Open Economy

In an **open economy**, we have $Y = C + I + G + NX$. Rewrite as $Y - C - G = I + NX$. LHS is savings S, so $S = I + NX$. Subtract I and

$$S - I = X - M = NFI,$$

where NFI is **net foreign investment**. If savings is greater than investment in a country, then that *excess savings* is invested abroad, hence, net foreign investment. Balanced trade, $X = M$, is equivalent to $S = I$ and $NFI = 0$.

A small open economy is a **price taker**, i.e. is subject to the real interest rate r^w established in the rest of the world. Can have $S < I$ if r^w is low enough, so $X < M$. And vice versa.

Exchange Rates

The **nominal exchange rate**, e_n, expresses how many units of currency A it takes to buy one unit of currency B. If it takes 120 yen to buy one dollar, then the nominal exchange rate is

$$e_n = \frac{120 \text{ JPY}}{1 \text{ USD}}.$$

The **real exchange rate**, e_r is the exchange rate of *goods*,

$$e_r = e_n \times \frac{P}{P^*},$$

where P is the domestic price level (in the domestic currency), and P^* is the foreign price level(in the foreign currency). If e^r goes up, then foreign goods are relatively cheap and domestic goods are relatively expensive. And vice versa. *(5.6)*

Demand for Net Exports

You are a SOE and your real exchange rate falls. Then domestic goods become less expensive relative to foreign goods, so you would import less and export more. Thus the demand schedule for net exports, $NX(e_r)$, is inversely related to the real exchange rate, i.e. is downward sloping.

There exists some real exchange rate at which net exports equals zero. The real exchange rate is determined by the intersection of a vertical line representing $S - I$ and the $NX(e_r)$ demand function.

Suppose domestic G falls. Then domestic S goes up. I doesn't change because it is still intersecting r^w in the same spot. Thus, $S-I$ becomes larger. So shift the $S-I$ line on the NX/e_r graph to the right. This shows that NX has become larger, and so has NFI. But e_r has fallen because the domestic price level P is now growing slower due to the decrease in G, which means that

$$e_r = e_n \times \frac{P}{P^*}$$

is getting smaller and P is becoming relatively smaller when compared to P^* (nothing has happened to change e_n or P^* in this example).

Know how to deal with changes in the ROW, SOE, and NX/e_r graphs. (5.3, 5.4, 5.9, 5.10)

Solow Model

Production function exhibits **constant returns to scale** if $F(zK, zL) = zF(K, L)$. We can have $z = 1/L$ so that

$$Y = F(K, L) \quad \Longrightarrow \quad \frac{Y}{L} = F\left(\frac{K}{L}, 1\right).$$

- Y/L is output per worker and it is a function $F(K/L)$ of capital per worker K/L. (We can ignore that 1 above.)
- Let $y = Y/L$ and $k = K/L$. Then we can write $y = f(k)$.
- Let $C/L = c$ and $I/L = i$. It follows that $y = c + i$ if we ignore government and have a closed economy.
- Let s be the fraction of income that people save, so sy is the level of savings.
- Savings equals investment in a closed economy, so $i = sy$.
- Let γ be the depreciation rate. It measures the rate at which capital becomes worn down.
- Let n be the rate of growth of the labor force L.

The sum $\gamma + n$ captures the rate at which capital is being destroyed. If γ is high, then capital is of poor quality and falls apart quickly. If n is high, then there are more people using each piece of capital so it falls apart more quickly. $(\gamma + n)k$ represents how much capital is *destroyed* in one period.

The amount of investment $sf(k) = sy = i$ represents how much capital is *created* in a period. So if $i > (\gamma + n)k$ this period, then you create more new capital than you destroy, so k will increase for next period. In math,

$$\Delta k = sf(k) - (\gamma + n)k.$$

Now notice that if $i > (\gamma + n)k$, then k will be larger in the next period. So then $(\gamma + n)k$ will be closer to i in the next period. It will keep growing in such a manner until $i = (\gamma + n)k^*$. The amount of capital being destroyed is exactly the same as the amount of capital being created, so there is no change in total capital in the next period. We call this the **steady-state** level of capital, k^*.

Vary the saving rate s to shift the sy curve and find a new steady-state level of capital k^* and a corresponding steady-state output $f(k^*)$. Let's make a graph of *only* steady-states. Plot all k^* and $f(k^*)$ for every possible level of s onto a graph along with the steady-state destruction line $(\gamma + n)k^* = sy = i$. There is a certain steady-state level of capital k^*_G that maximizes consumption. Since $c = y - i = f(k^*) - (\gamma + n)k^*$ at the steady-state, we can use calculus to show that c is maximized at $MPK = \gamma + n$. That is, c is maximized when the slope of the steady-state capital destruction line $(\gamma + n)k^*$ is tangent to the steady-state output $f(k^*)$, i.e. when $MPK = \gamma + n$. This is the **Golden Rule level of capital**.

Now suppose we care about how efficient labor is. Then we consider a sort of "effective labor force", $L \times E$, where E represents **worker efficiency**. We can rewrite everything in terms of $L \times E$, for instance now we have $f(k) = y = Y/(L \times E)$.

Let g be the growth rate of worker efficiency. It measures much more skillfully people do their jobs. *This is not technological improvement, just general skill improvement. Technological improvement is captured by another variable A that is hidden in $F(K, L)$.* If g is high, then people work "faster" and thus use each piece of capital more often. So now the capital destruction is $(\gamma + n + g)$, the steady-state condition is $(\gamma + n + g)k = sy = i$, and the Golden Rule level condition is $MPK = \gamma + n + g$.

At the steady state, $Y/(L \times E) = f(k^*)$. Since k^* is fixed by definition, it follows that $Y/(L \times E)$ is fixed. But we know that L is growing at a rate of n and E is growing at a rate of g, so it must be that Y is also growing at rate $n + g$ as well (so that the fraction $Y/(L \times E)$ does not change in value). So if we then consider just Y/L, we know that Y is growing at a faster rate than L is by the term g. So *income per laborer is increasing based on how more skilled the labor becomes.* This is analogous to an increase in MPL in the equation

$$Y = MPK \times K + MPL \times L.$$

Suppose $MPK > \gamma + n + g$. Then you can increase s to increase k^*, and a higher k^* implies a lower MPK because of diminishing marginal capital of $f(k)$ — higher k implies lower MPK and vice versa. Hopefully you will increase s until $MPK = \gamma + n + g$. Furthermore, higher s initially implies a lower c since $c = y - sy$. But as k^* makes its way to the Golden Rule level of capital k^*_G, eventually c will be at its maximum. So, provided you are saving too little now, you can start to save more now to maximize consumption later (try plotting the trajectory of c in this scenario). This is the other Golden Rule at work: "do unto others as you would have others to undo you." In other words, if you sacrifice and save more now, then you can increase the welfare of those in future generations. Presumably you would be grateful if your ancestors had sacrificed their own consumption to improve your welfare, so the Golden Rule says you should do the same thing.

Understand steady-states, the Golden Rule(s) and its conditions, how to achieve the Golden Rule level of capital, and the implications from doing so. (6.3, 6.5, 6.7, 6.8, 6.9, 6.10, 6.11, 6.12, 6.14)

Economic Fluctuations

Aggregate Demand

Recall that $MV = PY$, which we can rewrite as $M/P = Y/V$. If we assume that V is fixed, then an increase in Y causes M/P to increase. So higher output implies higher level of real money balances. If we assume that M is fixed, then it must be the case that P falls. Hence, the aggregate demand is downward sloping where Y and P are the endogenous variables.

If M or V change, then the demand curve itself moves. For instance, an increase in M will increase Y for any price level, so the AD curve will shift up. So M and V determine the position of AD whereas P and Y determine its shape.

Aggregate Supply

In the long run prices are perfectly flexible and thus we can assume full utilization of capital and labor. Output is determined by capital and labor, $Y = F(K, L)$. So in the long run, aggregate supply is just a vertical line – it is inelastic to the price level. We can deduce what will shift the LRAS from the equation $Y = MPK \times K + MPL \times L$.

In the short run, prices are all fixed (aka "sticky"). So whatever the level of output happens to be, it has to be at the the existing price level. Thus, the Y is infinitely elastic to the price level, i.e. horizontal. "Price shocks" will shift SRAS, e.g. droughts will shift SRAS up as an adverse supply shock; breaking up a cartel will shift SRAS down as a favorable supply shock.

If AD increases, then AD intersects SRAS at a higher Y but the same P. LRAS intersects new AD at a higher P but the original Y.

An adverse supply shock will shift SRAS up, which means SRAS and AD intersect at lower Y and higher P. In long run, LRAS and AD will intersect at the original spot (since LRAS and AD have not shifted). So in the short run, Y down and P up; in the long run, Y and P at their original values. If government does not want to wait for the long run to get back to the original value of Y, it might try to shift AD instead. In what direction? How? What would happen to P?

Know what happens in the short run and the long run when shifts in LRAS, SRAS, and AD occur. (7.1, 7.2, 7.4, 7.6, 7.7, 7.8, 7.9)