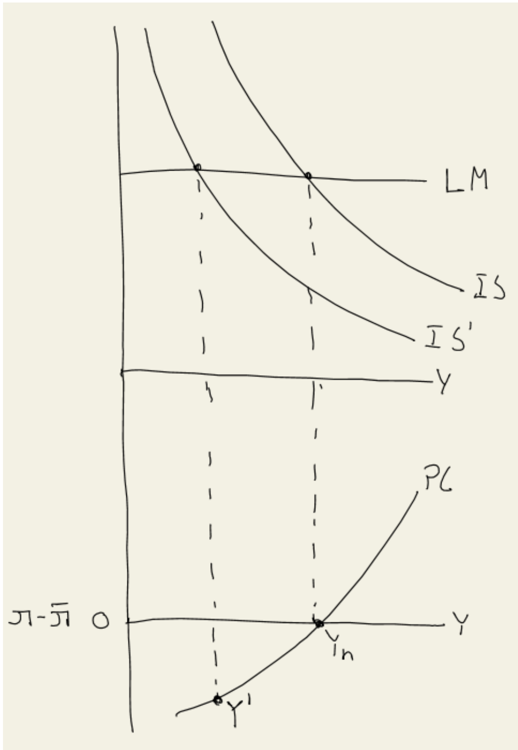
## Multiple Choice

1. B
2. B
3. A
4. B
5. B

## Exercise 1

# a)

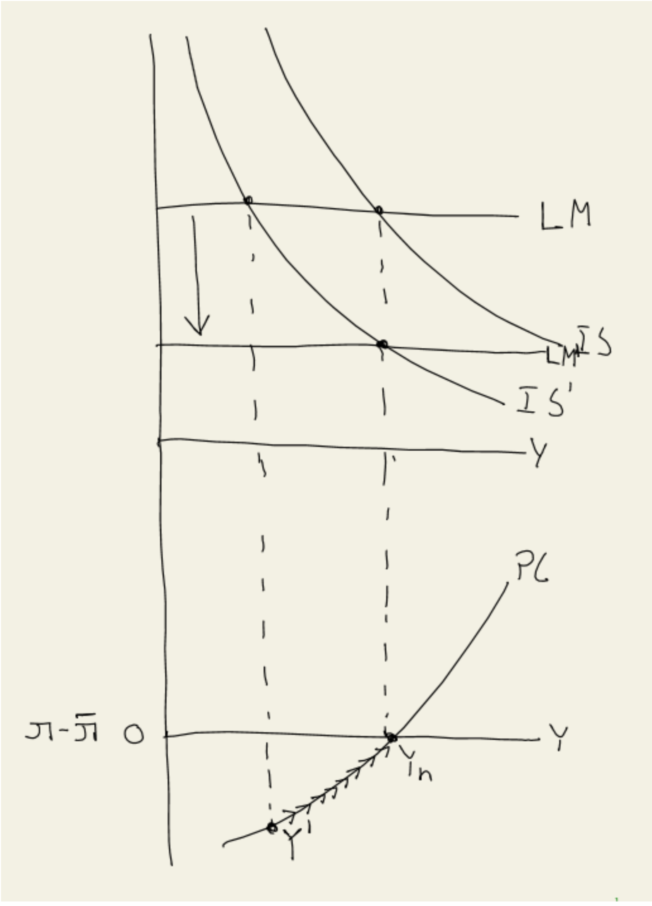
Based on table 1 we see that for every eurozone country the consumer confidence dropped after the war in Ukraine. This has led to a decrease in $c_0$ for every country (although the magnitude of this change varies). The decrease in consumer confidence has led to a decrease in consumption and hence a decrease in output. Because output has decreased, disposable income (which is a function of output) has also decreased, which further has led to lower output through the multiplier. (If we assume that investment has the parameter; $d_1 Y$, then investment will also be reduced through the multiplier).




The decrease in output has shifted the IS curve to the left, which has led to an equilibrium output below potential. Because of this reduced output, less workers are needed and hence unemployment goes up. With higher unemployment, we expect lower nominal wages (remember that $W = P^e F(u, z)$). These lower nominal wages lead to lower prices, which lead to lower inflation. This is why we are at a point on the Philips curve, where we have inflation below target.

# b)

The Central Bank's job is to keep inflation in check. Hence, it can be expected, that it will regulate the real interest rate (through its policy rate) to bring inflation back up to target. In this case, it is done through expansionary monetary policy. This is where the central bank buys bonds, which increase the demand for bonds, which increase the price for bonds which then lowers the policy rate $i$. This leads to a lower real interest rate (assuming constant inflation), which leads to a lower borrowing rate (assuming constant risk premium), which encourages investment. When investment goes up, output goes up, which increases disposable income through the multiplier. So, in conclusion, the central bank reduces the real interest rate to bring back output to its normal level. This is seen in the IS-LM-PC graph below:




# c)

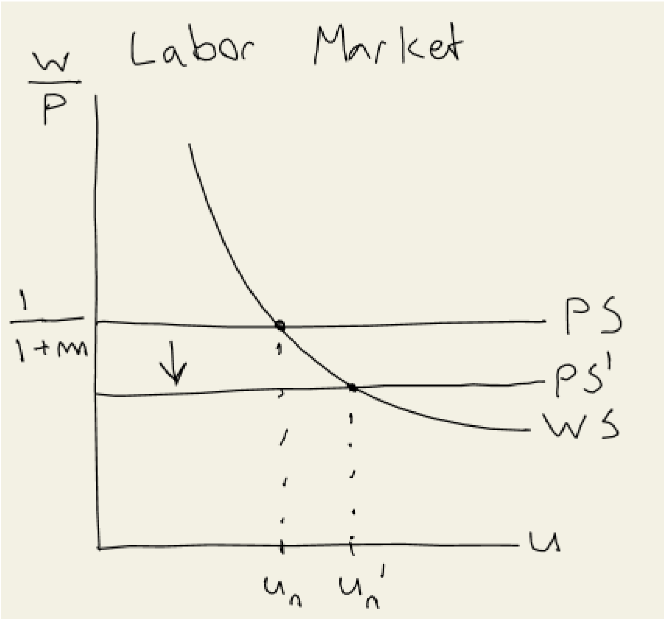
The composition of output is different in the medium run. Previously, we had a higher consumer confidence, which meant we had a higher consumption. At the same time we saw lower investment thanks to the higher real interest rate.

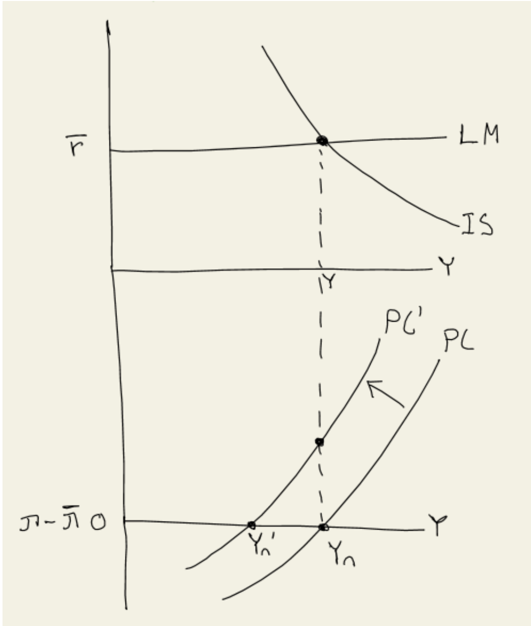
In the new scenario (medium run), we see increased investment, due to the lower real interest rates, and a lower consumption (although this consumption is higher consumption than in the short run, since we increased disposable income when we went from short to medium run). Government spending remains the same. In total, the reduction in Y caused by the reduction in consumer confidence, is offset by the increased investment.

# d)

Here, we proxy the increase in oil prices by an increase in the markup. Hence, we must look at the labor market.

When the oil prices increase, we shift the PS-curve downwards. This is because, due to the price increase, firms will be demanding a lower real wage (also, since m is in the denominator, real wages go down). Since the WS-curve is the same as before, the same amount of people are willing to work for any given real wage as before. So, when the real wage is shifted down, less people are willing to work for these new real wages, and thus we see an increase in the natural level of unemployment.




When the natural level of unemployment shifts, we will likewise see a shift in the Philips curve. This is due to the natural level of output and potential output being negatively correlated.

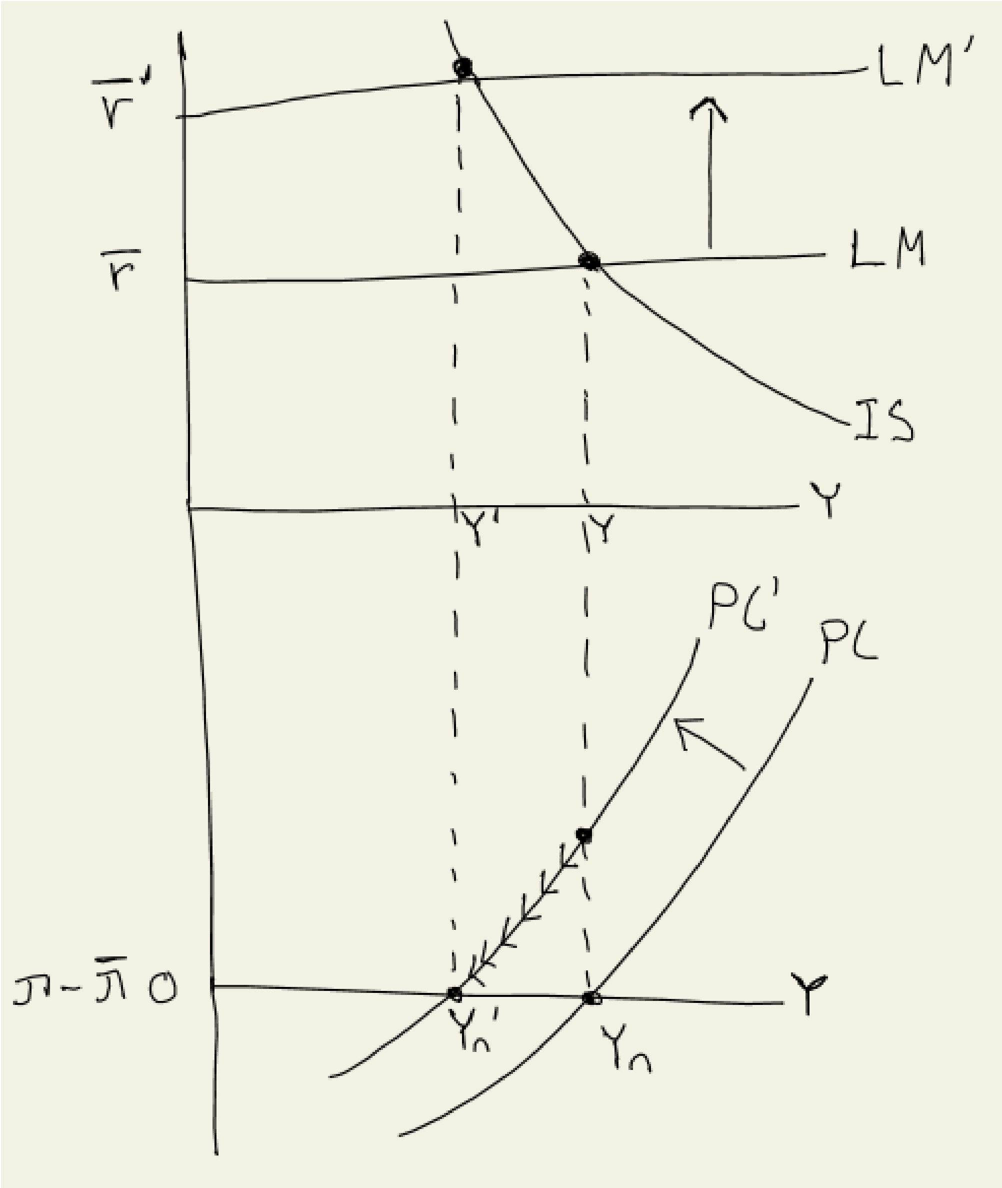
As we can see, we are now in a situation (in the short run) where we will see inflation above the target. This is of course due to the fact that the increased markup lead to increased prices. The whole chain of events go like this:

$$m \uparrow \Rightarrow P \uparrow \Rightarrow \pi \uparrow$$

The reason the answer differs from question a) is because here in d) we talk about a shift in the PS-curves and Philips-curves, rather than a shift in the IS-curve. A leftward shift in the IS curve leads to inflation below target, whereas a downward shift of the PS-curve, leads to a leftward shift in the Philips curve, with reduced potential output. The changes happen with different variables ($c_0$ and $m$) and is thus applied through different models.

# e)

Since the Central Banks job is to keep inflation in check, the central bank can be expected to react with contractionary monetary policy. Inflation is too high, and the central bank will combat this by selling bonds. By selling bonds, demand for bonds become lower, the prices for bonds become lower and thus, the interest rate becomes higher. Since we assume risk premium to be constant, the real interest rate increases. We thus, see an upwards shift in the LM-curve. The increased real interest rate, increases borrowing rate, which reduces people's incentive to invest. Investment is lowered, leading to a reduction in output. The reduction in output leads to reduced consumption, as disposable income is reduced through the multiplier. (If we assume that investment has the parameter; $b_1Y$, then investment will also be further reduced through the multiplier). This overall leads to a reduced equilibrium output. The reduced equilibrium output, leads to higher unemployment which makes us move down the WS curve into the new natural rate of unemployment. At this state (medium run equilibrium), output is also equal to the new potential output. The higher real interest rate $\bar{r}'$ is now the new natural interest rate $r_n$.




# f)

The big tradeoff with these two situations happening simultaneously is, that on one hand, the central bank wants to reduce its policy rate, thus shifting the LM-curve downwards to increase output; whereas on the other hand, the central bank wants to increase its policy rate, shift upwards the LM curve to combat the rising inflation caused by the increase in energy prices. Overall, it must be a really tough situation for the central bank, especially considering we already came out of the COVID-19 crisis. Furthermore, we see shortages on many goods, too, e.g. semiconductor chips. Perhaps this is also why the central bank has been lenient with combating inflation in 2022, only stopping its PSAPP-programme, but not increasing its policy rate unlike the FED.

The central bank must choose whether it wants to combat inflation, or keep the economy from going into a recession. Depending on where what the actual situation looks like (taking both these changes into account at the same time), if we are in a situation with inflation below target, it might be an idea to use a policy-mix where the government also helps with expansionary fiscal policy. However, it seems quite unlikely that this is the case, as inflation is very high all around the world.

# Exercise 2

## a)

**IS-relation**

$$Y = C + I + G$$

$$Y = c_0 + c_1 Y - c_1 T + I_0 + d_1 Y - d_2(r + x) + G$$

$$Y - c_1 Y - d_1 Y = c_0 - c_1 T + I_0 - d_2(r + x) + G$$

$$(1 - c_1 - d_1)Y = c_0 - c_1 T + I_0 - d_2(r + x) + G$$

$$\boldsymbol{Y = \frac{1}{1 - c_1 - d_1}(c_0 - c_1 T + I_0 - d_2(r + x) + G)}$$

Now we have the general IS relation.

Plugging in the numbers we get:

$$Y = \frac{1}{1 - 0{,}6 - 0{,}15}(200 - 0{,}6(500) + 100 - 2500(r + x) + 550)$$

$$Y = 4(200 - 300 + 100 - 2500(r + x) + 550)$$

$$Y = 4(550 - 2500(r + x))$$

$$Y = 2200 - 10000(r + x)$$

**LM-relation**

$$\boldsymbol{r = i - \pi^e}$$

$$r = \bar{r}$$

$$\bar{r} = i - \pi^e$$

Plugging in the numbers we get:

$$\bar{r} = 0{,}04 - 0{,}02$$

$$\boldsymbol{\bar{r} = 0{,}02}$$

**The equilibrium output:**

Inserting the LM equation into the IS relation, we get:

$$Y = 2200 - 10000(0{,}02 + 0)$$

$$Y = 2200 - 200$$

$$\boldsymbol{Y = 2000}$$

**The equilibrium disposable income:**

We plug our numbers into the formula:

$$Y_D = Y - T$$

$$Y_D = 2000 - 500$$

$$\boldsymbol{Y_D = 1500}$$

**The equilibrium consumption:**

We plug our numbers into the formula:

$$C = c_0 + c_1(Y_D)$$

$$C = 200 + 0{,}6(1500)$$

$$C = 200 + 900$$

$$\boldsymbol{C = 1100}$$

**The equilibrium investment:**

We plug our numbers into the formula:

$$I = I_0 + d_1 Y - d_2(r + x)$$

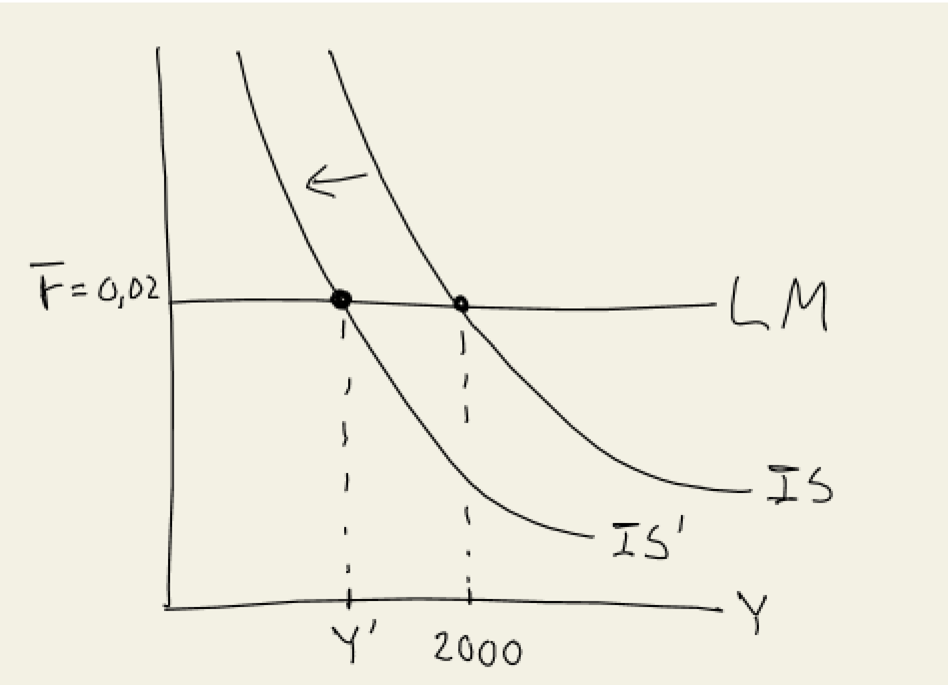
$$I = 100 + 0{,}15(2000) - 2500(0{,}02 + 0)$$

$$I = 100 + 300 - 50$$

$$\boldsymbol{I = 350}$$

**In conclusion, the equilibrium levels are: $\boldsymbol{Y = 2000}$ ; $\boldsymbol{Y_D = 1500}$ ; $\boldsymbol{C = 1100}$ ; $\boldsymbol{I = 350}$**

# b)




A decrease in the autonomous component of investment, $I_0$, leads to lower output, and hence, shifts the IS curve to the left. Based on the general IS curve derived earlier, we can easily pinpoint what happens when $I_0$ gets reduced. Since we know from before that the multiplier is 4, the effect of a decrease in autonomous spending will be multiplied 4 times, so a reduction of 50 will reduce equilibrium output by 200. This because, a decrease in $I_0$ decreases Y, which then further reduces investment and consumption through the multiplier. (Remember that Investment depends on Y, in the $d_1Y$ parameter).

$$Y = \frac{1}{1 - c_1 - d_1}(c_0 - c_1T + I_0 - d_2(r + x) + G)$$

**So in conclusion, both the decrease in output and investment will be greater than 50, as both has exogenous variables which depend on Y.**

# c)

To check the output rate required, we can solve for the real interest rate. We know, that since expected inflation is 2%, the lowest possible real interest rate achievable is minus inflation, in this case -0,02. We still assume risk premium is 0.

$$2000 = 4(200 - 0{,}6(500) + 50 - 2500(r + 0) + 550)$$

$$2000 = 4(500 - 2500r)$$

$$2000 = 2000 - 10000r$$

$$10000r = 2000 - 2000$$

$$\boldsymbol{r = 0}$$

Setting the policy rate to $i = 0{,}02$, making the real interest rate $r = 0{,}02 - 0{,}02 = 0$ will give:

$$Y = 4(200 - 300 + 50 - 2500(0 + 0) + 550)$$

$$Y = 4(500)$$

$$\boldsymbol{Y = 2000}$$

**In conclusion, the required real interest rate is r=0 to bring output back to Y=2000. This is possible, as it would simply require the central bank to reduce its policy rate from 4% down to 2%. That way $\boldsymbol{r = 0{,}02 - 0{,}02 = 0}$.**

# d)

Yes, it is still possible to bring output back to its initial level. As mentioned, the lowest possible real interest rate, is minus inflation. And minus inflation, would in this case be 0% with the new lower inflation. Hence, if the central bank reduces its policy rate further, all the way down to 0%, it can still reach the old level of output. However, bear in mind, that now, the central bank has hit the zero lower bound and is unable to reduce its policy rate further, so if we later end up seeing deflation, or a risk premium increase, the central bank might be in an unfortunate situation.

Setting the policy rate to $i = 0$, making the real interest rate $r = 0 - 0 = 0$ will give:

$$Y = 4(200 - 300 + 50 - 2500(0 + 0) + 550)$$

$$Y = 4(500)$$

$$\boldsymbol{Y = 2000}$$

**In conclusion, it is still possible. Central bank should set its policy rate at $\boldsymbol{i = 0}$**

# e)

$$2000 = 4(200 - 0{,}6(500) + 50 - 2500(r + 0{,}01) + 550)$$

$$2000 = 4(500 - 2500r - 25)$$

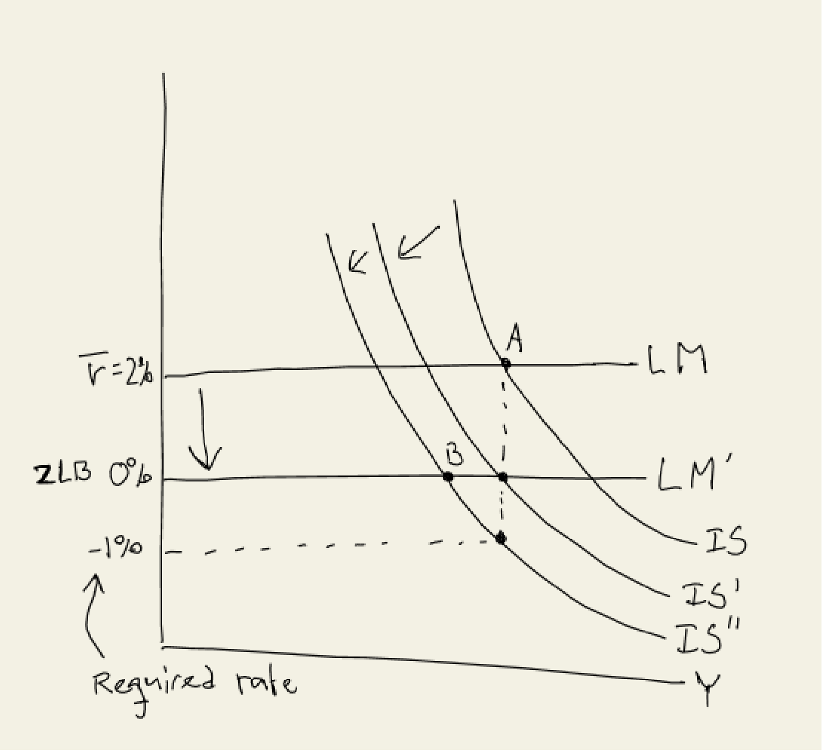
$$2000 = 4(475 - 2500r)$$

$$2000 = 1900 - 10000r$$

$$10000r = -100$$

$$\boldsymbol{r = -0{,}01}$$

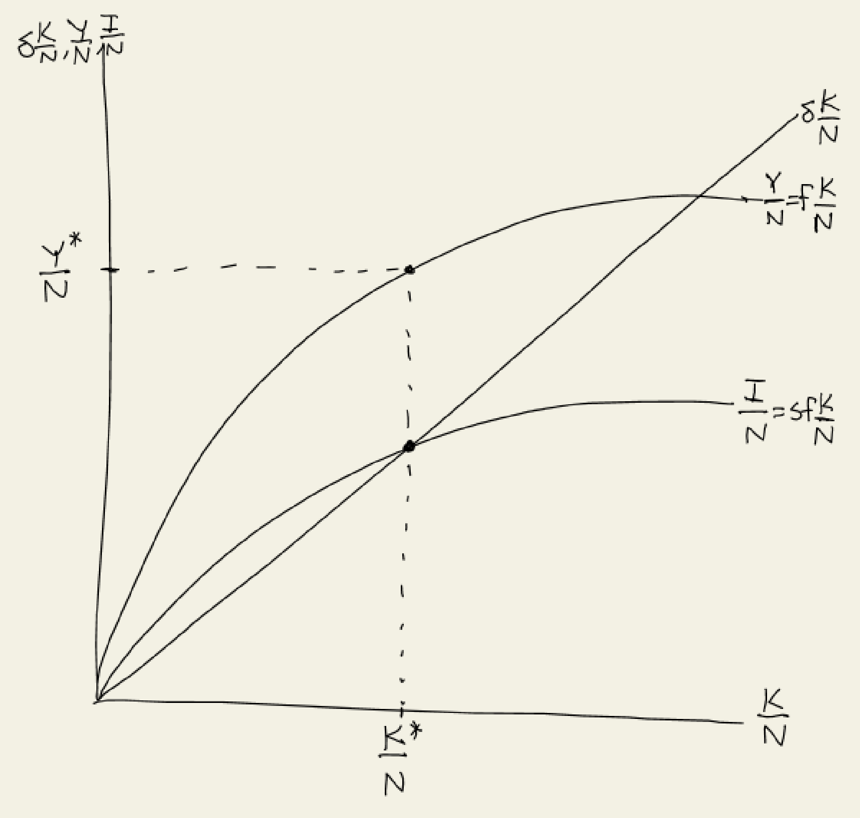
If the risk premium was to increase to 1%, then the required real interest rate to bring output back to normal would be -1%. Since, the lowest possible real interest rate the central bank can set, is minus inflation (which is 0%), the central bank will not be able to bring output back to the original level.




As you can see from the IS-LM model here, the required level in order to bring output back to normal is at -1%. However, the central bank cannot shift the LM curve down below the 0% mark, as this is the zero lower bound. Hence, the highest possible output the central bank can achieve with its policy is at point B. It will help bring output up, but it will not be enough to bring it all the way up to the old output value.

## Exercise 3

# a)




The shape of output per worker and investment per worker is concave. On the other hand, the depreciation per worker is linear. How much lower the investment per worker curve is below the output per worker curve, depends on the savings rate.

The steady state equilibrium can be found at the intersection between investment and depreciation. The shape of all curves, are functions of K/N, which are based on a Cobb-Douglas production function with constant returns to scale. We also see decreasing returns to Capital and Labor.

# b)

The condition of the steady state is that investment equals required investment. In the case of no population and technological growth, it is simply depreciation.

SS condition:

$$I = I^r$$

$$sf\left(\frac{K^*}{N}\right) = \delta\frac{K^*}{N}$$

We start by inserting our output per worker function.

$$sf\left(\frac{K^*}{N}\right) = \delta\frac{K^*}{N}$$

$$s\left(\frac{K^*}{N}\right)^{\frac{1}{3}} = \delta\frac{K^*}{N}$$

Now we solve for K/N

$$s = \delta \frac{K^*}{N} / \left(\frac{K^*}{N}\right)^{\frac{1}{3}}$$

$$\frac{s}{\delta} = \left(\frac{K^*}{N}\right)^{\frac{2}{3}}$$

$$\left(\frac{s}{\delta}\right)^{\frac{3}{2}} = \left(\left(\frac{K^*}{N}\right)^{\frac{2}{3}}\right)^{\frac{3}{2}}$$

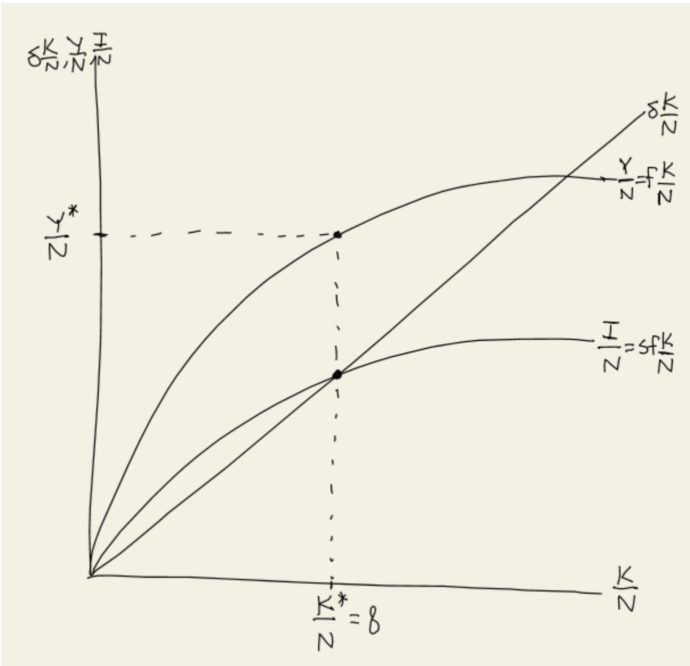
$$\left(\frac{s}{\delta}\right)^{\frac{3}{2}} = \frac{K^*}{N}$$

Now we have the steady state capital per worker as a function of s and delta. We can now insert our parameters.

$$\frac{K^*}{N} = \left(\frac{0,2}{0,05}\right)^{\frac{3}{2}}$$

$$\frac{K^*}{N} = (4)^{\frac{3}{2}}$$

$$\boldsymbol{\frac{K^*}{N} = 8}$$

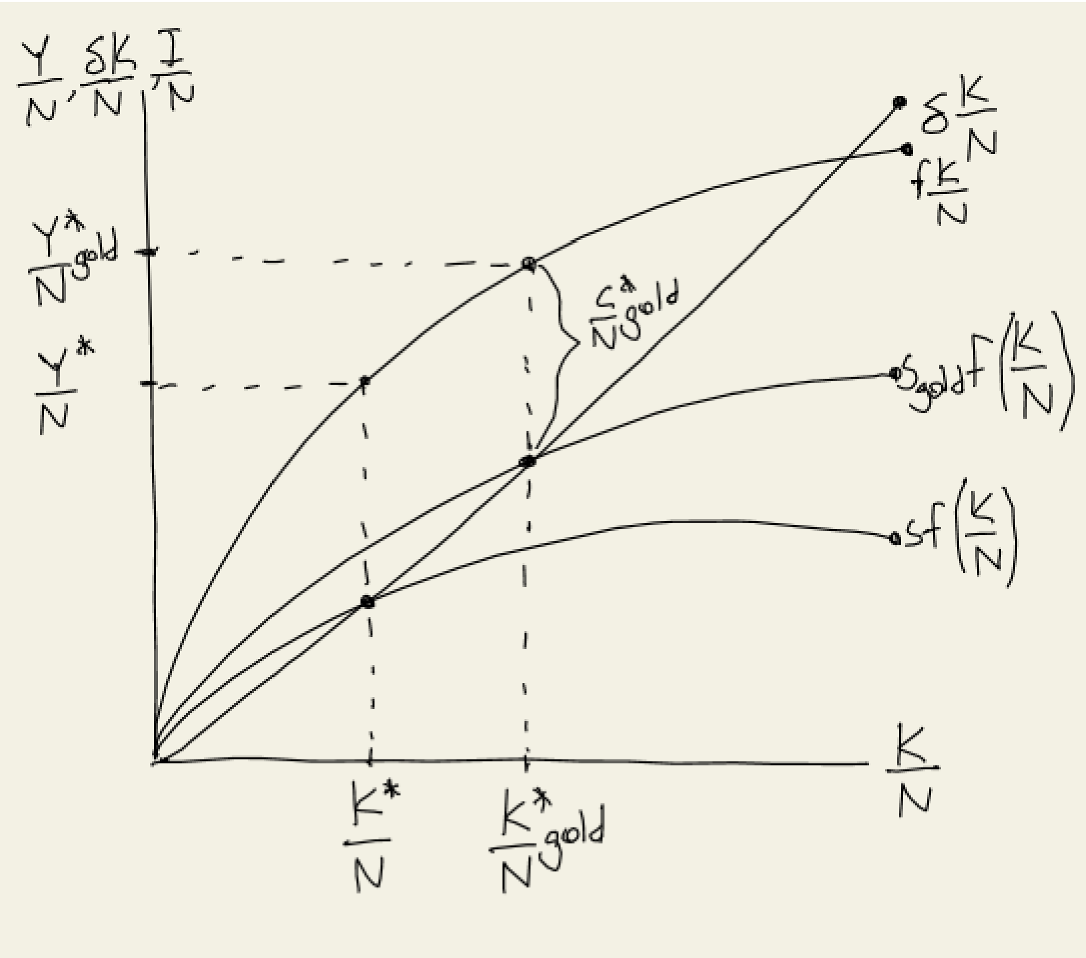



**To conclude, the steady state capital worker is 8. You can see it in the graph above.**

# c)

The golden rule level of capital per worker, is the level of capital per worker, which maximizes consumption per worker. This level is found by deriving the golden savings rate, which is the savings rate which gives the highest possible consumption per worker.

Why do people care about the golden rule? While both output and capital per worker keeps going up when we increase the savings rate, the change in consumption per worker is dependent on the golden rule savings rate: If we move away from the golden savings rate, we decrease consumption per worker; but if we move closer to it, we increase consumption per worker. Since consumption per worker is believed to be a proxy for welfare and living standard, it is generally seen as highly desirable to maximize consumption per worker. Therefore it becomes important to figure out what the golden savings rate is, and how the economy can move closer to it (assuming it is not already there).




## d)

To find the savings rate, when we are given a level of K/N is quite simple:

We have the equation from before:

$$\left(\frac{s}{\delta}\right)^{\frac{3}{2}} = \frac{K^*}{N}$$

We plot in our given number.

$$\left(\frac{s_{golden}}{\delta}\right)^{\frac{3}{2}} = 17{,}21$$

We assume that depreciation is still the same at 0,05.

We solve for s

$$\left(\frac{s_{golden}}{0{,}05}\right)^{\frac{3}{2}} = 17{,}21$$

$$\frac{s_{golden}}{0{,}05} = 17{,}21^{\frac{2}{3}}$$

$$\frac{s_{golden}}{0{,}05} = 6.666$$

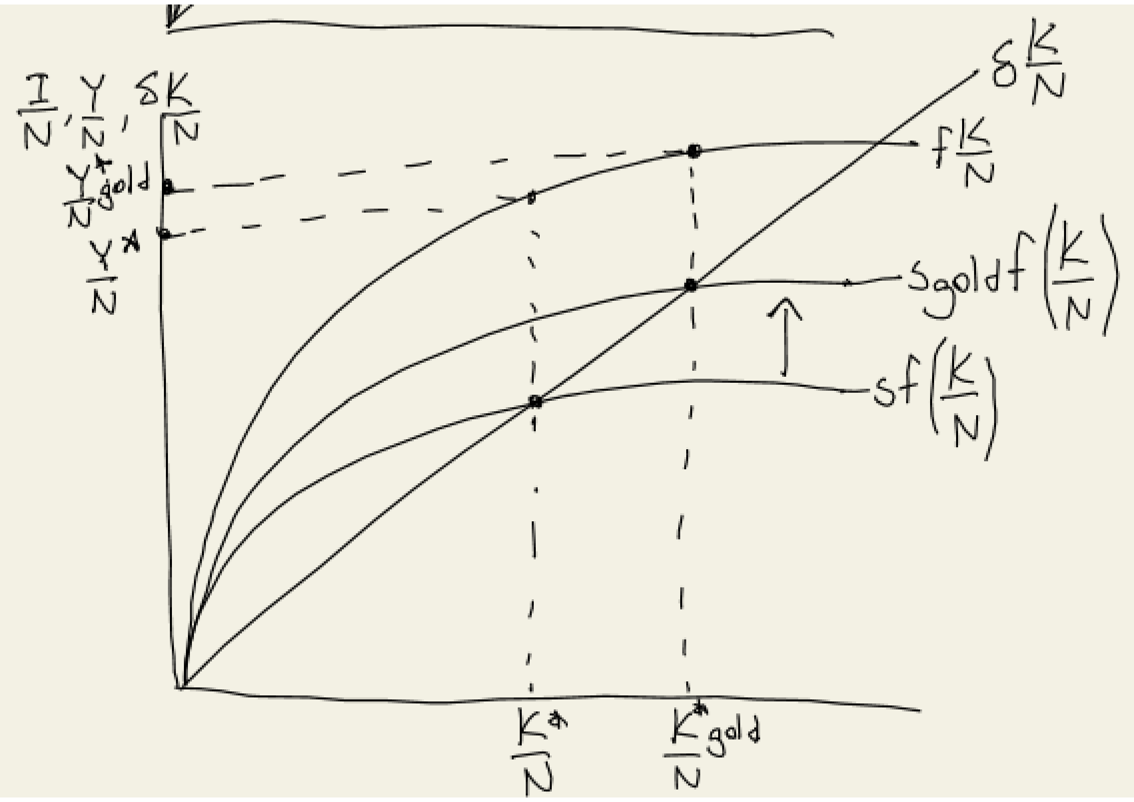
$$s_{golden} = 6.666 * 0{,}05$$

$$\boldsymbol{s_{golden} = 0{,}333}$$

**In conclusion, the golden savings rate that must be imposed is $\boldsymbol{s_{golden} = 0{,}333}$**

# e)

Before, we had a savings rate of 0,2. Increasing the savings rate to the golden savings rate, which is 0,333, will pivot the investment curve upwards once implemented. This will change the steady state, to a higher steady state output, capital and consumption per worker. The reason for this, is that with the new savings rate, we invest more, and hence, it will take longer for the depreciation (required investment) to be equal to our investment. Hence, the two curves intersect further to the right. We know that consumption goes up since we move closer to the golden savings rate.

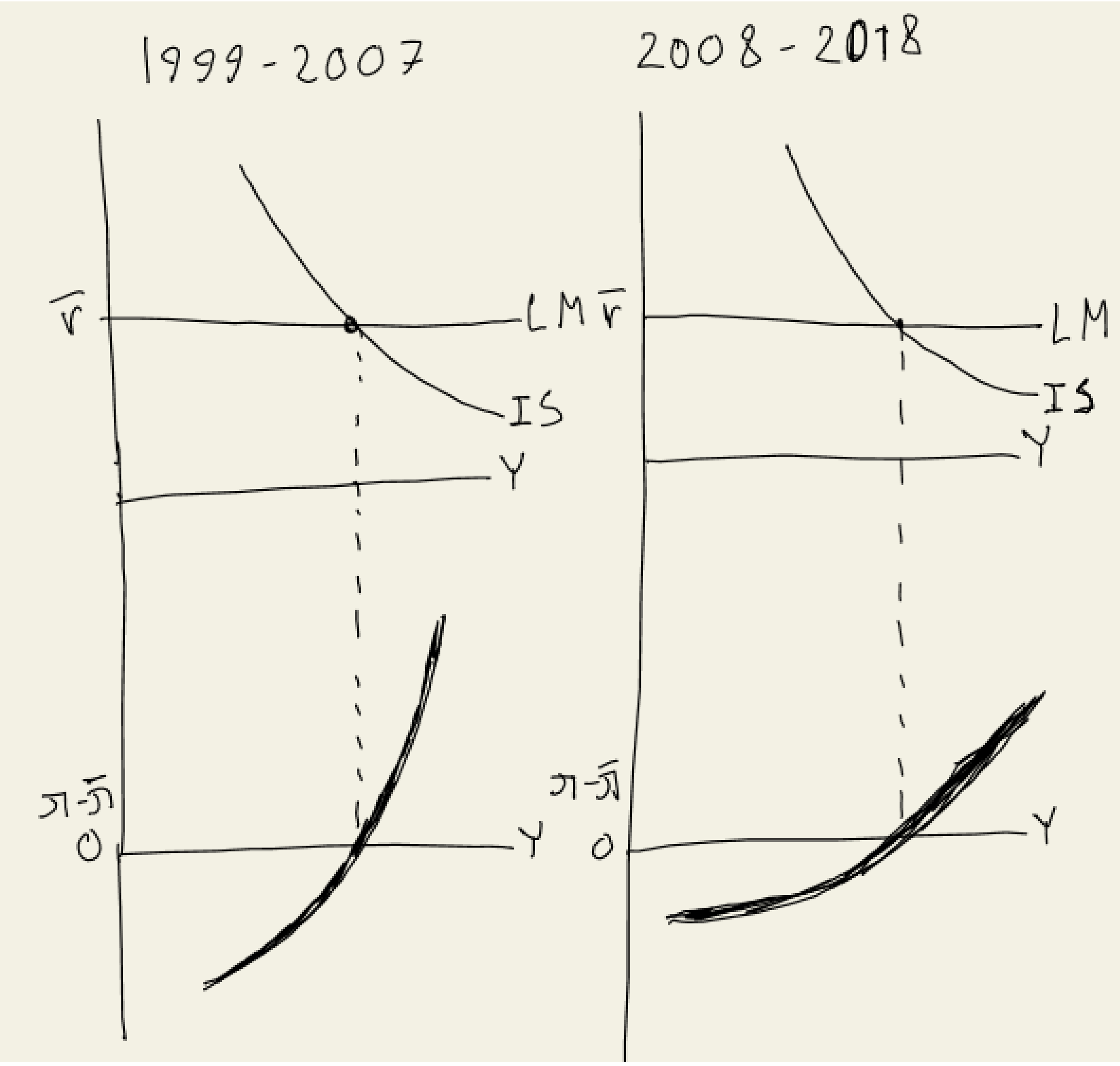



# f)

Following the change in the steady state, the economy will see a short term increase in growth rate. However, this is ONLY until it reaches its steady state. In the steady state, there is no growth in K/N or Y/N.

It is not always beneficial for the economy to aim for the highest possible savings rate. The higher the savings rate, the higher capital and output per worker. But as mentioned in part c), the most desirable savings rate will be the golden savings rate, which maximizes consumption per worker. In this case, since we shift the savings rate to the golden rate at s=0,333, it would not be a good idea to increase it further. Increasing the savings rate above the golden rate, will decrease consumption per worker. Since consumption per worker is seen as a proxy to welfare and living standard, this would be undesirable.

## Open question




Above, you see the flattening of the original Philips curve, also flattens the Philips curve which shows inflation minus target inflation. There are several implications of the flattening of the Philips curve. First of, it makes the inflation rate less sensitive to changes in output and unemployment. (We know that unemployment and output has an inverse relationship.) This means that changes shifts in the IS-LM model, will mean a lower change in inflation (in the absolute sense). What implications does this bring to the central bank? First of all, it should generally mean that, we see lower changes to inflation, and hence the central bank does not need to change its policy rate as much to combat this. However, it does also mean, that IF for some reason we still see high inflation (i.e. numbers that deviate as much from the target as before) then it will require more to bring back. This is because, we would be further out on the Philips curves, and thus the difference between the natural and current output level would be greater. The flattening of the Philips curve might not immediately be observed, since it requires you to know where you are on the Philips curve. In these times with unstable inflation, stagflation and supply shocks in 2022, it can be hard to derive where exactly we are on the Philips curve, as its constantly moving around. If we were at our medium run equilibrium, with inflation equal to target (and we knew this), I would argue that it would be easier for the Central bank to observe the flattening of the Philips curve. But it can be hard to spot a trend, when the Philips curve is constantly shifting, making the regression line into a cloud of datapoints.