r}{1-MPE}\right) r_\pi$$

Let's take a moment to make sense of what we just did. First, what is u_0? The unemployment rate will be equal to u_0 when the Fed sets r equal to r_0. The larger is A_0, the smaller is u_0, and vice-versa.

What about ϕ? ϕ is the sensitivity of unemployment to inflation as a result of this combination of demand-side (aggregate-demand-affecting) factors and is a combination of four forces:

1) How much the Fed changes the real interest rate in response to changes in inflation, r_π.
2) How much planned expenditure changes when the interest rate changes, $I_r + X_\varepsilon \varepsilon_r$
3) How much output changes when there is an initial change in planned expenditure. That is, the multiplier, 1 / (1 – MPE)
4) The Okun's law coefficient (0.4) and potential output (Y), which determine how much of an effect the change in output has on the unemployment rate.*

B. (1 point) Using words, not the equations, explain how and why the slope of the MPRF changes when there is a decrease in the marginal propensity to consume, C_y. In your explanation, be sure it's clear what "the slope of the MPRF" means in terms of the relationship between unemployment and inflation in the economy.

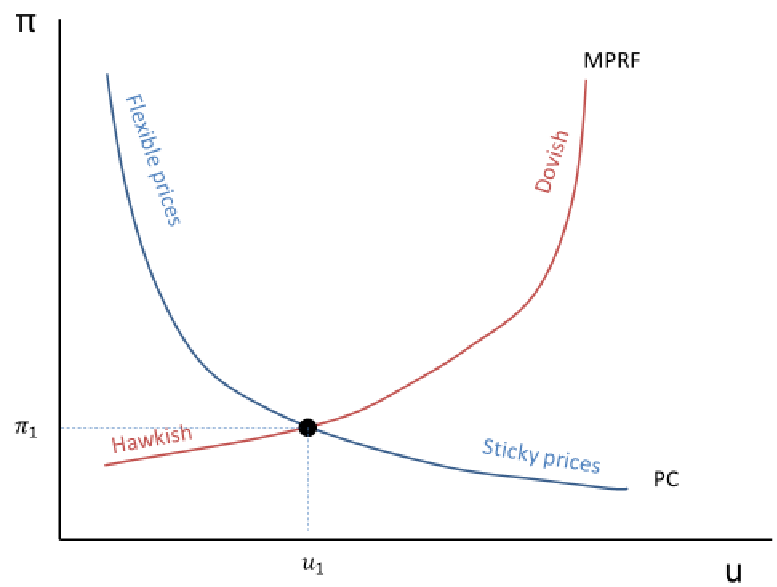
When the mpc is lower, the spending multiplier is smaller. That is, starting from any change in autonomous spending, there will be a smaller change in equilibrium output as a result of the smaller mpc. This is because people are spending less out of any change in disposable income, thus decreasing the injections into the economy in each round of the multiplier process. A smaller change in output means there will be a smaller change in unemployment because unemployment changes in proportion to the change in output.

Therefore when there is an increase in inflation and the central bank responds by increasing interest rates, the decrease in output and resulting increase in unemployment will be smaller with a lower mpc. This makes the MPRF steeper.

5. (1 point; from Fall 2010 final, #4)

Suppose that the MPRF and PC are both non-linear. Prices are much more flexible when unemployment is low than when unemployment is high. When price flexibility is very high, the Fed is very hawkish. When prices are particularly sticky, the Fed is more dovish. Draw these MPRF and PC together on one set of axes. Briefly explain why you drew your graph as you did.

MPRF: When unemployment is low, price flexibility is high, and the Fed is very hawkish (from the prompt). A hawkish Fed will increase interest rates aggressively as inflation rises, triggering substantial increases in unemployment. We show this with a relatively flat MPRF (small change in π, big change in u). When unemployment is high, prices are sticky, and the Fed is dovish (from the prompt). A dovish Fed will increase interest rates as inflation rises but not by much, thus triggering only small increases in unemployment. We show this with a relatively steep MPRF (big change in π, small change in u).



PC: When unemployment is low, price flexibility is high, which means wages and prices will rise rapidly as unemployment falls. The value of β will be relatively high. We show this with a relatively steep PC (small change in u associated with big change in π). When unemployment is high, prices are sticky, which means wages and prices will rise slowly as unemployment falls. The value of β will be relatively low. We show this with a relatively flat PC (big change in u associated with small change in π.

6. (1 point; from Spring 2017 final, #1)
Briefly define each of the three models of expectations: static, adaptive, and rational.

Static: expectations never change, regardless of what happens to actual inflation. People never change their answer to "What do you think the inflation rate will be next year?" π^e *is a constant*

Adaptive: expectations change, adapting to what actually is happening. Here, we assume that with adaptive expectations, we expect next year to be just like this year. $\pi^e_{t+1} = \pi_t$

Rational: generally the definition of rational expectations is that people use all available information and knowledge to form their expectations of the future. (Indeed that is the type of expectation we implicitly assumed in the answer to 3A above.) We use the strongest possible form of rational expectations, which is that people can predict the future accurately, so their answer to "what do you think the inflation rate will be next year?" always equals what the inflation rate actually turns out to be. I (Olney) call them "crystal ball expectations." $\pi^e_{t+1} = \pi_{t+1}$.

7. (4 points; from Spring 2017 final #4)
Suppose a recession has hit and the economy can be described by the following:

$$Fed's\ target\ inflation\ rate = 3\%$$
$$initial\ expected\ inflation\ rate = 2\%$$
$$r_\pi = 0.8$$
$$r_0 = 2\%$$
$$MPE = 0.6$$
$$A_0 = 3{,}800$$
$$I_r = 30{,}000$$
$$X_\varepsilon \varepsilon_r = 20{,}000$$
$$u^* = 5\%$$
$$Y^* = \$10{,}000\ billion\ per\ year$$
$$supply\ shocks = 0$$
$$\beta = 0.5$$

A. (2 points) Suppose expectations are static. What are the short-run sticky-price equilibrium values of the inflation rate, the unemployment rate, the Fed's target real interest rate, and real GDP? Show your work.

Phillips Curve:

$$\pi = \pi^e - \beta(u - u^*) + ss$$
$$\pi = 0.02 - 0.5(u - 0.05) + 0$$
$$\pi = 0.02 - 0.5u + 0.025$$
$$\pi = 0.045 - 0.5u$$

Taylor Rule

$$r = r_0 + r_\pi(\pi - \pi^t)$$
$$r = 0.02 + 0.8(\pi - 0.03)$$
$$r = 0.02 + 0.8\pi - 0.024$$
$$r = -0.004 + 0.8\pi$$

IS Curve (substitute in Taylor rule)

$$Y = \frac{A_0 - (I_r + X_\varepsilon \varepsilon_r)r}{1 - MPE}$$
$$Y = \frac{3{,}800 - (30{,}000 + 20{,}000)r}{1 - 0.6}$$
$$Y = \frac{3{,}800 - 50{,}000r}{0.4}$$
$$Y = 9{,}500 - 125{,}000r$$
$$Y = 9{,}500 - 125{,}000\ (-0.004 + 0.8\pi)$$
$$Y = 9{,}500 - 125{,}000(-0.004) - 125{,}000(0.8)\pi$$
$$Y = 9{,}500 + 500 - 100{,}000\pi$$
$$Y = 10{,}000 - 100{,}000\pi$$

Okun's Law (substitute in IS curve)

$$u = u^* + 0.4\left(\frac{Y^* - Y}{Y^*}\right)$$
$$u = 0.05 + 0.4\left(\frac{10{,}000 - (10{,}000 - 100{,}000\pi)}{10{,}000}\right)$$
$$u = 0.05 + 0.4\left(\frac{100{,}000\pi}{10{,}000}\right)$$
$$u = 0.05 + 0.4(10\pi)$$
$$u = 0.05 + 4\pi$$

So our simplified MPRF is that last equation, u = 0.05 + 4π

If we want to put the MPRF in its usual form, we don't simplify as much early on

Taylor Rule

$$r = r_0 + r_\pi(\pi - \pi^t)$$
$$r = 0.02 + 0.8(\pi - 0.03)$$

IS Curve (substitute in Taylor rule)

$$Y = \frac{A_0 - (I_r + X_\varepsilon \varepsilon_r)r}{1 - MPE}$$
$$Y = \frac{3{,}800 - (30{,}000 + 20{,}000)r}{1 - 0.6}$$
$$Y = \frac{3{,}800 - 50{,}000r}{0.4}$$
$$Y = 9{,}500 - 125{,}000r$$
$$Y = 9{,}500 - 125{,}000\ (0.02 + 0.8(\pi - 0.03))$$
$$Y = 9{,}500 - 125{,}000(0.02) - 125{,}000(0.8)(\pi - 0.03)$$
$$Y = 9{,}500 - \ 2{,}500 - 100{,}000(\pi - 0.03)$$
$$Y = 7{,}000 - 100{,}000(\pi - 0.03)$$

Okun's Law (substitute in IS curve)

$$u = u^* + 0.4\left(\frac{Y^* - Y}{Y^*}\right)$$
$$u = 0.05 + 0.4\left(\frac{10{,}000 - \left(7{,}000 - 100{,}000(\pi - 0.03)\right)}{10{,}000}\right)$$
$$u = 0.05 + 0.4\left(\frac{3{,}000 + 100{,}000(\pi - 0.03)}{10{,}000}\right)$$
$$u = 0.05 + 0.4(0.3) + 0.4(10(\pi - 0.03))$$
$$u = 0.05 + 0.12 + 0.4(10(\pi - 0.03))$$
$$u = 0.17 + 4(\pi - 0.03)$$

From this form of the MPRF we can easily see that

$$u_0 = 0.17 = 17\ percent$$
$$\phi = 4$$

This would be a very bad recession if the Fed did nothing!

Now solve for equilibrium using the MPRF and PC. It's easiest to start from the most simplified forms of those two equations.

$$\pi = 0.045 - 0.5u$$
$$u = 0.05 + 4\pi$$

Whichever solving-simultaneous-equations method works best for you, do that.

$$\pi = 0.045 - 0.5(0.05 + 4\pi)$$
$$\pi = 0.045 - 0.5(0.05) - 0.5(4\pi)$$
$$\pi = 0.045 - 0.025 - 2\pi$$
$$\pi = 0.02 - 2\pi$$
$$3\pi = 0.02$$
$$\pi = \frac{0.02}{3} = 0.00667 = 0.7\ percent$$

Substitute into MPRF to solve for u

$$u = 0.05 + 4\pi$$
$$u = 0.05 + 4(0.00667)$$
$$u = 0.05 + 0.02667$$
$$u = 0.0767 = 7.7\ percent$$

Because the unemployment rate would have been so very high (17 percent!) which would have generated very low inflation (plug u=0.17 into your Phillips Curve), the Fed reacts by lowering interest rates.

Fed's target interest rate is calculated from the Taylor rule, using the equilibrium value of π

$$r = 0.02 + 0.8(\pi - 0.03)$$
$$r = 0.02 + 0.8(0.00667 - 0.03)$$
$$r = 0.02 + 0.8(-0.02333)$$
$$r = 0.02 - 0.018667$$
$$r = 0.001333 = 0.13\ percent$$

The actual value of real GDP is calculated from the IS equation

$$Y = 9{,}500 - 125{,}000r$$
$$Y = 9{,}500 - 166.666$$
$$Y = 9{,}333.33\ billion\ \$\ per\ year$$

To summarize! $\boldsymbol{\pi = 0.006667, u = 0.0767, r = 0.001333, Y = 9{,}333.33\ bn\ \$\ per\ year}$

B. (2 points) Suppose instead that expectations are adaptive: $\pi_{t+1}^e = \pi_t$. In the next period, what are the new equilibrium values of the inflation rate and the unemployment rate? What real interest rate does the Fed now set? What is the new equilibrium value of real output? Show all your work.

At the back of the PS solutions is a spreadsheet that shows the full process of adapting expectations and how the economy eventually returns to full employment (u=u and Y=Y*). Note that, with rounding, it takes about 7 or 8 periods for the economy to get back to full employment.*

Here what we do is take the equilibrium value of π from part a and use that as the expected value of inflation π^e. All other parameter values from the prompt in a are unchanged.

The expected inflation rate enters the Phillips curve directly, so we need a new equation for the PC.

$$\pi = 0.00667 - 0.5(u - 0.05)$$
$$\pi = 0.00667 - 0.5u + 0.025$$
$$\pi = 0.031667 - 0.5u$$

The MPRF is unchanged; the expected inflation rate is not part of the MPRF.

$$u = 0.05 + 4\pi$$

Again, solve two equations with two unknowns. Just for kicks, I'll do it differently this time. The point: it doesn't matter whether you substitute u into π, or π into u. Same result. Choose the one least likely to produce an arithmetic or algebra error.

$$u = 0.05 + 4(0.031667 - 0.5u)$$
$$u = 0.05 + 0.12666 - 2u$$
$$3u = 0.01766$$
$$u = \frac{0.01766}{3}$$
$$u = 0.05889 = 5.9\ percent$$

Substitute into PC equation to solve for π

$$\pi = 0.031667 - 0.5(0.05889)$$
$$\pi = 0.031667 - 0.02944$$
$$\pi = 0.002222 = 0.2\ percent$$

Fed's target interest rate is calculated from the Taylor rule, using the equilibrium value of π

$$r = 0.02 + 0.8(\pi - 0.03)$$
$$r = 0.02 + 0.8(0.00222 - 0.03)$$
$$r = 0.02 + 0.8(-0.02777)$$
$$r = 0.02 - 0.02222$$
$$r = -0.00222 = -0.22\ percent$$

The actual value of real GDP is calculated from the IS equation

$$Y = 9{,}500 - 125{,}000r$$
$$Y = 9{,}500 - 125{,}000(-0.002222)$$
$$Y = 9{,}500 + 277.777$$
$$Y = 9{,}777.78\ billion\ \$\ per\ year$$

To summarize! $\boldsymbol{\pi = 0.00222, u = 0.059, r = -0.0022, Y = 9{,}777.78\ bn\ \$\ per\ year}$

Because our expectations of inflation have fallen from 2 percent to 0.7 percent, wage and price inflation falls (the shift down in the PC). The Fed reacts by lowering the real interest rate from 0.13 percent to -0.22 percent. That makes real GDP rise from $9,333 billion per year to $9,777 billion per year. Because real GDP has risen, more workers are employed and therefore the unemployment rate is lower, 5.9 percent rather than 7.7 percent. And because the unemployment rate is lower, the inflation rate doesn't fall as far as it would have if unemployment hadn't fallen; inflation is 0.2 percent, lower than the previous period (0.7 percent) but higher than the inflation rate would have been (-0.7 percent) at 7.7 percent unemployment (use the new PC and plug 0.077 into $\pi = 0.031667 - 0.5u = -0.0072 = -0.7\ percent$*).*

8. (1 point)

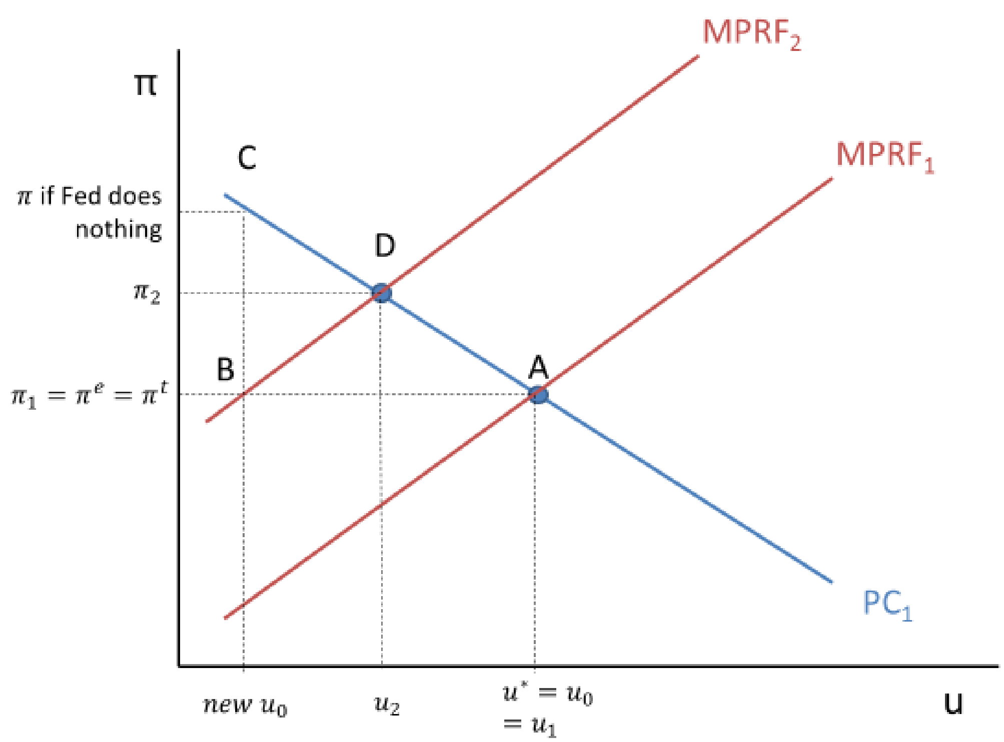
Suppose inflationary expectations are static (never change). Draw an initial MPRF and Phillips Curve, with initial equilibrium at $u=u^*=u_o$ and $\pi = \pi^e = \pi^t$. Now, show the effect of the government increasing its spending.

The original equilibrium is at point A.

An increase in government spending (G) shifts the IS curve to the right, causing the MPRF to shift to the left to $MPRF_2$*. Point B shows the new value of* u_0 *(the unemployment rate that results when the Fed sets the interest rate to* r_0 *which is what it does if the inflation rate equals its target … that is, the point on the new MPRF associated with the target inflation rate,* π^t*).*

If the Fed did nothing, the economy would move to point C (much lower unemployment but higher inflation).

In response to the higher inflation, the Fed will raise interest rates and the economy converges to its new equilibrium at point D. The net effect will be a lower unemployment rate (lower than it had been, but not as low as u would have been, had the Fed done nothing) and a higher rate of inflation (higher than it had been, but not as high as it would have been, had the Fed done nothing).



	full employment	start here														
Period		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Taylor Rule																
pi(t)	*0.03*	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
r(pi)	*0.8*	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
r(0)	*0.02*	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
IS curve																
MPE	*0.6*	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
A(0)	*5,000*	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800
I(r)	*30,000*	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
X(eps)esp(r)	*20,000*	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Y(0) with r(0)	*10,000*	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Okun's Law																
u*	*0.05*	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Y*	*10,000*	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
u(0) with r(0)	*0.05*	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Phillips																
pi(e)	*0.03*	0.02	0.006667	0.002222	0.000741	0.000247	0.000082	0.000027	0.000009	0.000003	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000
beta	*0.5*	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
u*	*0.05*	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
ss	*0*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MPRF																
phi	*4*	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
pi(t)	*0.03*	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
u(0)	*0.05*	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
solve MPRF & PC																
phi*beta	*2*	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
pi	*0.03*	0.00667	0.00222	0.00074	0.00025	0.00008	0.00003	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
u	*0.05*	0.07667	0.05889	0.05296	0.05099	0.05033	0.05011	0.05004	0.05001	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
Fed's r	*0.02*	0.00133	-0.00222	-0.00341	-0.00380	-0.00393	-0.00398	-0.00399	-0.00400	-0.00400	-0.00400	-0.00400	-0.00400	-0.00400	-0.00400	-0.00400
actual Y	*10,000.00*	9,333.33	9,777.78	9,925.93	9,975.31	9,991.77	9,997.26	9,999.09	9,999.70	9,999.90	9,999.97	9,999.99	10,000.00	10,000.00	10,000.00	10,000.00