

Macroeconomics

-Understanding and analyzing the performance of an economy as a whole.

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Topic 1 – Measures

Terminology:

Market value: the price at which each item is traded in markets

Final goods and services: a final good is an item that is bought by its final user during a specific time period

Main macroeconomics variables: the main factors influencing the economy
(GDP, Unemployment rate, Inflation rate)

GDP (gross domestic product):

(Aggregate output. A measure of the situation of an economy)

Nominal GDP: Can be measured in 3 ways:

1. The market value of the final goods and services produced in the economy during a given period (not intermediate goods) (prices * quantities)
2. The sum of value added in the economy during a given period
3. The sum of incomes in the economy during a given period

Notes:

Labor income is by far the largest component of GDP

Exports is included in the value of production and imports must be deducted from the equation

Taxes is considered as an income (for the government)

GNP: The market value of the goods and services produced by the nationals of a country during a given period (i.e. also what is produced in foreign countries by the domestic country's nationals, but not what is produced in the domestic country by non-nationals)

Real GDP: because prices tend to increase over time (inflation), prices should be held constant when one wants to compare GDP over time. Thus real GDP is prices in a certain year (*base year*) x quantities

PPP (purchasing power parity) adjusted GDP: because prices vary between countries, to compare their GDP prices should be determined. Thus PPP adjusted GDP is prices in a certain country (*base country*) x quantities

Unemployment rate:

Employment: the number of people who have a job (N)

Unemployment: the number of people who do not have a job, but is looking for one (U)

Labor force: the sum of employed and unemployed people ($L = N+U$)

Unemployment rate: $u = U/L$

Discouraged workers: people who are no longer looking for a job and therefore not counted as unemployed

Participation rate: the amount of people in the working age who are in the labor force

Okun's law: if output growth is high, unemployment will decrease (and vice versa)

Inflation:

Inflation: increase in the general level of prices

Deflation: decrease in the price level (negative inflation rate)

Inflation rate: the rate at which the price level increases

GDP deflator: index to measure inflation rate (P)

$P = \text{nominal GDP} / \text{real GDP}$

CPI (consumer price index): consumers care about what they consume and not about what is produced. This index measures inflation rate relative to the price of a certain basket of goods over time

GDP movements:

GDP growth rate:

Expansion: GDP growth

Recession: negative GDP growth

Procylical variable: a variable that follows the GDP (e.g. inflation rate, employment, import, investment, real consumer spending, stock and bond prices)

Countercyclical variable: a variable that goes opposite of the GDP (e.g. unemployment rate)

Acyclical variable: a variable that does not move with the GDP

Time periods:

Short run: (demand side) GDP movements come from movements in demand for goods. Firms adjust labor to match the level of demand

Flexible: Labor

Fixed: Prices, Nominal wages, Capital

Medium run: (supply side) GDP movements are constrained by how much firms can produce (depending on capital, labor force size)

Flexible: Labor, Prices, Nominal wages

Fixed: Capital

Long run: (supply side) GDP movements are based on ability to innovate, savings, education, corporate laws etc.

Flexible: Labor, Prices, Nominal wages, Capital

 Topic 2 – Goods market

Terminology:

GDP (Y): The market value of the goods and services produced in an economy (=supply of goods)

Demand for goods (Z): The market value of the goods and services demanded in an economy

Consumption (C): All goods and services purchased by consumers

Investment (I): Purchase of new capital goods by firms or households (machines, buildings, houses etc.)

Government spending (G): all goods and services purchased by the government

Exports (X): all goods and services purchased by foreign agents

Imports (IM): all goods and services purchased by domestic agents

Endogenous variable: variable that depend on other variables (e.g. consumption depends on income and taxes)

Exogenous variable: variable that are taken as a given (e.g. government spending)

Closed economy: No imports or exports

Open economy: Imports and exports

Demand for goods and equilibrium:

$$Z \equiv C + I + G + X - IM$$

We assume that:

1. We are in closed economy ($X = IM = 0$)
2. Investment and government spending are exogenous ($I = \bar{I}$)
3. Consumption is a function of disposable income, $C = c_0 + c_1 Y_D$, where c_0 is consumer confidence (what consumers would spend if their income was zero), c_1 is the propensity to consume ($0 < c_1 < 1$) and Y_D is disposable income ($Y_D = Y - T$, where Y is income and T is taxes)
4. At equilibrium, supply = demand ($Y = Z$)

Combining these assumptions, we get that the equilibrium demand for goods is

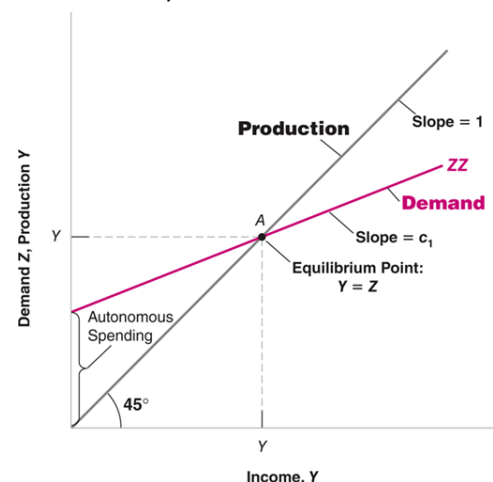
$$Y = c_0 + c_1(Y - T) + \bar{I} + G$$

or rewritten

$$Y = \frac{1}{1 - c_1} (c_0 + \bar{I} + G - c_1 T)$$

Where $(c_0 + \bar{I} + G - c_1 T)$ is *autonomous spending* and

$\frac{1}{1 - c_1}$ is the *multiplier*



The IS relation:

Another way of expressing the equilibrium in the goods market is in terms of savings being equal to investment

Private savings: $S^{\text{private}} = Y - T - C$

Public savings: $S^{\text{public}} = T - G$

IS relation:

$$Y = C + I + G$$

subtract T from each side

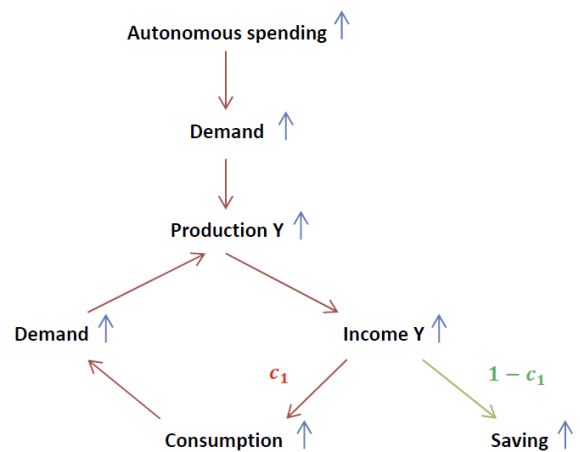
$$Y - T = C + I + G - T$$

$$I = S^{\text{private}} + S^{\text{public}}$$

The multiplier effect:

Because of the multiplier an increase in autonomous spending will lead to an increase in output that is larger than the initial increase in autonomous spending ($1/(1-c_1) > 1$).

This is because when autonomous spending increases, demand increases → output increases → income increases → consumption (demand) increases → output increases and so on (successive rounds, where output increases by less and less).

Fiscal policy:

Balanced budget: The case when government spending is equal to government income (taxes), $G = T$

Expansionary fiscal policy: government increases government spending or decreases taxes (increasing the budget deficit) (which increases output thus shifting the demand curve up)

-An increase in G leads to an increase in Y of $\frac{1}{1-c_1} * \Delta G$

-A decrease in T leads to an increase in Y of $\frac{1}{1-c_1} * \Delta T$

Contractionary fiscal policy: government decreases government spending or increases taxes (decreasing the budget deficit) (which decreases output thus shifting the demand curve down)

Note:

If G and T increase by the same amount, Y will also increase by this amount

 Topic 3 – Financial market

Terminology:

Wealth: the value of all your financial assets

Money: financial asset that be readily used to pay for transactions (can easily be converted to goods -> very liquid), but pays no interest. Can either be currency, CU, or deposits, D

Bonds: non-money financial assets that are less liquid, but in turn pays interest

Central bank: monetary authority that manages a state's currency, money supply, and interest rates. Central bank money is denoted by H

Banks: receive deposits from people of which they keep a percentage, θ , as reserves, R, while using the rest to buy bonds and make loans to people

Note:

People will want to hold money for the transactions they need and keep the rest of their wealth in bonds to get interest. The higher the interest rate, the higher the initiative to hold a larger proportion of the wealth in bonds.

The Central Bank:

Central bank money supply: The Central Bank controls the amount of money it supplies, H^s , by buying and selling bonds.

Expansionary monetary policy: the central banks creates money and uses this to purchase bonds, thus increasing the amount of central bank money.

Note: this will increase the demand for bonds, thus also increasing the price -> interest rate drops leading to further demand for money and through this increasing supply even more

Contractionary monetary policy: the central sells bonds and removes the money it gets for these, thus decreasing the amount of central bank money.

Central bank money demand: people hold a portion, c , of their money in currency, CU, and a portion, $1-c$, in deposits, D. The sum of this currency and reserves kept by banks, is all the money demanded from the central bank

$$H^d = CU^d + R^d$$

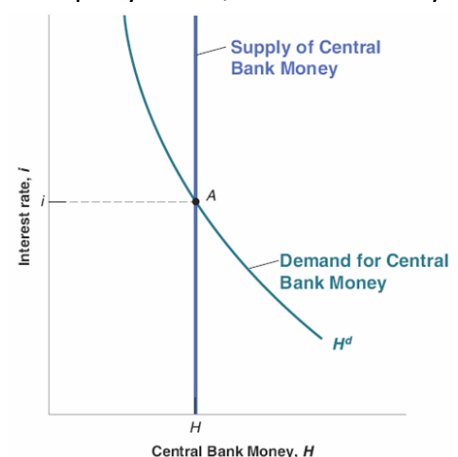
$$H^d = cM^d + \theta D^d$$

$$H^d = cM^d + \theta(1-c)M^d$$

$$H^d = (c + \theta(1-c))M^d$$

From the demand for money in the next section, this can also be written as $H^d = (c + \theta(1-c))\$YL(i)$

Equilibrium: the equilibrium interest rate is found at the intersect between H^d and H^s



Money market:

Demand for money: is determined by income and a decreasing function of the interest rate

$$M^d = \text{\$}Y * L(i)$$

(-)

Supply of money: rewriting the demand for central bank money in terms of supply we get that

$$H^s = (c + \theta(1-c))M^s$$

$$M^s = \frac{1}{c + \theta(1-c)} H^s$$

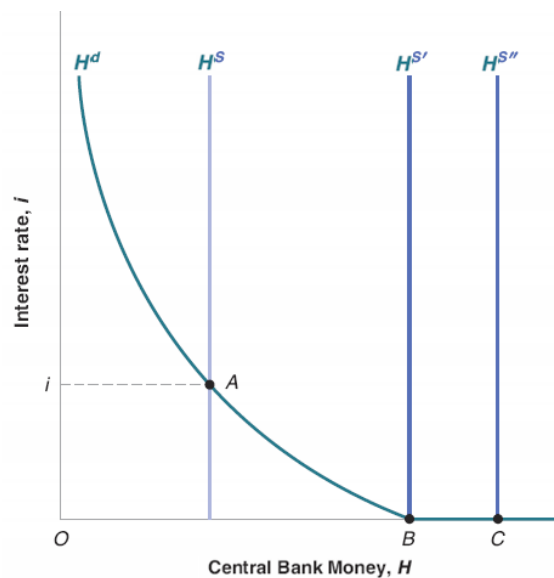
Real money demand and supply:

Price level: to express a variable in real terms, one divides by the price level, P (GDP deflator).

Thus, real money demand is M^d / P and real money supply is M^s / P

The liquidity trap/ zero lower bound:

When the interest rate is equal to zero, people are indifferent between holding their wealth in currency or in bonds. The interest rate cannot become negative



Topic 4 – IS-LM model

IS relation:

Investment: In the last topic interest rate was the return you would get on bonds. But interest rate is also what it costs you to borrow money. If the interest rate is high, banks want more for lending you money, because they could also use this money to buy bonds and get interest from these. Because interest rate changes over time it is realistic to assume that investment also does (not fixed as in topic 2). The lower the interest rate, the cheaper it is to borrow, and thus the more investment will occur. Also when production, Y , is high more investment will logically occur. Thus:

$$I = I(Y, i)$$

(+, -)

Demand for goods: combining the demand function from topic 2 ($Z = C(Y, T) + I + G$) with this new investment function we get that

$$Z = C(Y, T) + I(Y, i) + G$$

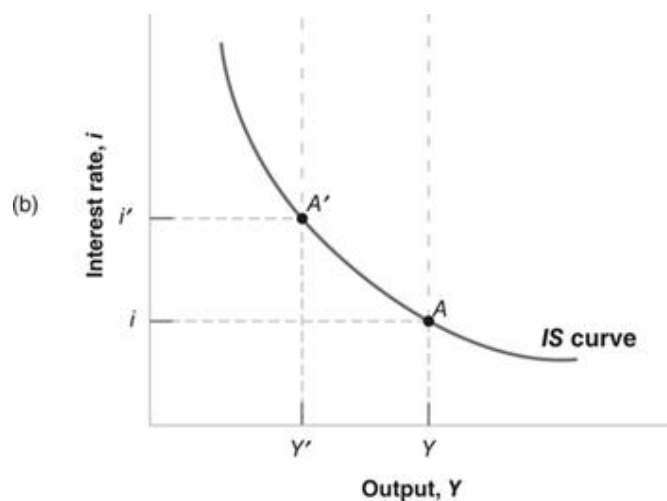
(+, -) (+, -)

which at equilibrium (supply = demand, $Y = Z$) is

$$Y = C(Y, T) + I(Y, i) + G$$

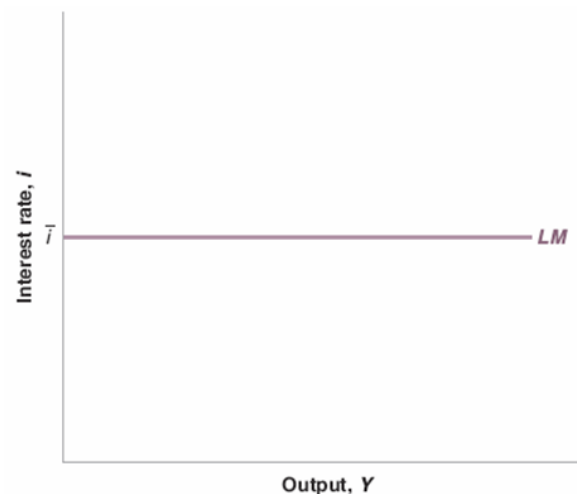
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IS relation: from the new demand function, we see that output decreases when the interest rate increases. This is called the IS relation. Any changes in T or G will shift the IS curve left or right. This curve shows all the equilibria between goods supply and demand depending on the interest rate



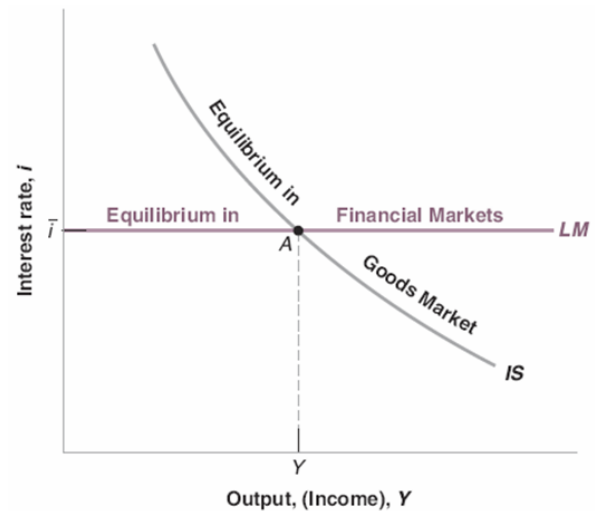
LM relation:

LM relation: the equilibrium interest rate is found at the equilibrium between money supply and money demand. The central bank controls the supply to set the interest rate. It is more convenient to talk about this relation in real terms, $M^s/P = YL(i)$, where Y is real income. This is the IS relation, where the central bank controls the equilibrium interest rate, $i = \bar{i}$



IS-LM model:

Equilibrium: both the IS and the LM curve are equilibrium concepts. The overall equilibrium is found at the intersect between these two

Policy changes:**Fiscal policy**

-*Fiscal contraction/consolidation:* increasing taxes or decreasing government spending (reducing the budget deficit). Shifts the IS curve left

-*Fiscal expansion:* increasing government spending or decreasing taxes (increasing the budget deficit). Shifts the IS curve right

Monetary policy

-*Monetary contraction/tightening:* decreasing the money supply by selling bonds to increase interest rate. Shifts the LM curve up

-*Monetary expansion:* increasing the money supply by buying bonds to decrease interest rate. Shifts the LM curve down

Monetary-fiscal policy mix (policy mix): Using both monetary and fiscal policies to create a double effect. E.g. really increase output by having both a monetary and fiscal expansion

Quantitative easing: if an economy reaches the zero lower bound, and thus cannot use monetary policies (buying government bonds) to affect the output, it can buy financial assets from commercial banks and financial institutions, driving the price of these up and thus the return down. The sellers of these assets will then use the money they receive to buy other assets driving the price of these up too and the return down. Lower returns, also means lower borrowing rate, which increases spending and investment.

Extending the IS-LM model:

Real interest rate: because of inflation the nominal interest rate might not be very reliable, so we use the real interest rate to get a more realistic picture of borrowing or savings rate

$$1 + r_t = \frac{P_t(1+i_t)}{P_{t+1}^e}$$

where r_t is the real interest rate in period t , P_t is the CPI in period t , i_t is the interest rate in period t and P_{t+1}^e is the expected CPI in period $t+1$ (the end of the savings / borrowing period)

Because the expected inflation rate is $\pi_{t+1}^e = \frac{P_{t+1}^e - P_t}{P_t}$ we can also express the real interest rate in a more intuitive way:

$$r_t \approx i_t - \pi_{t+1}^e$$

the real interest rate is the nominal interest rate minus the expected inflation

Risk premium: because some bonds are riskier than others, these bonds have a higher interest rate. The added interest rate (the risk premium, x) should be taken into account when calculating investment.

When the government affects interest rate by buying bonds it does it with riskless bonds. We say the government affects the *policy rate*.

The interest rate on the riskier assets, household and firm loans, is called the *borrowing rate*.

With a fixed risk premium, any change in policy rate will translate into a change the borrowing rate.

Extended IS-LM model: Taking the real interest rate and the risk premium into account, investment can be expressed as

$$I = I(Y, i - \pi^e + x)$$

Which leads to the extended IS-model being

$$Y = C(Y, T) + I(Y, i - \pi^e + x) + G$$

(+, -) (+, -)

And the extended LM-model being

$$r = \bar{r}$$

because even though the central bank formally controls the interest rate, it sets it so that the real interest rate matches the policy it wants to achieve

 Topic 5 – IS-LM model (open economy)

Terminology:

Nominal exchange rate: price of the domestic currency in terms of the foreign currency, denoted by E (e.g. if Denmark is the domestic country, $E = 0,13$ (1DKK = 0,13Euro))

Real exchange rate: price of domestic goods in terms of foreign goods, denoted by ϵ . This is more realistic as price differences are taken into account

$$\epsilon = \frac{EP}{P^*}$$

Where P is the price level in the domestic country and P^* is the price level in the foreign country

Exchanges rate regimes: How the exchange rate between countries is controlled

Flexible exchange rates: the central bank lets the exchange rate adjust freely on the foreign exchange market.

Appreciation of the domestic currency: increase in the nominal exchange rate

Depreciation of the domestic currency: decrease in the nominal exchange rate

Fixed exchange rates: the central bank has an explicit exchange rate target and uses monetary policy to achieve this target

Revaluation of the domestic currency: increase in the nominal exchange rate

Devaluation of the domestic currency: decrease in the nominal exchange rate

Trade surplus/deficit: If a country imports more than it exports, it has a trade deficit. And vice versa it is a trade surplus

Goods market in open economy:**Assumptions:**

We are in open economy now, so net exports, NX , are taken into account; $NX = X - IM$.

IM is the value of imports in terms of foreign goods, so we divide this by ϵ to get imports in terms of domestic goods.

The more domestic output, the more will be imported. The higher the exchange rate the cheaper the foreign goods will effectively be. $IM = IM(Y, \epsilon)$

The more foreign output, Y^* , the more will be exported. The higher the exchange rate the more expensive the domestic goods will effectively be compared to foreign goods. $X = X(Y^*, \epsilon)$

To simplify things we assume there is no risk premium

Demand for domestic goods: from the above assumptions we get that

$$Z = C(Y - T) + I(Y, r) + G + X(Y^*, \epsilon) - IM(Y, \epsilon) / \epsilon$$

$$\begin{matrix} (+) & (+, -) & (+, -) & (+, +) \end{matrix}$$

Thus the IS relation in open economy is

$$Y = C(Y, T) + I(Y, r) + G + X(Y^*, \epsilon) - IM(Y, \epsilon) / \epsilon$$

Net exports: Because NX is

$$NX = X(Y^*, \epsilon) - IM(Y, \epsilon) / \epsilon$$

(+, -) (+, +)

It will be downward sloping. As income increases, there will be a larger trade deficit. This also means that the multiplier is smaller in open economy, because the demand for domestic goods does not increase as much, when some of the demand is covered by imports.

In open economy we have that $Y = C + I + G + NX$. If we subtract T from both sides and isolate NX we get that $NX = (Y - T - C) + (T - G) - I \rightarrow NX = S - I$. Net exports is equal to savings minus investment.

Marshall Lerner condition: if the real exchange rate decreases (a real depreciation), exports will increase, imports will decrease, thus an increase in NX (and vice versa)

$$NX(Y, Y^*, \epsilon)$$

(-, +, -)

Financial market in open economy:

Difference from closed economy: in closed economy people chose between money and bonds. Now they choose between money, domestic bonds and foreign bonds.

Arbitrage: the concept that investors will take advantage of a price difference and thus invest all their money in the bonds that yields the highest return rate. Because of this, the return on domestic and foreign bonds has to be the same

Return on domestic bonds: investing domestically will at a point in time, t , gives you returns of $1+i_t$

Return on foreign bonds: first you convert your money so you get E_t in foreign currency. Investing this in foreign bonds at a point in time, t , gives you returns of $1+i_t^*$. Thus in terms of foreign currency you get $(1+i_t^*)E_t$. Converting this back to domestic currency at the end of period $t, t+1$, you will expect to get $((1+i_t^*)E_t)/E_{t+1}^e$

(Uncovered) Interest parity condition: because of arbitrage the return on foreign and domestic bonds has to be equal. This is the interest parity condition (IPC)

$$1 + i_t = (1 + i_t^*) \frac{E_t}{E_{t+1}^e}$$

If E^e and i^* is given and you are asked to graph the IPC it would be advantageous to rewrite it as

$$E = \frac{1+i}{1+i^*} \bar{E}^e$$

Or because the domestic interest rate must be equal to the foreign interest rate minus the

expected appreciation rate of the domestic currency: $i_t \approx i_t^* - \frac{E_{t+1}^e - E_t}{E_t}$

IS-LM model in open economy:

IS relation: in the short run prices do not change, so $r = i$. This also means that nominal exchange rate impacts real exchange rate proportionally (if nominal doubles, so will real). By choosing a price level equal to the foreign price level ($P = P^*$) we get that $E = \epsilon$.

From these simplifications, we get that the equilibrium in the goods market is

$$Y = C(Y - T) + I(Y, i) + G + NX(Y, Y^*, E)$$

(+) (+, -) (-, +, -)

Or given the interest parity condition

$$Y = C(Y - T) + I(Y, i) + G + NX(Y, Y^*, \frac{1+i}{1+i^*} \bar{E}^e)$$

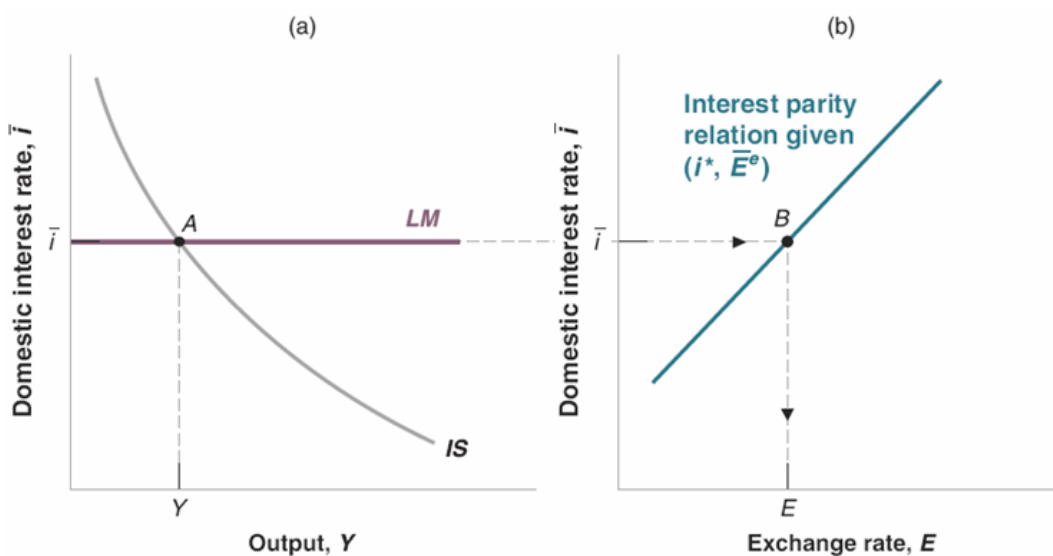
(+) (+, -) (-, +, -)

LM relation: the central bank still sets the interest rate through monetary policies, $i = \bar{i}$

IS-LM in open economy:

IS: $Y = C(Y - T) + I(Y, i) + G + NX(Y, Y^*, \frac{1+i}{1+i^*} \bar{E}^e)$

LM: $i = \bar{i}$



Topic 6 – Labor market

Note for you who are reading through this chronologically:

Congratulations! You now know everything about the short run. That's very cool! Great job learning! We now move to the medium run where prices and nominal wages are no longer fixed. If you made it through the first 5 topics, I'm sure you can make through this as well. Good luck!

Natural level of unemployment:

Wage determination: the higher the unemployment, the lower the bargaining power of the workers, thus also the wage of these. Other factors like unemployment protection and minimum wage will in turn increase the wage. Lastly expected future price level is also taken into account when wage is bargained. The wage is set in terms of expected prices in the future

$$W = P^e F(u, z)$$

(-, +)

Where W is wages, P^e is the expected price level, u is unemployment rate, and z is catch-all variable representing unemployment protection, minimum wage level etc.

This is called the wage setting relation (WS)

Price determination: we assume that firm's only cost is wages. They will set prices equal to their costs and add a percentage, m , depending on their market power. Thus prices can be expressed as

$$P = (1+m)W$$

Or rewritten

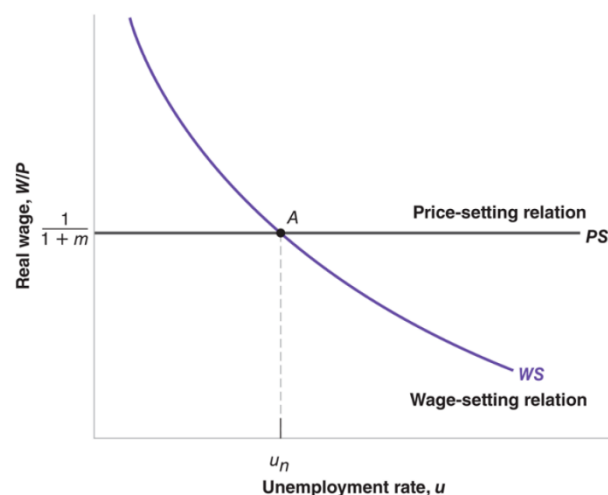
$$W/P = 1/(1+m)$$

This is called the price setting relation (PS)

Natural level of unemployment: we assume that the price level is stable, $P = P^e$. We can thus rewrite the wage equation as $W/P = F(u, z)$.

At the intersect between WS and PS, we find the natural level of unemployment, $F(u_n, z) = 1/(1+m)$.

Please note that we have real wages on the y-axis and unemployment on the x-axis



Natural level of output: We assume that production only depends on labor, so that $Y = N$.

Remember the notation from topic 1:

u is the unemployment rate (U/L)

U is the unemployment level

N is the employment level

$L = U + N$ is the size of the labor force

So we can rewrite the production function:

$$Y = N$$

$$Y = L - U$$

$$Y = L - LU/L$$

$$Y = L - Lu$$

$$Y = L(1 - u)$$

The natural level of output is the output where $u = u_n$:

$$Y_n = L(1 - u_n)$$

 Topic 7 – Inflation and unemployment

The Phillips curve (PC):

Equilibrium on the labor market: From last topic we found that

$$\text{WS: } W = P^e F(u, z)$$

$$\text{PS: } P = (1+m)W$$

Combining these we get that

$$P = P^e (1+m) F(u, z)$$

Now let us assume a specific function $F(u, z) = 1 - \alpha u + z$, and add a time subscript, so that

$$P_t = P_t^e (1+m) (1 - \alpha u_t + z)$$

This can be rewritten in terms of inflation (see page 196 if you're interested)

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

$$\text{Where } \pi_t = \frac{P_t - P_{t-1}}{P_{t-1}} \text{ and } \pi_t^e = \frac{P_t^e - P_{t-1}}{P_{t-1}}$$

The original Phillips curve: in the past people expected the inflation rate to fluctuate around a value $\bar{\pi}$, so the equation from the last section can be rewritten as

$$\pi_t = \bar{\pi} + (m + z) - \alpha u_t$$

This relation is also known as *the original Phillips curve*

The (modified) Phillips curve: today people base their expectations of the inflation rate on the past inflation rate:

$$\pi_t^e = (1 - \theta)\bar{\pi} + \theta\pi_{t-1}$$

θ is a value between 0 and 1 that expresses how much people base their expectations on the past inflation rate.

If $\theta = 0$, people do not expect any correlation between past and present inflation rate

If $\theta = 1$, people expect today's inflation rate to be the same as yesterday, $\pi_t^e = \pi_{t-1}$

We assume that $\theta = 1$, and can thus rewrite the original Phillips curve:

$$\pi_t - \pi_{t-1} = (m + z) - \alpha u_t$$

This relation is known as *the modified Phillips curve*. This is what is referred to in general when we say Phillips curve

The Phillips curve and unemployment: over time we assume that people learn from their mistakes can figure out how the inflation rate moves so. Thus expected inflation is equal to actual inflation $\pi = \pi^e$: the economy converges to its natural level.

If $\pi = \pi^e$, then $P = P^e$, which is how we previously found the natural level of unemployment. We can relate the Phillips curve to the natural level of unemployment in the medium run by inserting π as the expected inflation rate:

$$\pi = \pi + (m + z) - \alpha u_n$$

$$0 = (m + z) - \alpha u_n$$

$$u_n = \frac{m + z}{\alpha}$$

We can rewrite the Phillips curve using this equation

$$\pi_t - \pi_{t-1} = (m + z) - \alpha u_t$$

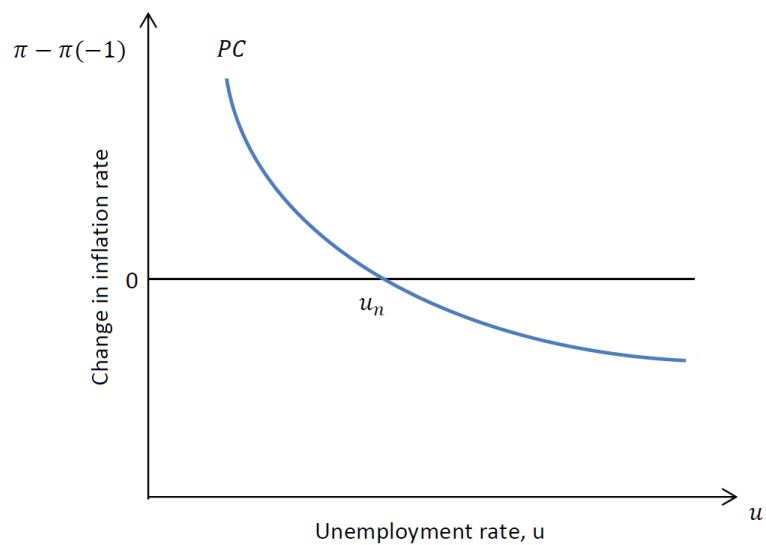
$$\pi_t - \pi_{t-1} = \alpha \frac{(m+z)}{\alpha} - \alpha u_t \quad \leftarrow \text{Multiplying and dividing } (m + z) \text{ by } \alpha$$

$$\pi_t - \pi_{t-1} = \alpha u_n - \alpha u_t$$

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

From this we see that when unemployment rate is above its natural level, the inflation rate decreases (and vice versa).

In addition, when unemployment is at its natural level the inflation rate is stable (change in inflation rate = 0)



Topic 8 – IS-LM-PC model

Note: in the following section to ease notation, the Phillips curve will instead of

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n) \text{ be denoted as } \pi - \pi(-1) = -\alpha(u - u_n)$$

IS-LM-PC model:

PC in terms of output: Remember from topic 6 the production function $Y = L(1 - u)$ with the relation between natural unemployment and output being $Y_n = L(1 - u_n)$. If we subtract each side from each other we get that

$$Y - Y_n = L(1 - u) - L(1 - u_n)$$

$$Y - Y_n = -L(u - u_n)$$

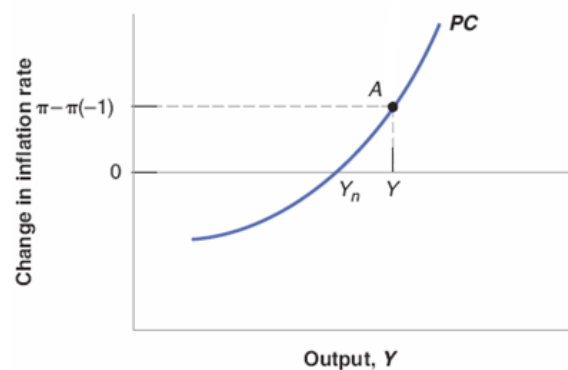
$$u - u_n = -\frac{Y - Y_n}{L}$$

Now we can insert this in the Phillips curve

$$\pi - \pi(-1) = -\alpha(u - u_n)$$

$$\pi - \pi(-1) = \left(\frac{\alpha}{L}\right)(Y - Y_n)$$

From this we see that inflation rate increases when output is above the natural level of output (and vice versa)

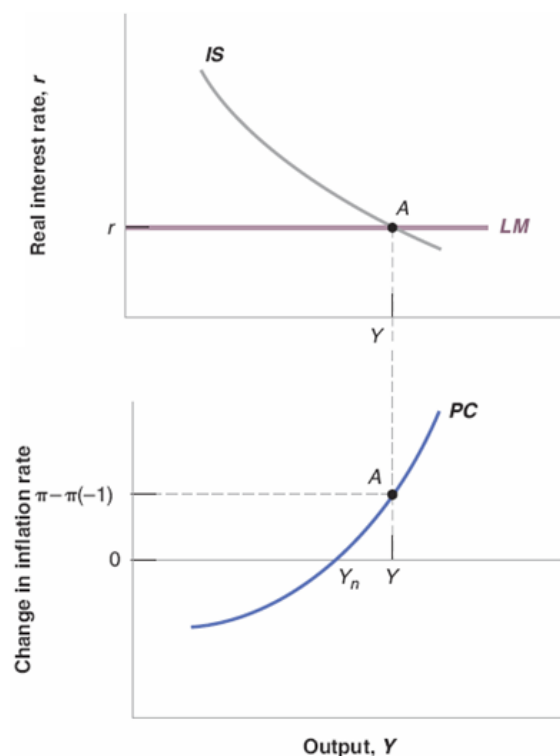


IS-LM-PC model:

Combining the PC expressed through output with the IS-LM model we get the relation seen on graphs to the right.

In the medium run the central bank will try to stabilize inflation. Thus, they set interest rate so that output is at its natural level. The real interest rate at this point is called the natural rate of interest, r_n . At this level the change in inflation rate is 0.

Please note that this does not mean that inflation is 0. It just means that the rate of inflation does not change.



Monetary policies in the medium run: In the medium run, if we are at the natural level of output, monetary policies will not work. This is due to the fact that any change in interest rate would bring the economy away from the natural level of output, change inflation rate, and then the central bank will want to reverse the policy. Only thing it changes is inflation, because while the economy was e.g. below natural level of output inflation was decreasing, so even though the economy went back to its initial level of output and inflation rate stabilized, inflation decreased during the time it took to get there.

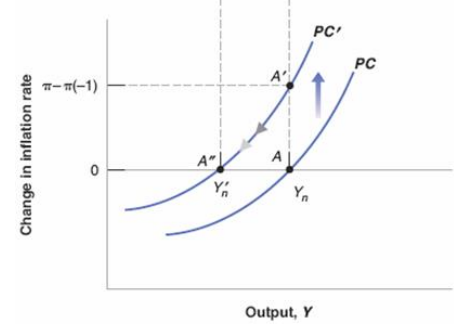
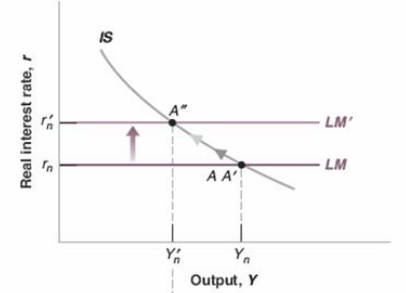
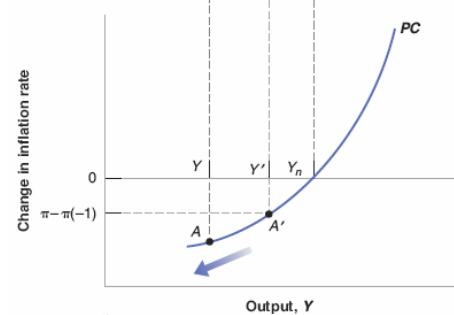
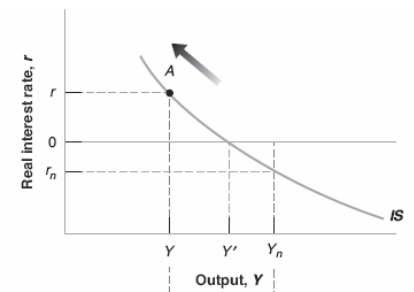
Deflation trap/deflation spiral: imagine the situation where an economy has zero inflation and is at its natural level of output. If output decreases, inflation decreases, and the central bank will want to decrease the interest rate to increase output back to the natural level.

Remember the zero lower bound. Interest rate, or in more realistic terms real interest rate, cannot go below zero. The real interest rate is $r = i - \pi^e$. We assume that people form their expectations based on past inflation, $\pi^e = \pi(-1)$. If the central bank decreases interest rate and hits zero we get that $r = 0 - \pi(-1) = -\pi(-1)$

So if inflation is negative, the real zero lower bound is positive. If the natural rate of interest is below the real zero lower bound, the central bank will not be able to reach it. Then the economy is stuck below natural level of output and inflation will be decreasing, increasing real interest rate further, decreasing output even more, decreasing inflation and so on. This is called a *deflation spiral*.

Stagflation:

Imagine a change in e.g. oil prices. This is an increased cost for firms which they will pass on to the consumers. This can be seen as an increase in m . Remember the PS relation $W/P = 1/(1+m)$. Increase in m will shift the PS curve down, increase u_n and thus decrease Y_n . The PC will shift to the left. In the transition between the short and medium run the economy will experience increased inflation rate, which in the medium run will lead to the central bank increasing interest rate, decreasing output. This increase in inflation while output decreases is called *stagflation*



Topic 9 – Exchange rate regimes

IS-LM-PC in open economy in the medium run:

Changes from previous topics: In topic 5 we disregarded price fluctuations and assumed that $r = i$ and $E = \epsilon$. In the medium run this is not valid assumptions. We will now look at the IS-LM model in open economy with $r = i - \pi^e$ and $\epsilon = \frac{EP}{P^*}$

To sum up:

Goods market, IS: $Y = C(Y^D) + I(Y, i - \pi^e) + G + NX(Y, Y^*, \frac{EP}{P^*})$

Financial market, LM: $i = \bar{i}$

Bonds market, IPC: $E = \frac{1+i}{1+i^*} E^e$

Inflation, PC: $\pi - \pi^e = \left(\frac{\alpha}{L}\right) (Y - Y_n)$

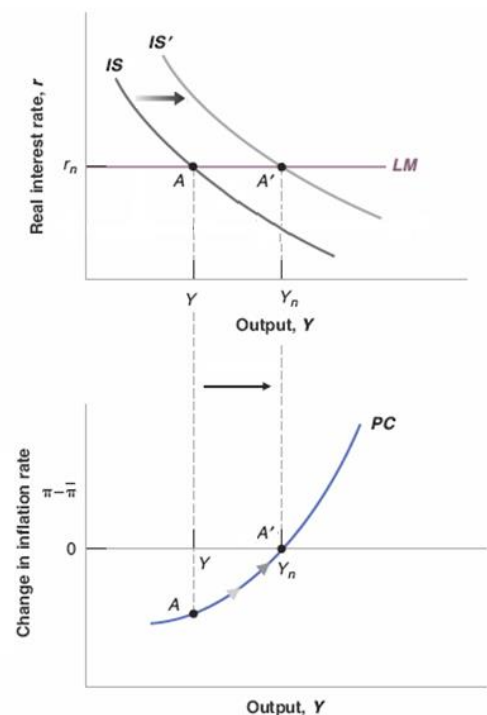
In open economy we must take into account that when the economy is above or below the natural level of output, prices will increase or decrease respectively. This will in turn push the real exchange rate up or down respectively, leading to a decrease or increase in net exports and thus also in output.

IS-LM-PC in open economy:

For simplification we assume that expected inflation and foreign inflation is constant, $\bar{\pi}$.

If the domestic economy is below its natural level, inflation rate will decrease, and thus the domestic prices will increase slower than foreign prices. This will decrease the real exchange rate even if the nominal exchange rate remains constant (independent of exchange rate regime), leading to net exports increasing (Marshall Lerner condition).

Over time (medium run) NX will increase enough to bring the economy up to its natural level. This does however take a long time, so the government or central bank might want to intervene to speed up the process



Exchange rate regimes:

Flexible exchange rate regime: If the economy is below its natural level, the government and central bank can utilize expansionary fiscal or monetary policy to bring the economy back up. They can also choose not to intervene and let the economy slowly get back the natural level on its own.

Fixed exchange rate regime: If the economy is below its natural level, the government can utilize expansionary fiscal policy to bring the economy back up. The central bank cannot utilize monetary policy as this would change interest rate which would change the exchange rate (no longer fixed). They can also choose not to intervene and let the economy slowly get back to its natural level on its own.

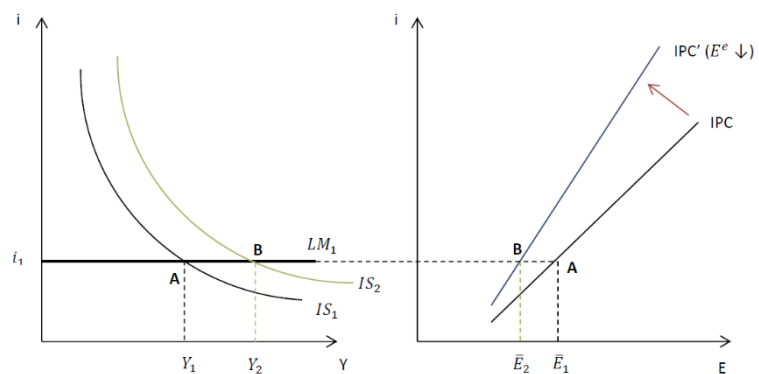
One thing that is also possible in a fixed exchange rate regime is to devalue. By decreasing the interest rate or by selling domestic currency the nominal exchange rate would drop. This will push NX up and shift the IS curve to the right, bringing the economy back to its natural level. This kind of policy does however breed distrust in the fixed exchange rate regime and is often avoided if possible.

Speculative attack/exchange rate crisis (fixed exchange rate)

If people believe there is going to be a devaluation, they will start buying foreign bonds lowering demand for domestic currency. To keep the fixed exchange rate the central bank would have to increase interest rate which will lead to a decrease in output. If it does adjust the interest rate, people will sell their domestic bonds and buy foreign bonds, lowering demand for domestic currency. The central bank will have to compensate for this by selling its own foreign bonds and buying domestically. If it runs out of foreign bonds, it will have to devalue or let the currency float.

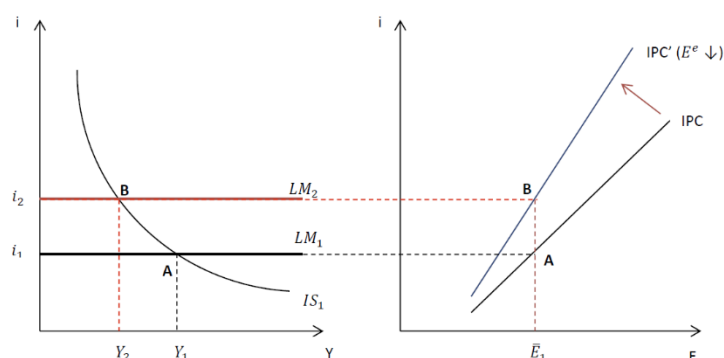
Giving in (devalue): We can rearrange the IPC, $i = \frac{1+i^*}{E^e}E - 1$. From this we can more easily see that a decrease in expected exchange rate, will lead to a steeper slope of the IPC; it rotates upwards.

This will for a given interest rate decrease the exchange rate, which in turn will increase NX and thus increase output.



Maintaining the parity:

Here the slope of the IPC will also increase, but the central bank will increase interest rate to keep the fixed exchange rate. This will lower investment and in turn output.



Topic 10 – Growth theory (Solow model)

Note for you who are reading through this chronologically:

Phew! That was a lot to take in huh? But you made it! Great job! You might feel like you can't juggle anymore in your head now, but don't worry. We're now moving to the long run where things are vastly different and to some extent not really related to what is happening in the short and medium run. Do you realize what that means? You don't really have to worry about combining this with everything you've learnt in the past 9 topics! See this as a new independent topic. You are awesome, hang in there, I believe in you, you can do this!

Positive Possum believes you can do the thing



Output in the long run:

Aggregate production function: in the long run capital and labor size is no longer fixed. Output can be seen as a function of these:

$$Y = F(K, N)$$

where K is capital (machines, plants etc.) and N is the labor/number of workers

Returns to scale: describes what happens to output when inputs are doubled (double the amount of capital and workers)

Constant returns to scale: Double the amount of output

Decreasing returns to scale: Less than double the amount of output

Increasing returns to scale: More than double the amount of output

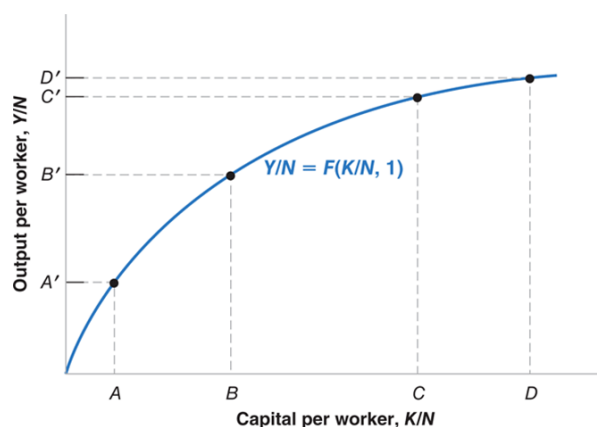
Output per worker:

We can rewrite the production function in per worker terms:

$$\frac{Y}{N} = F\left(\frac{K}{N}, \frac{N}{N}\right) = F\left(\frac{K}{N}, 1\right)$$

For now we assume that the population is not growing; N is fixed. When increasing capital with a fixed amount of workers, the output will increase less and less; decreasing returns to capital.

This is because a worker with little capital can do a lot more with a little more capital, while a worker who already has a lot of capital can only do a little more with a little more capital.



Technological progress: If technology increases, output per worker would shift upwards, because every worker would be able to produce more with any given amount of capital (more on this later)

Solow model:

Note: we change the notation from $Y/N = F(K/N, 1)$ to $Y/N = f(K/N)$

Investment and savings rate: Remember that in equilibrium in the goods market in closed economy, investment = savings. We disregard the savings made by the government so that $I = S^{\text{private}}$

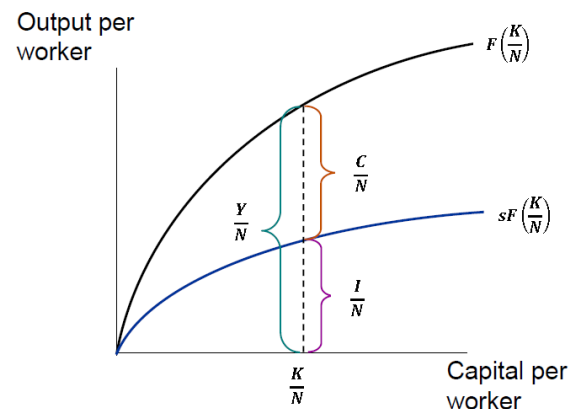
People save a fraction, s , of their income and consume a fraction $1-s$ of their income. This we can use to rewrite the equation in terms of investment per worker

$$I = sY$$

$$\frac{I}{N} = s \frac{Y}{N}$$

$$\frac{I}{N} = sf\left(\frac{K}{N}\right)$$

The savings rate, s , determine how income is divided between consumption and investment.



Investment and capital: capital depreciates over time. To determine the amount of capital available to us in the future we can write the following

$$K_{t+1} = (1 - \delta)K_t + I_t$$

So capital in the future is equal to the capital today minus the capital that depreciates, plus the investment made in new capital. This is *the law of motion of capital*.

We can rewrite this

$$K_{t+1} - K_t = I_t - \delta K_t$$

$$K_{t+1} - K_t = sY_t - \delta K_t$$

$$\frac{K_{t+1}}{N} - \frac{K_t}{N} = s \frac{Y_t}{N} - \delta \frac{K_t}{N}$$

$$\frac{K_{t+1}}{N} - \frac{K_t}{N} = sf\left(\frac{K_t}{N}\right) - \delta \frac{K_t}{N}$$

The difference in capital is equal to the amount of capital invested minus the amount of capital that depreciates.

If more is invested than depreciates, capital per worker will go up.

If less is invested than depreciates, capital per worker will decrease.

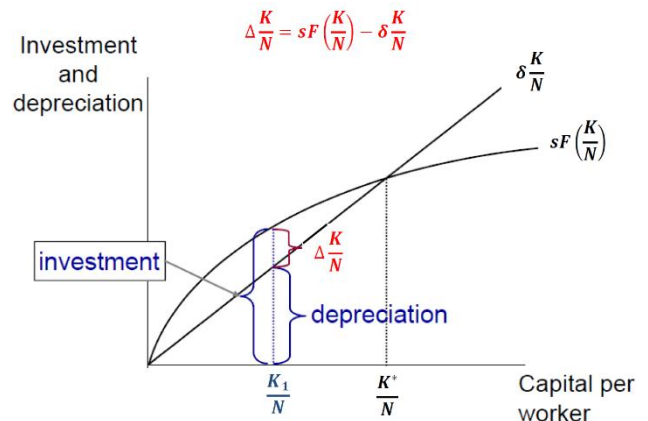
If just as much is invested as depreciates, capital per worker will stay constant; **steady state**

So the steady state is when $sf\left(\frac{K_t}{N}\right) = \delta \frac{K_t}{N}$.

This will be denoted K^* , $sf\left(\frac{K^*}{N}\right) = \delta \frac{K^*}{N}$.

The steady state value of capital per worker will yield the steady state value of output per worker:

$$\frac{Y^*}{N} = f\left(\frac{K^*}{N}\right)$$



The economy will converge towards the steady state.

If investment is larger than depreciation, capital per worker will keep growing until we hit K^*/N .

If investment is smaller than depreciation, capital per worker will decrease until we hit K^*/N .

How to calculate K/N , Y/N and C/N at the steady state:

Suppose we have the following information:

$$Y = K^{0,5}N^{0,5}$$

$$s = 0,3$$

$$\delta = 0,1$$

We can immediately see that this production function has constant returns to scale because adding the exponents $0,5+0,5 = 1$. If they add up to >1 there is increasing returns to scale, and if they add up to <1 there is decreasing returns to scale.

We start off by rewriting the production function in terms of per worker

$$\frac{Y}{N} = \frac{K^{0,5}N^{0,5}}{N} = \frac{K^{0,5}}{N^{0,5}} = \left(\frac{K}{N}\right)^{0,5}$$

We know that at the steady state $sf\left(\frac{K}{N}\right) = \delta \frac{K}{N}$.

We just found Y/N as a function of K/N , which is $f\left(\frac{K}{N}\right)$, so we can insert $\left(\frac{K}{N}\right)^{0,5}$ instead of $f\left(\frac{K}{N}\right)$:

$$s\left(\frac{K}{N}\right)^{0,5} = \delta \frac{K}{N}$$

$$\frac{s}{\delta} = \left(\frac{K}{N}\right)^{0,5}$$

$$\left(\frac{s}{\delta}\right)^2 = \frac{K}{N}$$

We now insert the values of s and δ

$$\frac{K}{N} = \left(\frac{0,3}{0,1}\right)^2 = 9$$

This we can now insert in the function for output per worker from previously

$$\frac{Y}{N} = \left(\frac{K}{N}\right)^{0,5} = 9^{0,5} = 3$$

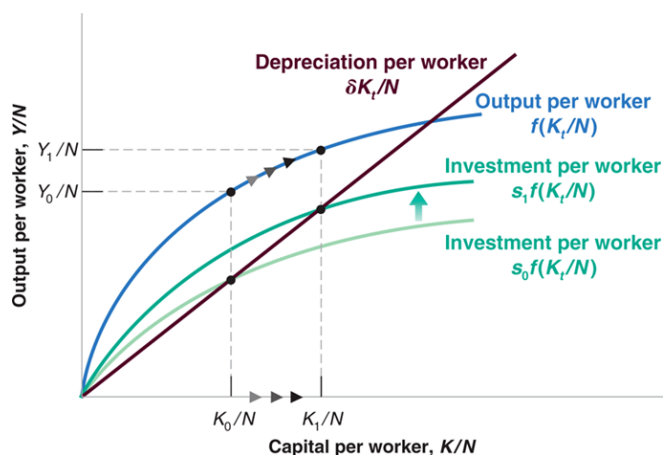
To find the consumption per worker, remember that people save sY and consume $(1-s)Y$. We write this in terms of per worker

$$\frac{C}{N} = (1 - s) \frac{Y}{N}$$

$$\frac{C}{N} = (1 - 0,3)3 = 2,1$$

Solow model and savings:

Increase in savings rate: Investment is equal to savings, so if the savings rate goes up, there will be more investment per worker, which will increase the growth rate of capital per worker and thus also output per worker. This increases the steady state level of capital per worker and thus also output per worker.



Golden rule savings rate: It might be ideal to have a savings rate such that the steady state yields the maximum consumption per worker.

If nothing is saved ($s = 0$), nothing will be invested, there will be no output and therefore no consumption.

If everything is saved ($s = 1$), everything will be invested and there will be nothing left for consumption.

The optimal level of savings rate is somewhere in between ($0 < s < 1$).

To find this, let us look at what determines consumption

$$\frac{Y}{N} = \frac{C}{N} + \frac{I}{N}$$

$$\frac{C}{N} = \frac{Y}{N} - \frac{I}{N}$$

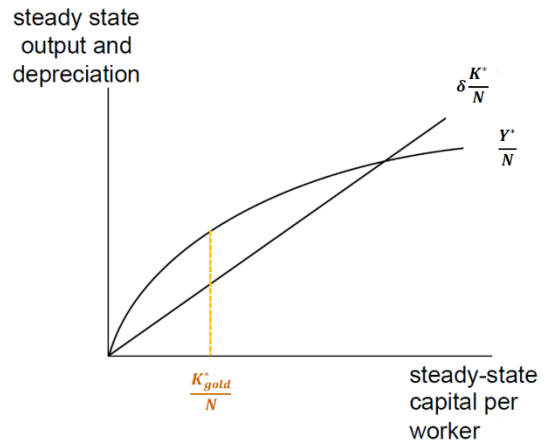
$$\frac{C^*}{N} = \frac{Y^*}{N} - \frac{I^*}{N}$$

$$\frac{C^*}{N} = f\left(\frac{K^*}{N}\right) - sf\left(\frac{K^*}{N}\right)$$

$$\frac{C^*}{N} = f\left(\frac{K^*}{N}\right) - \delta \frac{K^*}{N}$$

So consumption is what is left of steady state output after paying for what depreciates. Thus consumption is at its maximum when the difference between steady state output and depreciation is largest.

Graphically it is when the distance between the output and depreciation graph is the longest.



How to calculate the golden rule savings rate: Let us continue from the example from page 24.

To sum up:

$$\frac{K}{N} = \left(\frac{s}{\delta}\right)^2$$

$$\frac{Y}{N} = \left(\frac{K}{N}\right)^{0,5}$$

$$\frac{C}{N} = (1 - s) \frac{Y}{N}$$

We now want to express consumption per worker only in terms of savings rate and delta

$$\frac{C}{N} = (1 - s) \frac{Y}{N}$$

$$\frac{C}{N} = (1 - s) \left(\left(\frac{s}{\delta}\right)^2\right)^{0,5} = (1 - s) \frac{s}{\delta} = (s - s^2) \frac{1}{\delta}$$

We now take the derivative with respect to s and set it equal to zero to maximize consumption per worker

$$\frac{d \frac{C}{N}}{ds} = (1 - 2s) \frac{1}{\delta} = 0$$

$$1 - 2s = 0$$

$$s = 0,5$$

This is the golden rule savings rate for this example. It means that the optimal consumption per worker is when 50% of income is saved.

Note: the following sections are extensions of the Solow model. You will not be asked to do exercises in these, but you might just be asked about the intuition in the multiple-choice questions or the open question at the end. Cheer up!

This is a good thing! Now you can sit back and relax and only focus on understanding the intuition. No more complicated math calculations! You are quite incredible for making it this far. Now there's just a few more pages to go and you'll be a macro genius! Thanks for joining me on this journey.

Solow model and population growth:

Population growth: the population grows at a rate g_N . We assume that workers are a fixed proportion of the population, so the number of workers also grow as this pace

$$g_N = \frac{\Delta N}{N}$$

Effect of population growth on steady state: To keep capital per worker constant, investment must now be large enough to not only compensate for depreciation, δK , but also equip new workers with capital, $g_N K$. The new law of motion of capital thus becomes

$$\Delta K = I - (\delta + g_N)K$$

Or expressed in terms of per worker

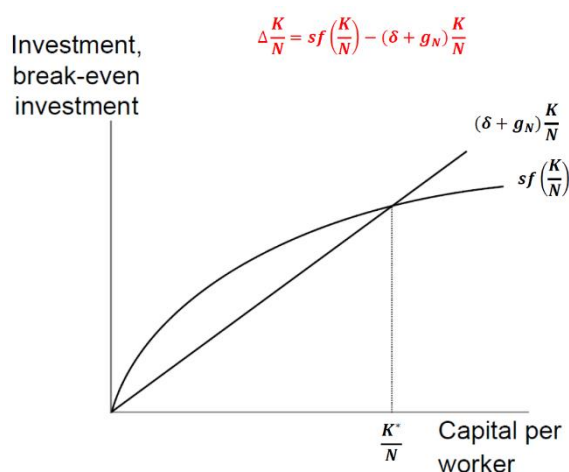
$$\Delta \frac{K}{N} = \frac{I}{N} - (\delta + g_N) \frac{K}{N}$$

$$\Delta \frac{K}{N} = s \frac{Y}{N} - (\delta + g_N) \frac{K}{N}$$

$$\Delta \frac{K}{N} = sf\left(\frac{K}{N}\right) - (\delta + g_N) \frac{K}{N}$$

At the steady state $sf\left(\frac{K}{N}\right) = (\delta + g_N) \frac{K}{N}$.

Because output per worker is constant at the steady state, output is growing at a rate g_N .



If the growth rate increases, the graph of $(\delta + g_N) \frac{K}{N}$ will become steeper, thus lowering the steady state capital and output per worker.

Solow model and technological progress:

Technology and the production function: The higher the technological level, A , the higher the output. Thus we can express the production function as following

$$Y = F(A, K, N)$$

(+, +, +)

We will assume that technology only affects the productivity of labor and not capital:

$$Y = F(K, AN)$$

AN is the amount of effective workers, i.e. if technology e.g. doubles, every worker will be as effective as two workers.

Instead of expressing everything in per worker terms, we will now express it in effective worker terms:

$$K/AN \quad I/AN \quad Y/AN \quad C/AN$$

Apart from increasing technology now impacting the amount of effective workers, the previous assumptions and intuitions still hold.

Technological progress: the technological progress is denoted

$$g_A = \frac{\Delta A}{A}$$

Effect of technological progress on steady state: To keep capital per worker constant, investment must now be large enough to not only compensate for depreciation, δK , and equip new workers with capital, $g_N K$, but also equip the new effective workers created by technological progress with capital. The new law of motion of capital thus becomes

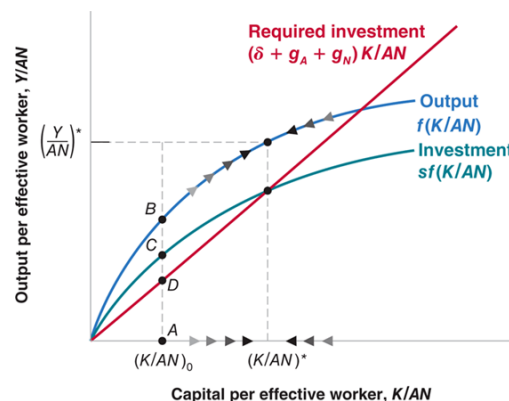
$$\Delta K = I - (\delta + g_N + g_A)K$$

Or expressed in terms of per effective worker

$$\Delta \frac{K}{AN} = \frac{I}{AN} - (\delta + g_N + g_A) \frac{K}{AN}$$

$$\Delta \frac{K}{AN} = sf\left(\frac{K}{AN}\right) - (\delta + g_N + g_A) \frac{K}{AN}$$

At the steady state $sf\left(\frac{K}{AN}\right) = (\delta + g_N + g_A) \frac{K}{AN}$



AN grows at a rate $g_N + g_A$. Because output and capital per effective worker is constant at the steady state, output and capital is also growing at a rate $g_N + g_A$. Capital and output per worker is growing at a rate g_A at the steady state.

To sum up, the growth rates of the different concepts at the steady state are:

Concept:	Growth rate:
Capital per effective worker	0
Output per effective worker	0
Capital per worker	g_A
Output per worker	g_A
Labor	g_N
Capital	$g_A + g_N$
Output	$g_A + g_N$