The two-period consumer

① utility maximisation

maximisation

$$\max_{c_1,c_2,\ell_1,\ell_2} u(c_1,\ell_1) + \beta(c_2,\ell_2)$$

$$\text{s.t. } c_1 + \frac{c_2}{1+r} = w_1(h-\ell_1) + \frac{w_2(h-\ell_2)}{1+r} + \pi_1 + \frac{\pi_2}{1+r} - \left(t_1 + \frac{t_2}{1+r}\right)$$

trades as price-takers

$\frac{dc_1}{d\ell_1} = -w_1$	$\frac{dc_2}{d\ell_1} = -(1+r)w_1$
$\frac{dc_1}{d\ell_2} = -\frac{w_2}{1+r}$	$\frac{dc_2}{d\ell_2} = -w_2$
$\frac{dc_2}{dc_2} = -(1+r)$	$\frac{dc_2}{dc_1} = -\frac{1}{1+r}$

FOCs

$$\frac{du}{dc_2} = \frac{\partial u(c_1,\ell_1)}{\partial c_1}\cdot\frac{dc_1}{dc_2} + \beta\frac{\partial u(c_2,\ell_2)}{\partial c_2} = 0$$

$$\frac{\partial u}{\partial \ell_1} = \frac{\partial u(c_1,\ell_1)}{\partial \ell_1} + \frac{\partial u(c_1,\ell_1)}{\partial c_1}\cdot\frac{dc_1}{d\ell_1} = 0$$

$$\frac{\partial u}{\partial \ell_2} = \frac{\partial u(c_1,\ell_1)}{\partial c_1}\cdot\frac{dc_1}{d\ell_2} + \beta\frac{\partial u(c_2,\ell_2)}{\partial \ell_2} = 0$$

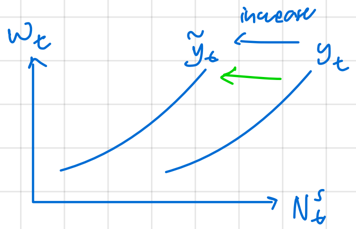
⇒ in general, sub $c_1 = f(c_2,\ell_1,\ell_2)$ using LBC into utility, then diff. wrt. c_2, ℓ_1, ℓ_2 & solve.

n^s_t vs. wealth

Δt or $\Delta\pi$ → leisure is a normal good

↑ disposable income, increase leisure, fall in labour supply.

$$\boxed{\frac{dN^s_t}{dy_t} < 0}$$



② labour demand

optimal leisure given w_t and r

n^s_t vs. w_t

$$n^s_t(w_t,r) = h - \ell^*_t(w_t,r)$$

substitution effect

price of leisure today is w_t.
as w_t increases, work less, so N^s_t increases.

$$\frac{dN^s_t}{dw_t} > 0$$

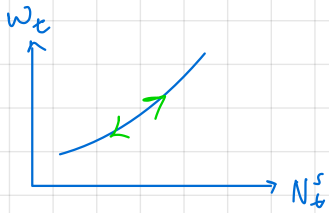
income effect

all else constant, as w_t increases, income increases.
leisure is a normal good.

$$\frac{dN^s_t}{dw_t} < 0$$

net effect

ambiguous but data suggests substitution effect dominates.
so $w_t - N^s_t$ is upward sloping



n^s_1 vs r

substitution effect

price of leisure today to tomorrow is $\frac{w_1(1+r)}{w_2}$

as r↑, price of leisure rises, so work more and n^s_1 ↑.

$$\frac{dN^s_1}{dr} > 0$$

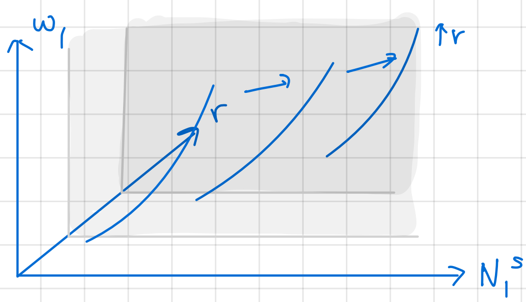
income effect

all else constant, as r increases, present value of earnings rise
leisure is a normal good.

$$\frac{dN^s_t}{dr} < 0$$

net effect

ambiguous but data suggests substitution effect dominates.



③ goods demand

how does c_i change w/ i/r ?

substitution effect

price of consumption today to tomorrow is $(1+r)$
as $r \uparrow$, $c_1 \downarrow$, $c_2 \uparrow$

$$\frac{dc_1}{dr} < 0 \qquad \frac{dc_2}{dr} > 0$$

income effect

consumption is a normal good. As $r\uparrow$, lifetime earnings rise if saver, fall if borrower

borrowers vs. lenders

i/r ↑ → relatively more expensive to consume in period 1, and need to pay more interest in second period / gain more interest in second period
↳ lenders stay lenders
↳ borrowers unknown

borrower: substitution: $c_1^* \downarrow$, $c_2^* \uparrow$; income: $c_1^* \downarrow$, $c_2^* \downarrow$ → $c_1^* \downarrow$, c_2^* ?
loss from interest smoothed over both periods

lender: substitution: $c_1^* \downarrow$, $c_2^* \uparrow$; income: $c_1^* \uparrow$, $c_2^* \uparrow$ → c_1^* ?, $c_2^* \uparrow$
gains from interest smoothed over both periods

i/r ↓ → relatively less expensive to consume in period 1, need to pay less interest over lifetime, gain less from interest over lifetime
↳ borrowers stay borrowers
↳ lenders unknown

borrower: substitution: $c_1^* \uparrow$, $c_2^* \downarrow$; income: $c_1^* \uparrow$, $c_2^* \uparrow$ → $c_1^* \uparrow$, c_2^* ?

lender: substitution: $c_1^* \uparrow$, $c_2^* \downarrow$; income: $c_1^* \downarrow$, $c_2^* \downarrow$ → $c_2^* \downarrow$, c_1^* ?

generally, we assume substitution dominates

$\frac{dc_1}{dr} < 0$, $\frac{dc_2}{dr} > 0$, $r - c_1$ is downward sloping

---

c_1 and income

consumption is a normal good. As Δt or $\Delta \pi$, in general $\frac{dc_i}{dy_j} > 0$

$$mpc_{i,j} = \frac{dc_i^*}{dy_j}$$

$$mps_{i,j} = \frac{ds_i^*}{dy_j}$$

1. solve for c_i using FOC
2. differentiate
3. magnitude indicates sensitivity

$mpc_{i,j} + mps_{i,j} = 1$
savings & consumption decisions in each period are dependent

The two-period firm

① lifetime π maximisation

optimisation problem

$$\pi_1 = z_1 F(K_1, N_1) - w_1 N_1 - I_1$$
$$\pi_2 = z_2 F_2(K_2, N_2) - w_2 N_2 + (1-\delta) K_2$$
$$K_2 = K_1 (1-\delta) + I_1$$

$$\max_{N_1, N_2, K_2 \leftrightarrow I_1} \pi_1 + \frac{\pi_2}{1+r}$$

FOCs

$$\frac{d\pi}{dN_1} = mpN_1 - w_1 = 0$$

$$\frac{d\pi}{dN_2} = \frac{mpN_2 - w_2}{1+r} = 0$$

$mpN_t = w_t$

firm will hire labour up till 1 unit of labour contributes to labour exactly how much he is worth

$$\frac{d\pi}{dK_2} = -1 + \frac{mpK_2(1-\delta)}{1+r} = 0$$

$mpK_2 = r + \delta$

firm will invest in capital up till 1 unit of capital in period equals opportunity cost of purchase : depreciation loss & earnings from i/r forgone

② labour demand

$N_t^d = mpN_t$

↳ anything that changes mpN_t will change N_t^D

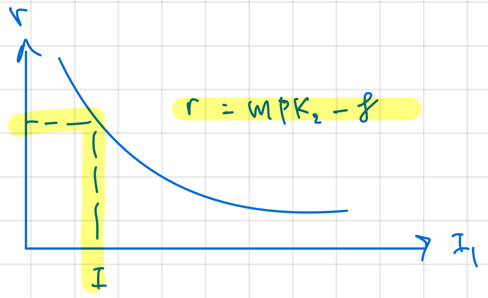
ΔK_t — more capital, 1 unit of labour can do more

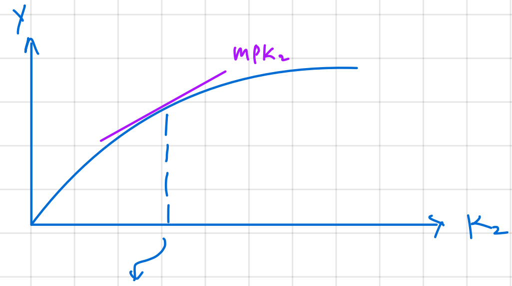
Δz_t

$\Delta mpN_t \rightarrow \Delta N_t^D$

③ investment demand

$r = mpK_2 - \delta$ describes the optimal investment for a given interest rate





$K_2 = K_1(1-\delta) + I_1$

anything that changes mpK_2 will change I_1

↳ remember that $K_2 = K_1(1-\delta) + I_1$

higher starting K_1
↓
higher K_2, lower mpK_2, since diminishing mpK
↓
$\downarrow mpK_2$, $\downarrow I_1$

Δz_2
↓
ΔmpK_2, ΔI_1

government & the credit market

① budget constraint

$G_i = T_i + B_i$ $\quad T_i = N \cdot t_i$

$$G_1 + \frac{G_2}{1+r} = T_1 + \frac{T_2}{1+r}$$

② Social security

$N_t b = N_{t+1} \cdot t \iff b = (1+n) t$

$$c_1 + \frac{c_2}{1+r} = y_1 - t + \frac{y_2}{1+r} + \frac{b}{1+r}$$
$$= y_1 + \frac{y_2}{1+r} + t\left(\frac{1+n}{1+r} - 1\right)$$

Two period intertemporal model

① current labour market

demand $N_1^D = mpN_1^D$

ΔK_t: more capital, 1 unit of labour can do more

ΔZ_t

$\Rightarrow \Delta mpN_t$

clearing

$N_1^S(w) = N_1^D(w) \Leftrightarrow$

$h - l_1^*(w, r) = mpN_1$

supply $N_1^S = h - l_1^*(w_1, r)$

shifts

interest rate $r\uparrow$, $N_1^S\uparrow$

price of leisure today to tomorrow is $\frac{w_1(1+r)}{w_2}$. as $r\uparrow$, price of leisure rises. since substitution effect dominates, work more and $n_1^S\uparrow$.

wealth $y\uparrow$, $N_1^S\downarrow$

Δt or $\Delta\pi \longrightarrow$ leisure is a normal good

$\uparrow$ disposable income, increase leisure, fall in labour supply.

movement along

price of leisure today is w_t

as w_t increases, work less, so N_t^S increases. $\frac{dN_t^S}{dw_t} > 0$

② current goods market

demand $y_1^D = C_1(r) + I_1(r) + G_1$

movement along

1. as $r\uparrow$, price of consumption today to tomorrow $(1+r)$ increases. so C_1 falls.
2. as $r\uparrow$, rate of returns from alternative assets to investment rises and opp. cost of investment rises. so I_1 falls.

shift affects C, I or G, except through r

- C $\rightarrow$ change in wealth π, t, in either period
- I_1 $\rightarrow$ $\Delta TFP_2 \longrightarrow \Delta mpK_2$ $\Rightarrow I_1 = mpK_2 - \delta$
- G $\rightarrow$ change in spending

supply

movement along

price of leisure today to tomorrow is $\frac{w_1(1+r)}{w_2}$. as $r\uparrow$, price of leisure rises. since substitution effect dominates, work more and $n_1^S\uparrow$.

so $Y_1^S = Z_t F(K_1, N_1)$ rises along Y_1^S.

clearing

$y_1^D = y_1^S$

$C_1(r) + I_1(r) + G_1 = Z_1 F(K_1, N_1^*)$

$mpK_2 = r + \delta$, $K_2 = I_1 + K_1(1-\delta)$

shift

- shifts in production function
  - change in Z_1 $\rightarrow$ change in Y per N, K
  - change in K $\rightarrow$ change in mpN_1 $\rightarrow$ change in Y per N
- changes in labour market eqm
  - demand side
  - supply side
  - $\rightarrow$ change in N^*

$\Rightarrow$ change in Y_1^S

③ competitive equilibrium

Given that the government's spending and taxing $\{G_1, G_2, T_1, T_2\}$ in such a way that its LBC holds, a competitive equilibrium is an allocation $\{C_1^*, C_2^*, S_1^*, S_2^*\}$ and $\{N_1^{S*}, N_2^{S*}, N_1^{D*}, N_2^{D*}, I_1^*\}$ and prices $\{r_1^*, w_1^*, w_2^*\}$ such that:

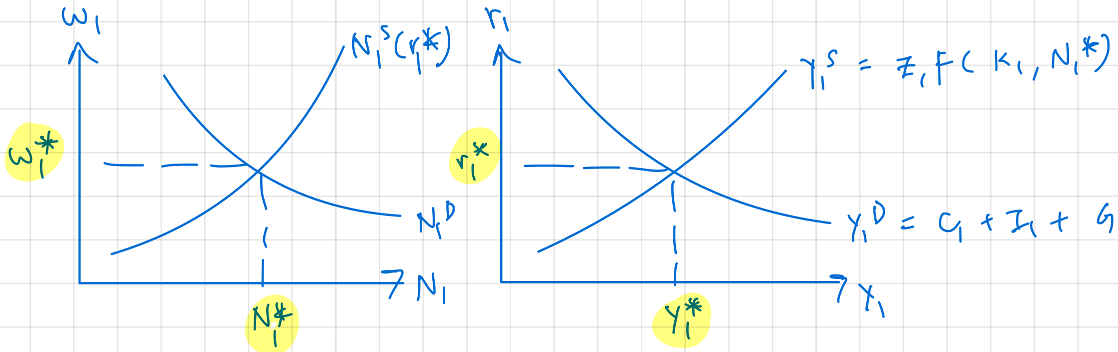
1. the representative consumer chooses $\{C_1^*, C_2^*, S_1^*, S_2^*, N_1^{S*}, N_2^{S*}\}$ in order to maximize his lifetime utility, taking $\{r^*, w_1^*, w_2^*\}$ as given

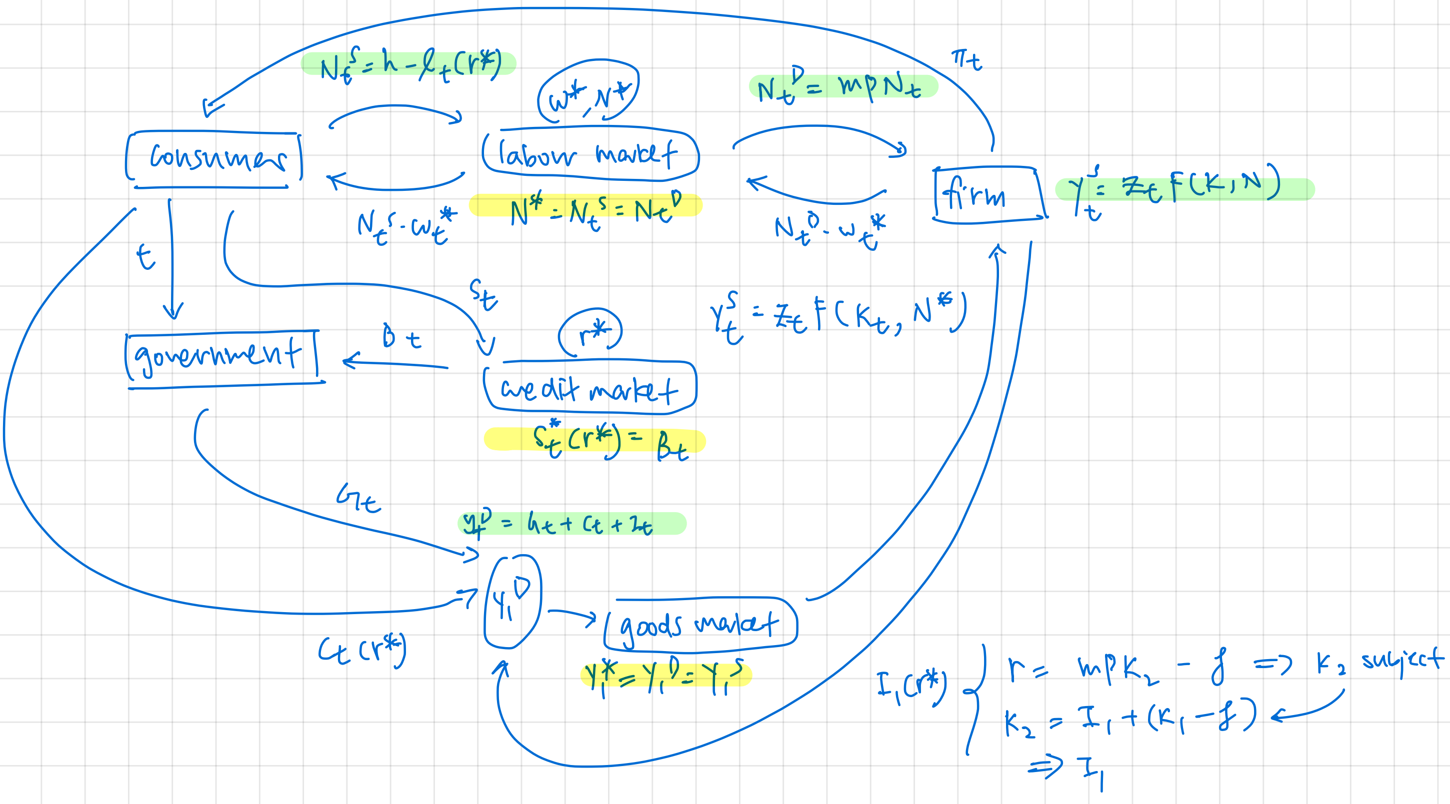
2. the representative firm maximizes its present value of profits by choosing $\{N_1^{D*}, N_2^{D*}, I_1^*\}$, taking $\{r^*, w_1^*, w_2^*\}$ as given

3. the goods market clears, goods supplied equals goods demanded for each period. $Y_t^* = Y_t^S = Y_t^D = C_t^*(r^*) + I_t^*(r^*) + G$ for $t = 1, 2$, at $r = r^*$

4. The labor market clears in each period at w_t^*, when labor supply equals labor demand. $N_t^* = N_t^S = N_t^D$ for $t = 1, 2$

By walras law, if goods and labour markets clear in each period, then the credit market also clears in every period. $S_t^* = B_t^*$





④ shocks to general equilibrium

change in K_1 shock that damages capital

1. suppose currently in equilibrium.
2. effects on goods market

   2.1 K_1 falls, so $Y_1^S = z_1 F(K_1, N_1)$ falls.

   2.2 also, profit maximising I_1 where $MPK_2 = r + \delta$. $K_2 = I_1 + (1-\delta)K_1$

   2.3 since diminishing MPK_2, K_1 falls, K_2 falls, MPK_2 rises. so more investment.

   2.4 Y_1^D rises.

3. in the labor market, labour demand falls

   3.1 $\frac{\partial}{\partial K_t}(MPN_t) > 0$, so K_1 falls, MPN_1 falls, labour demand at every wage falls

   3.2 N_1^d falls, left shift

3. price mechanism. clearing of goods, labour and credit markets by walras' law.

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change in z_1 shock that affects current period productivity

1. suppose currently in equilibrium.
2. effects on labour market & output supply

   2.1 change in circumstances leads to change in z_1

   2.2 To profit maximise, hire where $MPN_1 = w_1$

   2.3 change in MPN_1, change in qt. of labour demanded at every wage.

3. no effects on goods demand
4. price mechanism. clearing of goods, labour and credit markets by walras' law.

---

change in z_2 expected change in future productivity

1. suppose currently in equilibrium.
2. no effects on labour market & output supply
3. effects on goods market

   3.1 change in circumstances, change in z_2, change in MPK_2

   3.2 lifetime profit maximising level of I_1 where $MPK_2 = r + \delta$, $K_2 = I_1 + (K_1 - \delta)$

   3.3 change in MPK_2, more/less productive per unit, change in I, shift in I_1 and Y_1^d.

   3.4 consumer expects higher income in period 2. so $C_1^d \uparrow$.

4. price mechanism. clearing of goods, labour and credit markets by walras' law.

Change in G_1

1. suppose currently in equilibrium.
2. explanation of changes
   2.1 ΔG, must balance LBC, ΔT (lifetime taxes). By Ricardian Equivalence, timing does not matter

   2.2 consumer lifetime wealth changes by $-\Delta T$

3. effect on labour market and goods supply
   3.1 change in ΔT, income effect, change in N_1^S at r^*
   3.2 change in labour market to $\tilde{N}_1$, shift in Y_1^S
4. effect on goods demand
   4.1 C falls due to ΔT and income effect by mpc

   4.2 C rises due to overall change f by mpc

   4.3 Y_1^D rises by ΔG

   4.4 if mpc is constant, $f = \Delta Y_1^D = \Delta G$.

5. price mechanism. Clearing of goods, labour and credit markets by walras' law.

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(5) price mechanism

1. at r^*, not in equilibrium
   1.1 Resolution of ambiguities / extents of shift
2. demand $\leftrightarrow$ supply, Δr
   2.1 as Δr, $\Delta I(r)$ and $\Delta C(r)$ due to opp. cost of investment and dominant substitution effect where relative price of consumption today to tomorrow is $(1+r)$
   2.2 as Δr, $\Delta N_1^S(r)$ due to dominant substitution effect, where relative price of leisure-time today to tomorrow is $\frac{w_1(1+r)}{w_2}$
3. equilibrium restored in the goods market when r has changed sufficiently so that $Y_1^D = Y_1^S$ at $\hat{r}$.

4. ambiguities in labour market, if any
5. net effects on w_1, N_1, Y_1, r_1 + C_1, I_1 during price mechanism

if I_1 rose but I_1 also falls as r increases

1. while there are contradictory effects on investments, overall investments must rise ...

eg. capital destruction leads to rise in MPK_2, which will at some point motivate I_1 despite rise in r

money

① money in the intertemporal model

people use money to transact because we don't have ideal "real units"

what does money model?

↳ in real life, a barter economy cannot work because of a double coincidence of wants

↳ money is the solution: a traded placeholder of value ie. we need money for all transactions

how much money do we pay for a unit of consumption?

↳ money as a unit is a placeholder for some unit(s) of consumption.

↳ But how many units? Suppose there are more dollars in the economy than units of real consumption at equilibrium - what then?

↓

the terms of trade between a dollar and a unit of consumption changes to reflect the dollars & units of consumption available

concept of price level The TOT between a unit of money and a unit of consumption

---

② nominal & real variables

nominal value value of x in units of money

real value value of x in some ideal unit of value / consumption

inflation rate change in price level across periods from now to then $i_t = \frac{P_t}{P_{t+1}}$

Fisher relation

normalizing for price levels

$$1+r_t = (1+R_t)\frac{P_t}{P_{t+1}} = \frac{1+R_t}{1+i_t} \Rightarrow r_t = R_t - i_t - r_t i_t$$

$$R_t \approx r_t - i_t \text{ if } (r_t i_t) \text{ is small}$$

---

rewriting the optimization problem multiply real variables w/ price in period t

consumers

$$\max_{c_1, c_2, l_1, l_2, s_1} u(c_1, c_2, l_1, l_2)$$

s.t. $P_1(c_1+s_1) = P_1[w_1(h-l_1) + \pi_1 - T_1]$

$P_2(c_2+T_2) = P_2[(1+r)s_1 + \pi_2 + w_2(h-l_2)]$

government

$P_1 G_1 = P_1(B_1 + T_1)$

$P_2[G_2 + (1+r)(B_1)] = P_2 T_2$

real variable

firms

$$\max \; P_1\pi_1 + \frac{P_2\pi_2}{1+r}$$

③ The money market

money supply M^S_t is an exogeneous variable like G, decided by the central bank.

money demand

units of tradeable currency desired (real demand) $\Rightarrow L(Y_t, r)$

more transactions, more money: $\frac{\partial L}{\partial Y} > 0$

real interest rate. higher i/r, higher opp cost of holding as cash on hand: $\frac{\partial L}{\partial r} < 0$

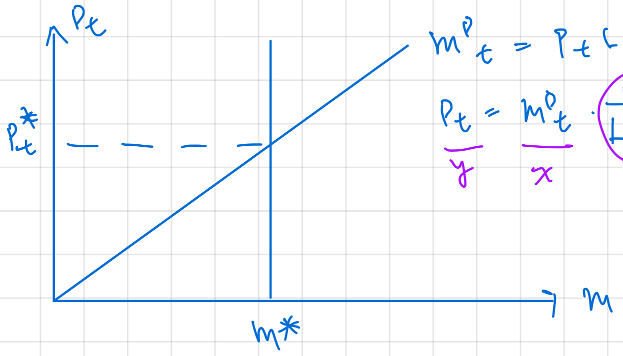
$\Rightarrow$ to convert to nominal money demand, we multiply by P_t:

$$M^D_t = P_t L(Y_t, R_t) = P_t L(Y_t, r_t - i_t - i_t r_t)$$

R_t: in nominal terms

equilibrium in the money market

↳ P_t (price level) is determined by infinitely inelastic supply (controlled) and nominal demand for money.



$$M^D_t = P_t L(Y_t, R_t)$$

$$\underbrace{P_t}_{y} = \underbrace{M^D_t}_{x} \cdot \frac{1}{L(Y_t R_t)}$$

$\frac{1}{\text{real demand}} \Rightarrow$ gradient

$\Rightarrow$ money market clears when money supplied = money demanded in each period

$$M_t^* = M^S_t{}^* = M^D_t{}^*$$

④ The money intertemporal model

In a cash-in-advance economy, given $\{G_t, T_t, M^S_t\}$ exogeneously, a competitive equilibrium is the allocation $\{C_t^*, S_t^*, M_t^*, N_t^{S*}, N_t^{D*}, I_t^*\}$ and prices $\{r_t^*, w_t^*, P_t^*\}$ for all $t \in \{1, 2\}$ such that:

1. The representative consumer chooses $\{C_t^*, S_t^*, M_t^*, N_t^{S*}\}$ such that he is maximising lifetime utility, taking $\{r_t^*, w_t^*, P_t^*\}$ as given

2. The representative firm chooses $\{N_t^{D*}, I_t^*\}$ taking $\{P_t^*, w_t^*, r_t^*\}$ as given to maximise life-time profit

3. The labour market clears at $\{w_t^*, N_t^*\}$ in each time period when labour supply N_t^{S*} = labour demand N_t^{D*}

4. The goods market clears at Y_t^* at each time period when goods supplied $Y_t^S = Y_t^D = C_t^* + I_t^* + G_t = Y_t^*$

5. The credit market clears at r_t^* when total savings S_t^* = total borrowing B_t^* by the government

6. The money market clears at M_t^*, P_t^* when money supplied M_s = money demanded $M_t^{D*} = M^*$

⑤ money neutrality

Definition	A model displays money neutrality when a change in the quantity of money leaves the real variables unchanged, and therefore only nominal variables are affected.

⇒ money intertemporal model exhibits money neutrality

Intuition

↳ qt. of money is determined exogenously by central bank in our model

↳ it is also not a decision variable in our model, because real variables are solved for in the labour, goods & credit markets, and the price level is then determined given real output and r^* in the money market.

eg. suppose ΔM_t^S and markets initially in eqm

⇒ $\Delta M^S_t \to$ no change in any real variables, no change in $L(Y^*, R^*)$

$\to$ but $P^* \to \tilde{P}$

$$\Rightarrow \frac{\Delta M_t}{M_t} = \frac{\Delta P_t}{P_t}$$

RBC model

Solow residual a statistical measure of TFP z_t

↳ observation : the detrended solow residual tracks closely w/ business cycle data of real GDP (measure of Y_t) detrended

variable	cyclicality	timing
consumption	pro-	coincident
investment	pro-	coincident
price level	counter-	coincident
employment	pro-	lagging
real wages	pro-	?
avg. labour productivity	pro-	coincident
nominal money supply	pro-	leading
TFP	pro-	coincident

persistent productivity shocks

↳ the solow residual is a persistent variable — when it is above (below) trend, it tends to stay there

↳ so when we model it, we can consider it as a change in both z_1 & z_2

Δz_1 & Δz_2 in money intertemporal model

↳ suppose we model $\uparrow z_1$ and $\uparrow z_2$. We expect - $C_1\uparrow$, $I_1\uparrow$, $N_1\uparrow$, $w_1\uparrow$, $Y/N_1\uparrow$, $MS_1\uparrow$, $P_1\downarrow$

1. An increase in z_1 has the effect of increasing MPN_1. So, at the current wage w_1, firm will hire more, increasing qt. of labour demanded at every wage level.

   1.1 This is represented by a shift from N_1^D to $\tilde{N}_1^D$ in the labour market.

   1.2 so the labour market adjusts to a new equilibrium at $\tilde{w}_1$ and $\tilde{N}_1$ where $\tilde{N}_1^D = N_1^S$

   1.3 This has the effect of increasing output supply from Y_1^S to $\tilde{Y}_1^S$ in the goods market.

2. An increase in z_2 has the effect of increasing MPK_2. Taking interest rate as given r^*, the profit maximising firm will choose to invest more in capital since the returns from capital will be greater than interest returns.

   2.1 Also, consumers expect higher income in period 2, and so consume more in period 1 due to income effect.

   2.3 these are represented by a shift from Y_1^D to $\tilde{Y}_1^D$.

3. There are simultaneous shifts in Y_1^D and Y_1^S. But it is likely that $\Delta Y_1^S > \Delta Y_1^D$, since the changes in output supply arise from actual changes in z_1, while changes in demand arise from anticipated changes in z_2.

4. At the current interest rate r^*, $y_1^s > y_1^D$. So the goods market cannot be in equilibrium.

4.1 With a shortage of demand for goods, consumers will borrow less, causing the interest rate to fall. As the interest rate falls, consumption rises since the price of consumption today to tomorrow at $(1+r)$ falls and the substitution effect dominates. The opportunity cost of investment in capital also falls as the returns from alternative assets fall, so I_1^D increases.

4.2 These are represented by a movement along $\tilde{Y}_1^D$.

4.3 As interest rate falls, the relative price of leisure today to tomorrow at $\frac{w_1(1+r)}{w_2}$ falls, and since the substitution effect dominates, labour supply falls.

4.4 So output supply also falls, as a movement along $\tilde{Y}_1^s$

4.5 These effects continue until the goods market clears at $\tilde{r}_1$ and $y_1^S = y_1^D = \tilde{y}_1$.

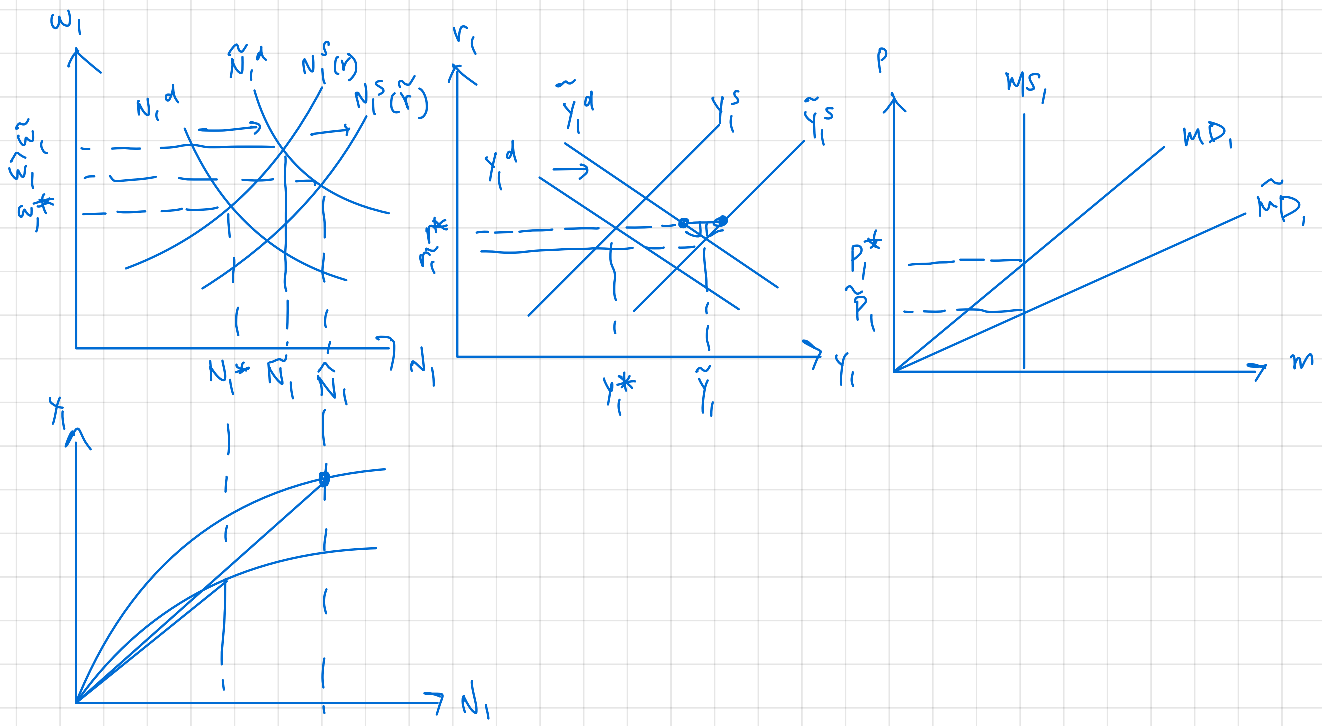
4.6 And in the labor market $N_1^s(r_1^*)$ has shifted to the right to $N_1^s(\tilde{r}_1)$ and $N_1^s = N_1^d = \tilde{N}_1$ and $\tilde{w}_1$ has fallen to $\hat{w}_1$
is higher, so $\hat{w}_1$ remains higher than w_1^*.

5. In the money market, as real output has risen and real interest rate has fallen, there is a rise in money demand. So the price level falls from P^* to $\tilde{P}$.

6. In all, we can observe that as z_1 and z_2 have increased:

6.1 C_1, I_1, N_1, w_1, Y_1 and Y_1/N_1 have risen.

6.2 r_1 and P_1 have fallen.



New Keynsian model

① the NK model with endogeneous ms targeting

money market

↳ because prices are fixed, we take both m^s and P as exogeneous and fixed

goods market

↳ we can model the fact that money market must always clear in the goods market by using the LM curve to represent the fixed state of the money market

⇒ the goods market equilibrium is where y^d and LM intersect

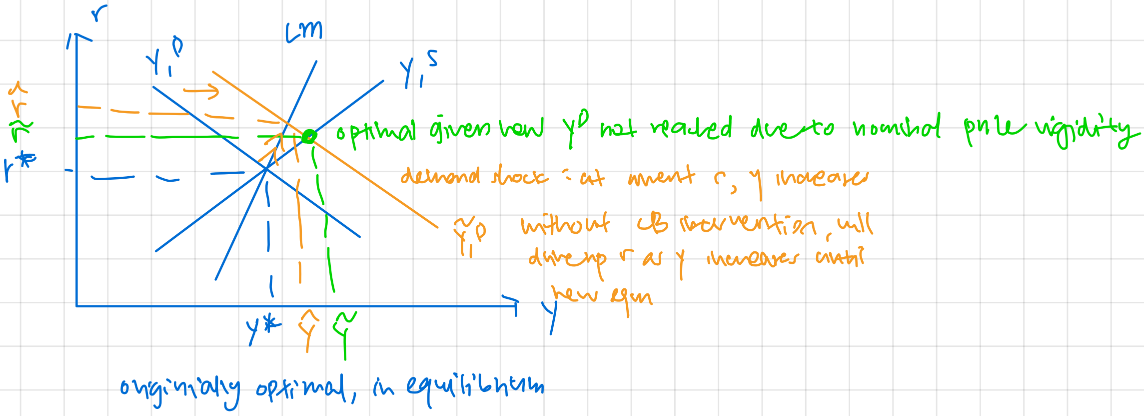
↳ intuition:

money is needed for all transactions. In a model with flexible prices, prices adjust simultaneously with the underlying real goods demand & supply, so all agents are acting optimal

However, in the short run, prices are fixed due to menu costs or contracting. so, prices no longer serve as an effective transmission mechanism to signal real changes in Y_1^d and Y_1^s.

Prices also serve as the price at which firms are willing to transact. As a result, we now have "demand creating its own supply".

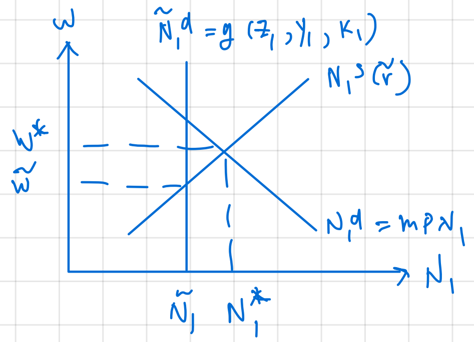
The LM curve describes combinations of Y and r at which the money market clears. without central bank intervention, because prices are nominally rigid, y and r will adjust along the LM curve through i/r changes, as will C(r) and I(r) along the LM curve



Labour market

↳ because goods market equilibrium is not where $Y_1^d = Y_1^s$, but rather where $Y_1^d = LM$, firms are not producing at their optimal level of output — simply wherever the goods market clears. So they hire labour accordingly.

⟹ labour demand, $N_1^d \neq MPN_1$, but infinitely elastic. $\tilde{N}_1^d = g(Z_1, Y_1, K_1)$



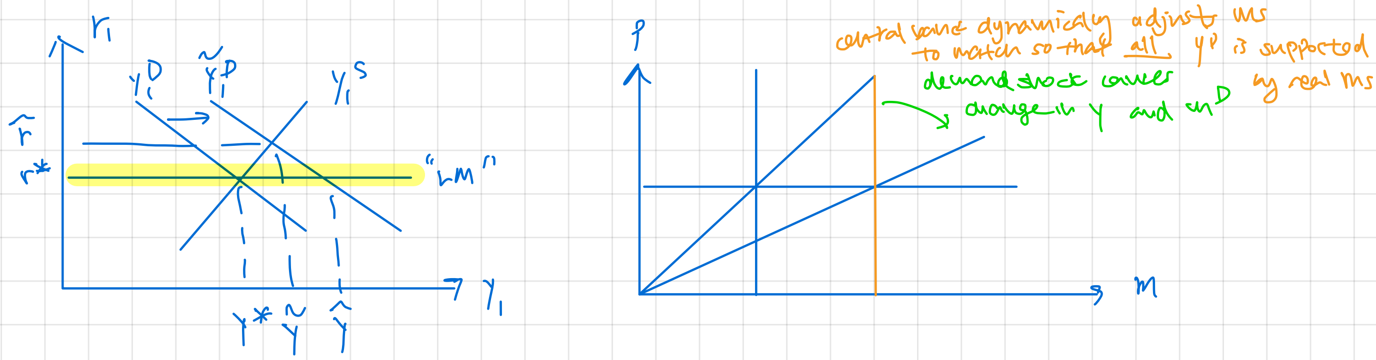
including endogeneous money market intervention

↳ suppose we model that central bank intervenes to provide laxity in money supply so that despite price rigidity, no Y–r tradeoff

i.e. Ms changes to keep r constant

↳ without CB intervention, because real money supply is rigid, Y and r adjust to demand shocks along LM curve

↳ if CB intervenes to maintain r via Ms to support changes in Y w/o changing cost of borrowing, then "LM" is flat.



as borrow more to purchase @ current prices, no change to r because CB provides laxity via Ms

② Shocks & policy response

↳ same shocks in NK model as RBC model — except that markets cannot clear, so not optimal

non-neutrality of money

↳ in a model of flexible prices, prices serve as effective signals of underlying real variables. i.e. they adjust to real variables. So, they do not in themselves change anything real.

↳ in the New Keynesian model, prices are not free to adjust, and because they are normally the intermediaries between demand and supply, they now have real effects

eg. ΔM^s (nominal variable) but P is fixed

⟹ so r changes in credit market

⟹ optimising consumers change their purchasing decisions in current period

⟹ firms change their I decisions

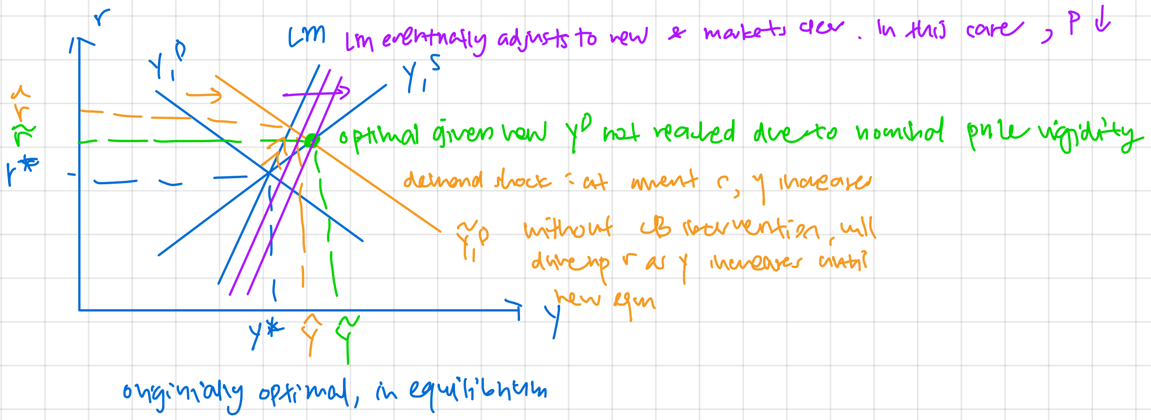
⟹ firms change their outputs Y and thus labour demand

$\underbrace{\text{labour demand}}_{w,\ N}$; Y, r

Stabilisation policy

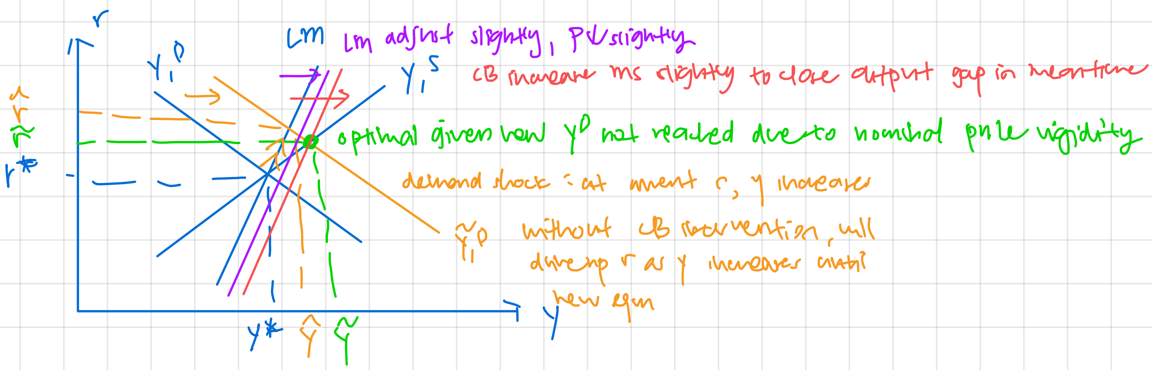
↳ NK models are based on the idea that P does not adjust in the short run, causing output gaps (positive or negative). inefficiencies since $Y_1^d \neq Y_1^s$, etc.

↳ left on their own, these prices will eventually adjust and markets will clear



↳ intervention can also smooth these by shifting LM via M^s until it catches up on its own

↳ LM curve describes the state of the money market — suggests that ΔM^s could lead to changes in LM and eqm r, y. By figuring out where Y_1^d and Y_1^s would intersect given some shock, a central bank could adjust ΔM^s to the real money supply such that $y_1^d = LM = y_1^s$ and achieve efficiency while waiting for P to adjust

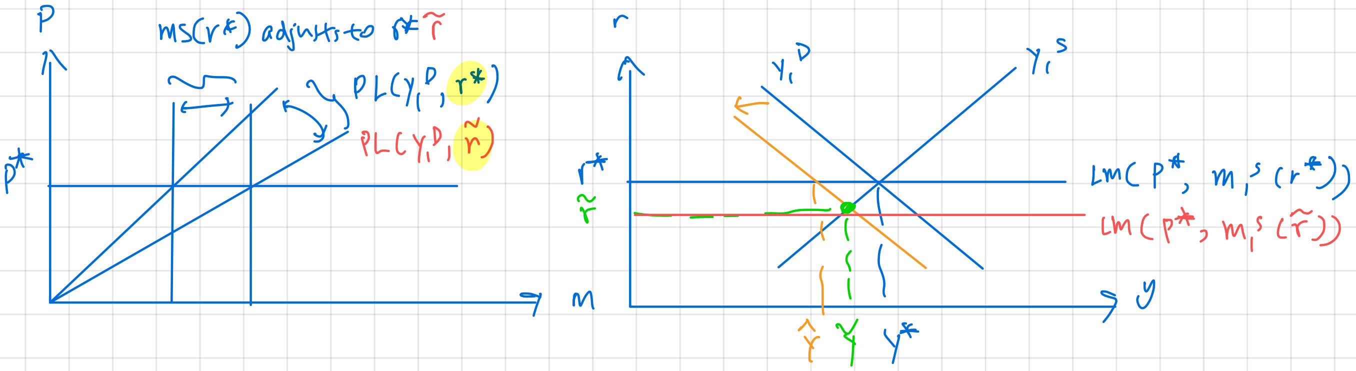


originally optimal, in equilibrium

monetary policy w/ interest rate targets

↳ endogeneously, we have it that CB adjusts to changes in Y_1^D so that real money supply is lax and r is stagnant

↳ as above, in the short run because P is rigid, we want to adjust ms so that the degree of laxity in the credit market is such that as y increases, r also increases, to coincide where $\tilde{Y}_1^D = \tilde{Y}_1^S$.



initially in equilibrium

demand shock. CB's ms laxity @ interest rate target r^* allows y to fall.

CB adjusts ms laxity to always match y such that r fixed at $\tilde{r}$ in the credit market

r causes changes in rational consumer & firms $I(r)$, $C(r)$ choices ⇒ y adjusts to $\tilde{y}$

business cycles as ΔZ_1 and ΔZ_2 + intervention

↳ suppose we model $\uparrow Z_1$ and $\uparrow Z_2$. we expect - $C_1\uparrow$, $I_1\uparrow$, $N_1\uparrow$, $w_1\uparrow$, $Y/N_1\uparrow$, $MS_1\uparrow$, $P_1\downarrow$

1. An increase in Z_1 has the effect of increasing MPN_1. So, at the current wage w_1, firm will hire more, increasing qt. of labour demanded at every wage level.

   1.1 This is represented by a shift from N_1^D to $\tilde{N}_1^D$ in the labor market.

   1.2 So the labor market adjusts to a new equilibrium at $\tilde{w}_1$ and $\tilde{N}_1$ where $\tilde{N}_1^D = N_1^S$

   1.3 This has the effect of increasing output supply from Y_1^S to $\tilde{Y}_1^S$ in the goods market.

2. An increase in Z_2 has the effect of increasing MPK_2. Taking interest rate as given r_1^*, the profit maximising firm will choose to invest more in capital since the returns from capital will be greater than interest returns.

   2.1 Also, consumers expect higher income in period 2, and so consume more in period 1 due to income effect.

   2.3 these are represented by a shift from Y_1^D to $\tilde{Y}_1^D$.

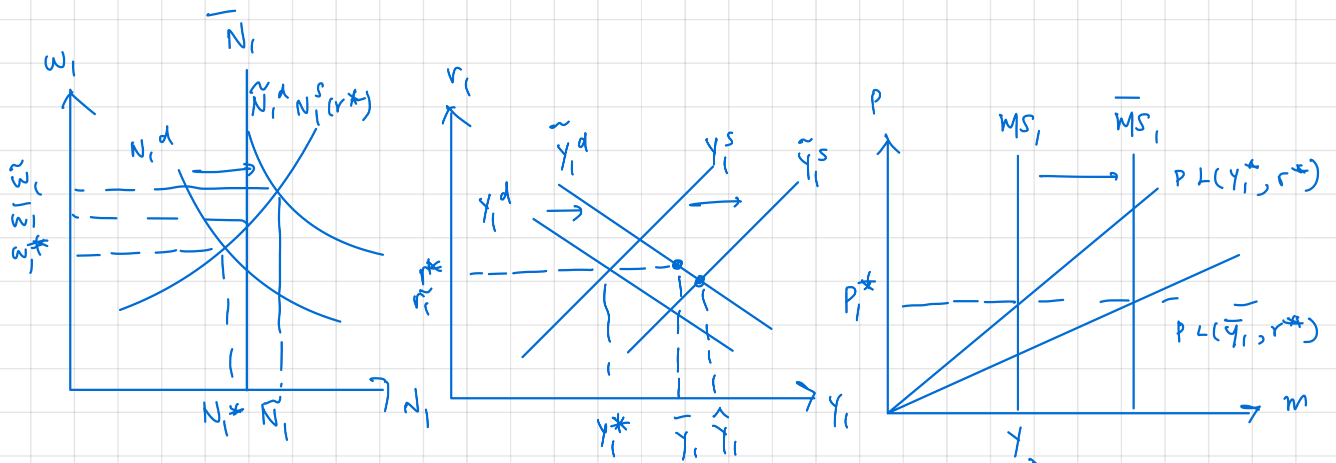
3. At the current interest rate r^*, output demand is at $\bar{Y}_1$.

   3.1 At the current interest rate r^*, real money demand has risen to $P_1 L(\bar{Y}_1, r^*)$

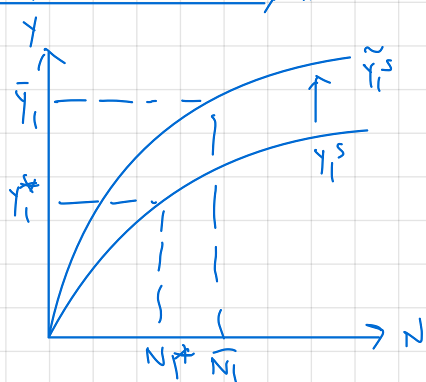
4. In this model we consider that the central bank controls money supply to target interest rate given sticky prices in the short run

   4.1 So in the money market, given that prices are sticky at P_1^* and real demand for money is now $P_1 L(\bar{Y}_1, r^*)$, the central bank will adjust money supply to $\bar{MS}_1$ to maintain interest rates at r^*.

   4.2 Because the market clearing optimal is where $Y_1^D = Y_1^S = \hat{Y}_1$, an output gap of $\hat{Y}_1 - \bar{Y}_1$ has opened up.



4.3 To produce $\bar{Y}_1$, firms hire $\bar{N}_1$ of labour at $\bar{w}_1$



Do nothing

5. One possible response is to do nothing.

5.1 In the short run, P_1 is sticky, and so is too high / too low to clear markets since it is an ineffective signal for real variables

5.2 With enough time, however, prices will adjust and the economy will move back to equilibrium as in the money intertemporal model, even if the central bank does not change money supply.

5.3 Intuitively, this is because as prices adjust, real demand for money changes — so output demand and interest rate changes

5.3 At some point equilibrium is reached when interest rate has fallen sufficiently to $\hat{r}_1$, price level to $\hat{P}_1$ and output to $\hat{Y}_1$.

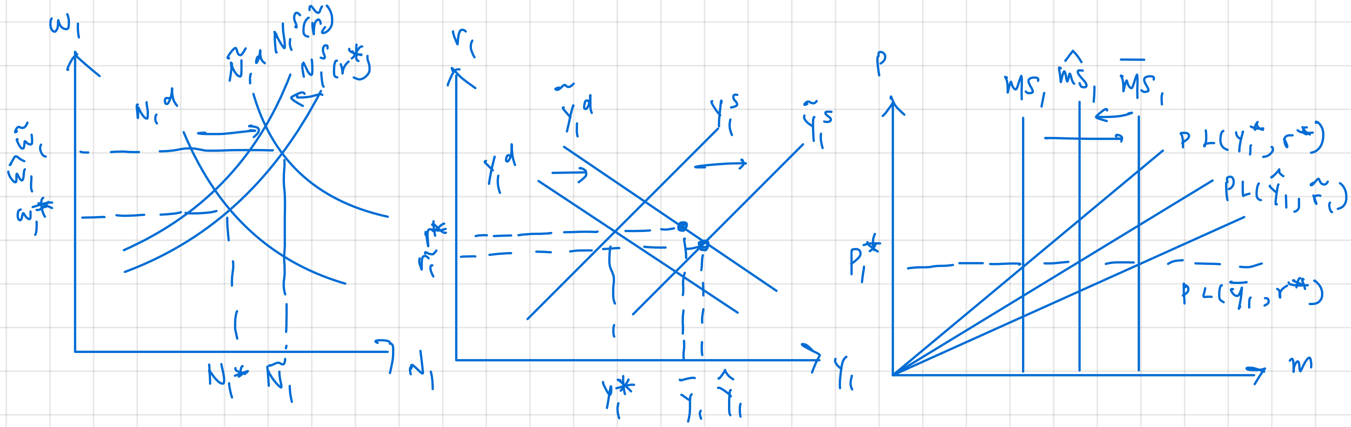
Monetary policy

6. But intervention can also smooth these by shifting r via ms until it catches up on its own

6.1 endogeneously, we have it that CB adjusts to changes in Y_1^D so that real money supply is lax and r is stagnant by way of adjusting ms_1 to $\overline{ms}_1$

6.2 Instead, the central bank can immediately adjust its interest target from r_1^* to $\tilde{r}_1$ and completely close the output gap, where $Y_1^D = Y_1^S = \hat{Y}_1$.

6.3 It does so by shifting money supply from $\overline{ms}_1$ to $\hat{ms}_1$



liquidity trap

↳ suppose $r = 0$

↳ $r < 0$ is not offered, because if it were, you can arbitrage by simply holding cash and then depositing it

⇒ when r cannot go lower, notice that m_D is virtually flat and cannot lower any more → LM cannot move expansionary-ly anymore

fiscal policy

7. suppose instead fiscal policy is used.

   7.1 suppose ΔG is just enough to restore equilibrium

   7.2 analysis of ΔG on Y_1^D & Y_1^S, but $\Delta Y_1^D > \Delta Y_1^S \Rightarrow \hat{Y}_1^D$

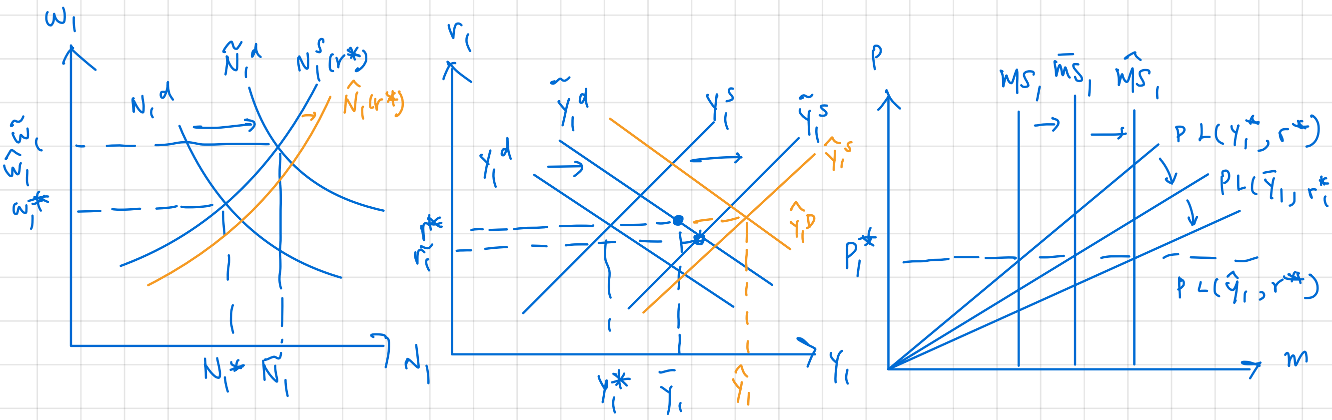
8. Then at the current interest rate target r^*, Y_1^D has risen to $\hat{Y}_1$, where $Y_1^D = Y_1^S$

   8.1 Because Y has risen, real money demand has also risen from $PL(\bar{Y}_1, r^*)$ to $PL(\hat{Y}_1, r^*)$

   8.2 To maintain the interest rate target, the CB must increase money supply to $\hat{ms}$.

   8.3 Because r is unchanged, C_1 and I_1 are unchanged and no crowding out has occurred.

   8.4 Now, the output gap has closed at $Y_1^S = Y_1^D = \hat{Y}_1$ at r^*.



fiscal vs. monetary policy

↓ rise in G only

↳ rise in I and C