Economics 285
Chris Georges — Help With Practice Problems 6

1. Recall that IS-LM is our foundation for aggregate demand (AD). AD tells us the equilibrium output for any value of the general price level (P). Dynamic AS models describe how this price level moves over time. Specifically, for our basic Dynamic AS model (see handout on Dynamic AS):

$$\pi_t = \mathrm{E}_{t-1}\pi_t + \phi\,(\mathrm{E}_{t-1}Y_t - \bar{Y}) + v_t$$

the inflation rate π_t (the percent change in the price level P from the last period) depends on the expected inflation rate ($\mathrm{E}_{t-1}\pi_t$), expected market tightness (as measured by the expected output gap ($\mathrm{E}_{t-1}Y_t - \bar{Y}$)), and price shocks ($v_t$).[1] Under our assumption of adaptive expectations, people predict that inflation and market tightness will continue at last period's rates: $\mathrm{E}_{t-1}\pi_t = \pi_{t-1}$ and $\mathrm{E}_{t-1}Y_t = Y_{t-1}$. Thus the basic dynamic AS equation together with adaptive expectations is

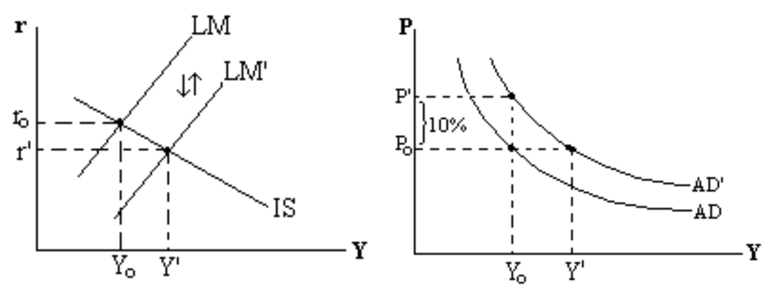
$$\pi_t = \pi_{t-1} + \phi\,(Y_{t-1} - \bar{Y}) + v_t$$

AD and the dynamic AS together with adaptive expectations imply that prices adjust over time in the direction required to bring Y back to $\bar{Y}$ in the Long Run. If, for example, output is below its natural rate, the inflation rate will fall over time. When the inflation rate becomes negative, output will rise toward $\bar{Y}$ along the AD curve.

a. True. In the short run, the increase in nominal money supply M shifts out the LM curve, lowering interest rates, and expanding spending and thus GDP. On the AD diagram, this appears as a shift of AD to the right. The vertical size of this shift is the price increase that would be required to keep output unchanged. This must be a 10% increase in P, since 10% increases in both M and P would leave real money supply (M/P) unchanged and thus leave Y unchanged according to the IS-LM model.

LM: $$\frac{M}{P} = L(r, Y)$$

In the diagram, the increase in M shifts LM to LM' and thus AD to AD'. A 10% price increase would shift LM back up from LM', raising interest rates and depressing spending back to Y_0.

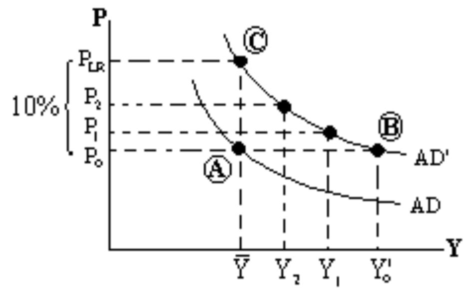


b. True. A 10% increase in the nominal money supply M will shift AD to the right. The vertical size of the shift is 10%.

[1] This can be motivated as follows. Assume that businesses set prices at the beginning of each period, given information publicly available as of the end of the previous period, and hold them constant during the period unless there is a price shock (v_t). In deciding how much to raise prices from last period, they start by matching the inflation rate that they expect others in the economy to set and then adjust this downward (upward) if they expect the economy to be in a recession (boom), since in that case demand for their products is likely to be weak (strong) and labor costs are likely to be bargained downward (upward). Additionally, if there is a positive (negative) aggregate price shock this period (e.g., $v_t > 0$ due to an increase in imported oil prices which increases costs of production), then businesses pass this on directly as yet greater (somewhat smaller) price increases.

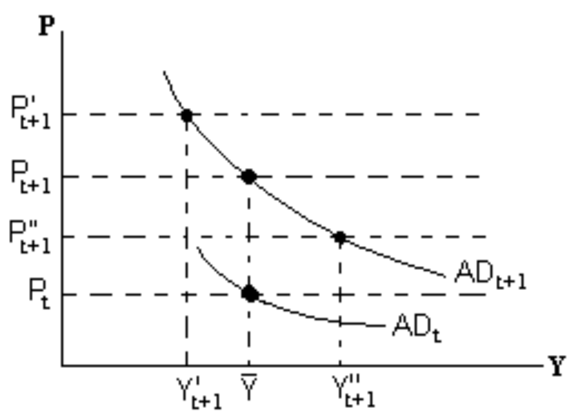
In the short run, prices are unchanged (remain at P_0) by the change in AD,[2] and so output rises to Y_0'. In the long run, the price level will rise to return Y to $\bar{Y}$. Consequently, in the long run, the price must rise by 10% (see part **a**).

Specifically, suppose that inflation has been zero for some time. The the expansion in the initial time period (period 0) causes prices to rise ($\pi_1 > 0$) in the subsequent period (period 1). The rise in the price level reduces spending and output along the AD curve. Inflation will remain positive until output falls back to its natural rate $\bar{Y}$.[3]



c. True. As long as money demand and IS are stable, in the long run, the rate of inflation will be the rate of growth of M. Suppose, for example that M grows by 10% each year. Then AD shifts vertically upward by 10% each year. If inflation π is less than 10% per year, then output grows along the AD curve. But this will eventually cause $Y > \bar{Y}$, which will cause the inflation rate to rise. Similarly, if the inflation rate is above 10%, output will eventually fall below $\bar{Y}$, causing the inflation rate to fall. Consequently, the inflation rate should adjust to be 10% in the long run.[4]

The diagram gives an example with Y starting at $\bar{Y}$. P_{t+1}' is an example of $\pi_{t+1} > 10\%$. P_{t+1}'' is an example of $\pi_{t+1} < 10\%$. In either case, π will adjust over time toward 10%.



d. It seems likely that inflation will be monetary in the long run. To sustain inflation in the long run, aggregate demand must be shifting outward (i.e., increasing) year after year. For example, a 10% rate of inflation can be sustained at $\bar{Y}$ by AD shifting vertically upward by 10% per year. This seems unlikely (though not impossible) to be sustainable unless M is growing by 10% per year in the long run; AD

[2] According to the Phillips Curve equation with adaptive expectations, changes in this year's output will not affect the price level until next year.

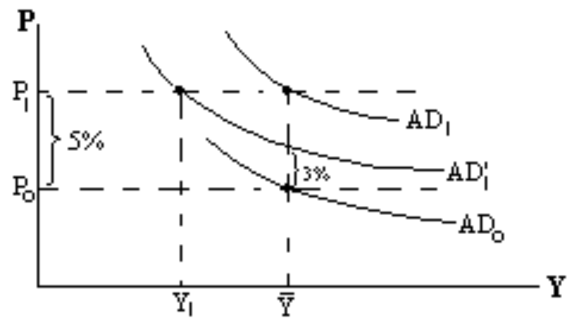
[3] The economy will actually overshoot $\bar{Y}$ and run a subsequent recession, since expected inflation will be positive just after Y reaches $\bar{Y}$. However, Y should cycle back in toward $\bar{Y}$, as the recession causes π to fall. In the long run, Y will converge to $\bar{Y}$.

[4] On IS-LM, we have the diagram above (part **A**) for each period in the long run. 10% increases each year in both M and P leave (M/P) unchanged, and so leave Y unchanged.

could be shifting out due to increasing exogenous spending or declining money demand (rising velocity), but there are probably limits as to how long this could be sustained.

e. According to the model, the Fed can use the recession to permanently reduce the inflation rate, or it can stabilize output and employment and leave inflation unchanged.

For example, suppose that inflation has been 5% for some time. If AD rises by less than 5% in some year (say by only 3%), then we get a recession in that year (call this year 1). The recession in year 1 will cause inflation in year 2 to fall below 5% (which is still expected inflation in year 2). The Fed can then, for example, stabilize output in year 2 at $\bar{Y}$ and, by doing so, lock in this new lower inflation rate. Alternatively, the Fed could stabilize Y at $\bar{Y}$ in year 1 (by increasing the money supply enough – an extra 2% – to push AD back out to AD_1), avoiding the recession altogether. In that case the inflation rate stays at 5% in year 2.



2.

a. Firms set their prices to keep up with their expectations of inflation, plus an adjustment for expected market tightness, plus direct price shocks. See the answer to problem **1** on the first page for more details.

Combining the dynamic AS equation with the adaptive expectations assumption, we have

$$\pi_t = \pi_{t-1} + 0.05\,(Y_{t-1} - \bar{Y}) + v_t$$

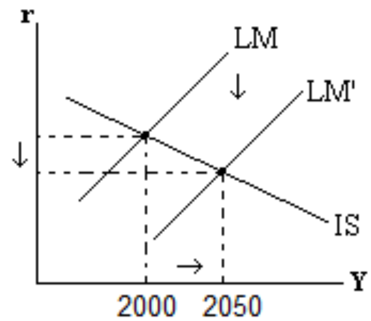
Due to the adaptive expectations, inflation is persistent. The inflation rate π_t will only fall below last period's rate π_{t-1} if there is a recession or a negative aggregate price shock (such as a fall in the price of imported oil or a burst of productivity growth). Also, due to adaptive expectations, market tightness affects prices with a lag. The lag implies that changes in aggregate demand have no effect on current prices. Rather, price adjustment takes place over time in the future. If Y rises above $\bar{Y}$ today (and there is no price shock, so $v = 0$), for example, firms will raise their prices in the next period by more than the expected inflation rate.

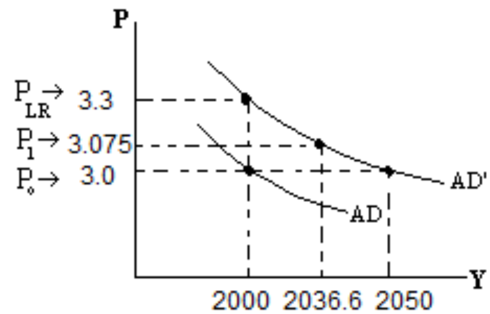
b. If the nominal money supply increases to 3300, aggregate demand increases (shifts out) according to the IS-LM response. Firms respond by holding prices fixed at 3 in the current period (period 0) and raising output. $Y = 1500 + 3300/6 = 2050$.

In the next period, expected inflation is zero, but the positive output gap this period causes actual inflation of 2.5 percent:

$$\begin{aligned}\pi_1 &= \pi_0 + 0.05\,(Y_0 - \bar{Y}) + v_1 \\ &= 0 + 0.05 \times 50 + 0 \\ &= 2.5\end{aligned}$$

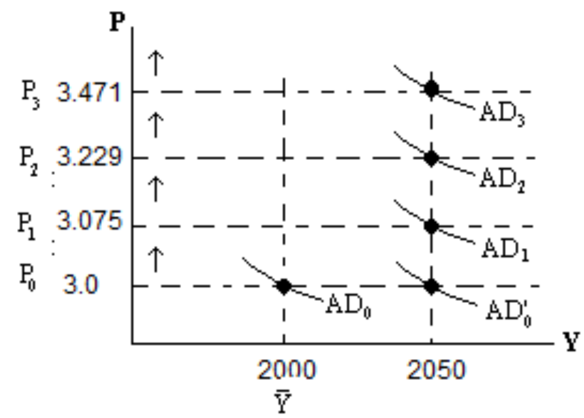
Since $\pi_1 = \frac{P_1 - P_0}{P_0} \times 100 = \frac{P_1 - 3}{3} \times 100$, this means that the price level rises from 3 to 3.075. As a result, equilibrium spending falls to $Y = 1500 + \frac{3300}{6.15} = 2036.59$. The reason for the fall in GDP is that the increase in the price level lowers real money supply. People sell bonds to acquire more nominal money balances, driving interest rates up. The high interest rates reduce investment spending.





c. Eventually, price adjustment causes GDP to return to 2000. Then by $Y = 1500 + \frac{3300}{2\,P}$ it must be that $P = 3.3$. A 10% increase in the nominal money supply is, in the long run, matched by a 10% increase in the price level. The inflation rate π will be zero in the long run.

d.



Yes. The Fed could simply raise M in each period by enough to shift AD to 2050 at that period's price level. Notice that this would keep the output gap at 50, which, according to the dynamic AS equation, would cause (in the absence of price shocks) inflation to always be greater than expected inflation by 2.5 percentage points.

$$\begin{aligned}\pi_t &= \mathrm{E}_{t-1}\pi_t + 0.05 \times 50 + v_t \\ &= \mathrm{E}_{t-1}\pi_t + 2.5\end{aligned}$$

Since $\mathrm{E}_{t-1}\pi_t = \pi_{t-1}$, this means that the inflation rate must rise by 2.5 percentage points each period.

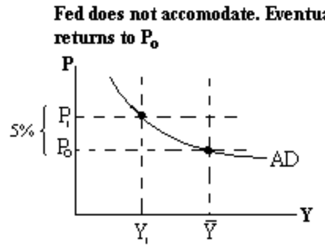
$$\pi_t = \pi_{t-1} + 2.5$$

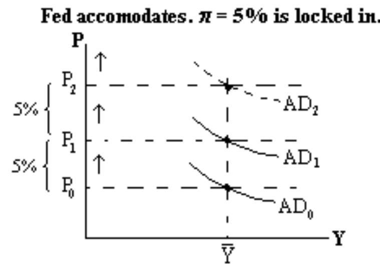
Inflation would soon become astronomical.

It is also worth noting that we would probably expect adaptive expectations to eventually be abandoned in this case. People ought to catch on eventually that they have underestimated inflation in every period.[5] If people do begin to realize that the inflation rate is growing over time, and adjust their expectations accordingly, the Fed will have to expand AD that much more quickly over time, making the situation even worse.

e. The expectation of inflation is translated into actual inflation in the next period. The price increase causes GDP to fall in the absence of any countervailing measures from the Fed. The Fed can respond by increasing the money supply by an extra 5% in that period only to shift AD back out to $\bar{Y}$, but this would not alter the inflation in that period, and actually will validate it (lock it in). Because subsequent expectations are adaptive, and the Fed kept the output gap at zero, inflation in the subsequent period will stay at 5%, so the Fed will have to increase the money supply again to keep GNP at $\bar{Y}$. The same is true for each subsequent period. The inflation will be locked in for all time, unless the Fed is willing to allow a recession.

[5] According to the dynamic AS equation, actual inflation will remain greater than expected inflation (i.e., inflation is underestimated) as long as Y remains greater than $\bar{Y}$.





f. This is essentially part **e** in reverse. The price shock immediately translates one for one into lower inflation in the current period. If the Fed does not alter money growth, the economy will go into an expansion which will eventually drive the inflation rate back up to its original value. On the other hand, the Fed can use the price shock to lock in the lower inflation rate, as follows. If the Fed stabilized GDP by reducing money growth by 5% in the current period, adaptive expectations will cause inflation to be locked in at the lower rate in the following period. The Fed can then continue to keep money growth at its new lower level in the future to lock in the lower rate of inflation in long run equilibrium.

3. The extended model of Dynamic AD and AS in Ch. 15 makes two major changes/additions to the basic model above:

i. Partial price adjustment in the short run: Only some firms are now assumed to have fixed prices in the short run. Consequently, both the SRAS and the Dynamic AS (DAS) are now upward sloping. An increase in AD will cause price (and thus inflation) to rise immediately, though by a small enough amount so that spending and output still increase in SR equilibrium.

ii. The central bank sets interest rates according to a monetary-policy rule (sometimes called a Taylor Rule). We now assume that, rather than holding the nominal money supply constant, the central bank will adjust the money supply to achieve its interest rate goal according to the monetary-policy rule. Under this rule, the interest rate responds positively to both the output gap $(Y - \bar{Y})$ and the gap between the inflation rate and the central bank's inflation target $(\pi - \pi^*)$.

3.1 The DAS is upward sloping because we (now) are assuming that the SR price level, and thus the current inflation rate, is increasing in the output gap. E.g., if output increases from $\bar{Y}$ to $Y' > \bar{Y}$, then some firms will increase price in the current period by more than they would otherwise have done.

3.2 The DAD is downward sloping because we (now) are assuming that, if the inflation rate rises, the central bank will raise the nominal interest rate more than one for one (i.e., by more than the increase in the inflation rate), thus driving up the real interest rate. The higher real interest rate will cause spending and thus output to fall.

3.3 Same as Figure 15-10 and 15-11, but with the central bank's inflation target rising rather than falling. The increase in the central bank's inflation target causes it to lower interest rates (DAD shifts to the right), allowing spending to grow past $\bar{Y}$, which drives the rate of inflation up over time (according to the Dynamic AS mechanism). Essentially, the increase in the central bank's inflation target causes it to induce a temporary boom in the economy until the inflation rate has risen to the new target.

3.4 See Figure 15-12. An increase in θ_π makes the DAD flatter. The central bank would now increase interest rates more aggressively to fight an increase in inflation, causing a larger recession.

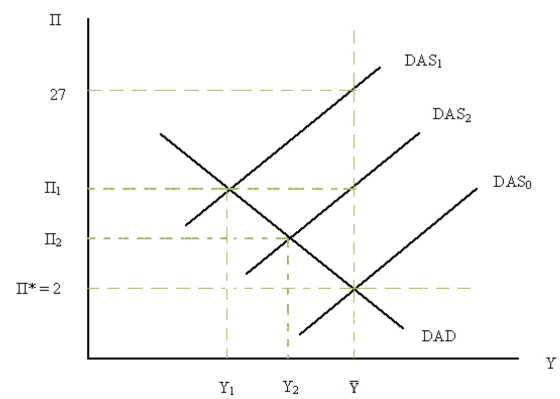
4. The price shock in period 1 will cause the rate of inflation to increase in period 1. This will induce the central bank to raise the interest rate to fight the inflation. Specifically, (since $\theta_\pi > 0$) the central bank increases the nominal interest rate i by more than the increase in the inflation rate, causing the real interest rate r to increase. The increase in r causes spending to fall, lowering Y in period 1. (see the diagram below)

According to the DAS model, the inflation rate will be less than 27% in period 1 due to the negative output gap in that period:

$$\begin{aligned}\pi_1 &= \pi_0 + \phi \cdot (Y_1 - \bar{Y}) + v_1 \\ &= 2 + \phi \cdot (Y_1 - \bar{Y}) + 25 \\ &< 27\end{aligned}$$

In period 2, expected inflation will have increased to the inflation rate in the first period ($E_1\pi_2 = \pi_1$), and we will still have a negative output gap. Thus the inflation rate will fall somewhat from period 1 to period 2:

$$\begin{aligned}\pi_2 &= \pi_1 + \phi \cdot (Y_2 - \bar{Y}) + v_2 \\ &= \pi_1 + \phi \cdot (Y_2 - \bar{Y}) + 0 \\ &< \pi_1\end{aligned}$$



Note that with the lower inflation rate in period 2, the central bank allows r_2 to fall, causing Y_2 to move toward $\bar{Y}$.

The price shock thus generates a period of *stagflation* (recession plus high inflation), as occurred in the 1970s following oil price shocks in 1973 and 1979.

5. DAD will shift to the right, causing output and inflation to rise today. Why is this the case? At the original level of output (which is the true natural rate of output), the Fed now thinks that there is a negative output gap, so lowers the interest rate to fight that output gap. This stimulates spending (DAD shifts to the right), and the resulting increase in output causes inflation to increase as well (we move along the DAS). In subsequent periods, expected inflation increases to meet the previous periods' actual inflation, causing inflation to increase further (DAS shifts upward). In the LR, the economy will thus return to $\bar{Y}$ at a permanently higher inflation rate.

This problem gives a possible additional explanation for why the stagflation in the 1970s was so severe. As noted above, the 1970s were marked by two recessions, triggered by oil price shocks in 1973 and 1979, in which inflation increased rather than decreased. That is what we would expect from recessions caused by price shocks (i.e., a supply side, rather than demand side shocks). However, it is less clear why the increases in inflation were so dramatic, as the price shocks don't seem large enough to explain the persistent increase in inflation from about 3% in 1972 to 13% in 1980. A likely explanation is that the Fed did not fight the increases in inflation aggressively, and actually contributed to the increases. One flavor of this explanation is the one given by Mankiw on pp. 465–466. He argues (based on empirical estimates of the Taylor Rule) that the Fed in the 1970s was not following the]it Taylor Principle of setting $\theta_\pi > 0$, i.e., of increasing the Federal Funds Rate more than one for one with increases in inflation. Thus, as inflation increased, the real interest rate fell, stimulating further spending and thus further inflation. However, a second flavor of this explanation (offered by Athanosios Orphanides of the Federal Reserve Board) is that the Fed did actually set $\theta_\pi > 0$, but it overestimated $\bar{Y}$ (equivalently, underestimated the natural rate of unemployment). In this flavor of the explanation, the oil price shocks coincided with a fall in the rate of growth of $\bar{Y}$ (and increase in the natural rate of unemployment), so the Fed. thought that it needed to lower the real interest rate to fight a negative output gap, when there was actually a positive output gap.