Chapter 7 : A Monetary Intertemporal Model

EE312

Macroeconomics, Stephen Wiliamson, Chapter 12

2015

* *Note: Much of the contents in this lecture presentation are from Dr.Pichit's. He kindly allowed us to use his lecture presentation. All rights and credits go to Dr.Pichit. Please note that I modified/added some parts on my own. Hence, any mistake is my own responsibility. Please notify me if you find any. Thank you!*

Definitions of the money supply

- **M0**: the monetary base, outside money, or high-powered money.
  - Liabilities of the central bank to the public.
  - Currency outside the central bank + deposits of financial institutions at the central bank.
- **M1** = currency + demand deposits + other checkable accounts.
  - The most liquid form of money.
- **M2** = M1 + savings deposits + small time deposits + retail money market mutual funds.
  - M1 plus highly liquid non-money assets.
- **M3** = M2 + large time deposits + institutional money market mutual funds + repurchase agreements.
  - M2 plus less liquid non-money assets.
  - Take time and cost to change to liquid assets.

The inflation rate

- Inflation is the rate of change of the price level.
- P = the current price level;
- P' = the future price level;
- i = the inflation rate.

$$i = \frac{P' - P}{P}$$

$$(1 + i) = \frac{P'}{P}$$

The Fisher relation

- R = nominal interest rate, the rate of return on a nominal bond in units of money.
- (1+R) = the return on a nominal bond in terms of money in the future period.
- The buyer must give up $\frac{1}{P}$ goods in the current period for $\left(\frac{1+R}{P'}\right)$ goods in the future period.
- r = real interest rate, the rate of return in terms of goods. The gross rate of return on the nominal bond in real terms:

$$1+r = \frac{\frac{1+R}{P'}}{\frac{1}{P}}$$

$$= \frac{1+R}{1} \times \frac{P}{P'}$$

The rate of return on money

- The nominal rate of return on money is zero.
- The nominal rate of return on a nominal bond is positive, or R > 0.
- So the real rate of return on money (r^m) :

$$1 + r^m = \frac{1+0}{1+i} = \frac{1}{1+i} < 1 + r = \frac{1+R}{1+i}$$

Simplified Fisher Relation

- Multiply each side of the Fisher relation by 1 + i. If i and r are very small, then ir is negligible.

$$
\begin{aligned}
1 + r &= \frac{1 + R}{1 + i} \\
(1 + r)(1 + i) &= 1 + R \\
1 + r + ri + i &= 1 + R \\
r &= R - ri - i \\
r &\approx R - i
\end{aligned}
$$

$$\text{Real interest Rate} \approx \text{Nominal Interest Rate -Inflation Rate}$$

Intertemporal model with money

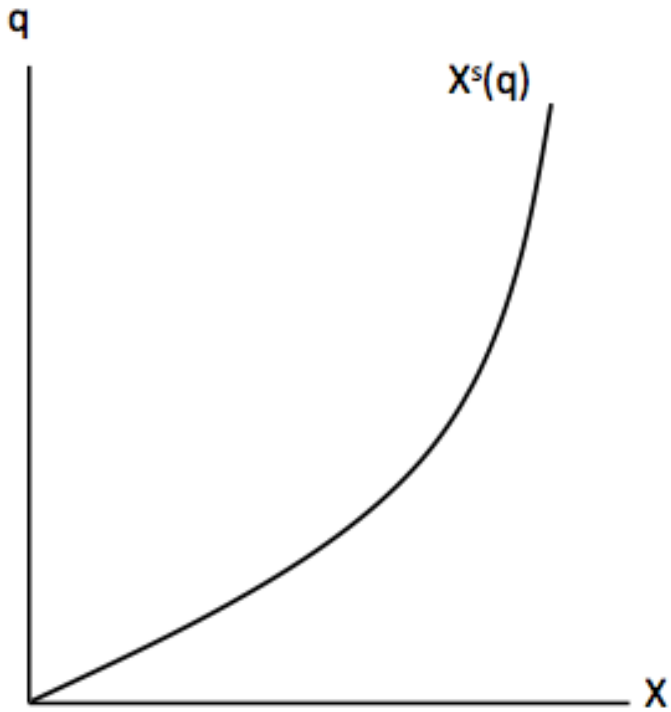
- **The labor market**: labor demand and supply, the real wage, employment.
- **The goods market**: output supply and demand, total output.
- **The credit market**: the real interest rate.
- **The money market**:
  - **Demand for money**: the consumer and the firm.
  - **Supply of money**: the central bank.
- **The market for credit card services**
  - **The supply of credit card services** by banks.
  - **The demand for credit card services** by consumers and firms.
  - The market equilibrium for credit card services.
  - The determination of the **demand for money**.

Currency and credit card services

- Money = money outside banks = currency.
- The economic agents (the consumer, the firm and the government) purchase goods.
  - Choices between currency and credit cards.
- Firms sell goods at the same price (P) for payments in money or credit cards.
- **Credit card services** are provided by banks with increasing costs.
- The economic agent buys goods using a credit card.
  - The agent acquires a debt with the bank.
  - Zero interest when paid off at the end of the current period.
- Credit card services are provided for purchase transactions only.
- The consumer, the firm and the government borrow or lend in the credit market.

Supply of credit card services

- q = the price of credit card services in terms of goods in transaction.
- X = quantity of credit card services in terms of goods.



Demand for credit card services

- Y = units of goods to be purchased by the economic agents.
- $X^d(q)$ = quantity of goods purchased by credit cards.
- Y – $X^d(q)$ = quantity of goods purchased by currency.
- Marginal benefit = marginal cost of buying one more unit of goods using credit cards.

- **Marginal benefit (MB)** of credit card services:
  - One additional unit of goods purchased with a credit card = P units of money available for lending in the credit market to receive P(1+R) units in the future.

$$MB = P(1 + R)$$

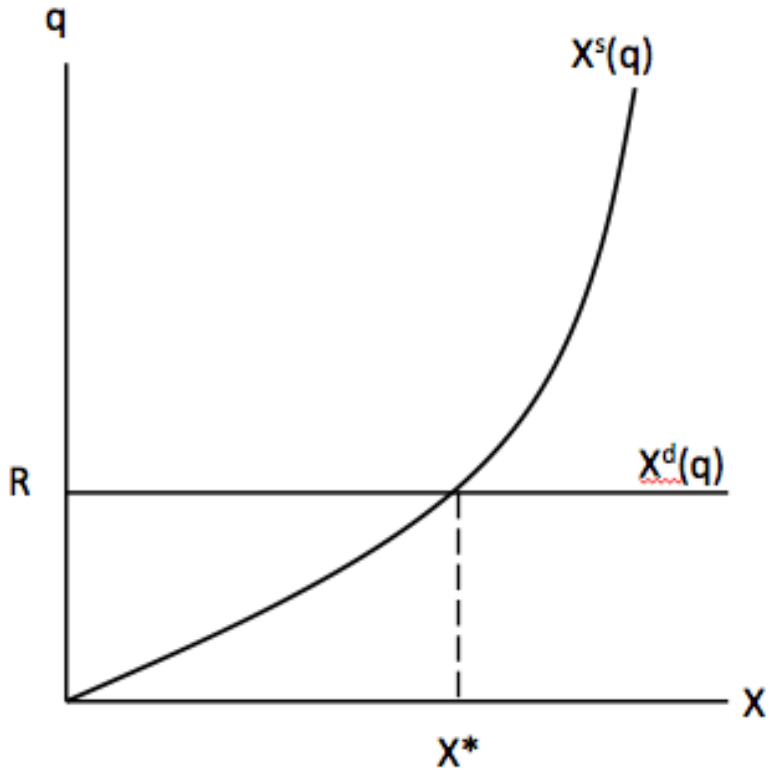
- **Marginal cost (MC)** of credit card services:
  - The agent pays off the credit card debt and fees at the end of the current period = P(1+q) units of money.

$$MC = P(1 + q)$$

- If P(1 + R) > P(1 + q) or R > q, the agent will purchase all goods with the credit card.
- If P(1 +R) < P(1 + q) or R < q, the agent will purchase all goods with currency.
- If R = q, the agent is indifferent between currency and the credit card.
- The demand for credit card services is perfectly elastic at q = R.

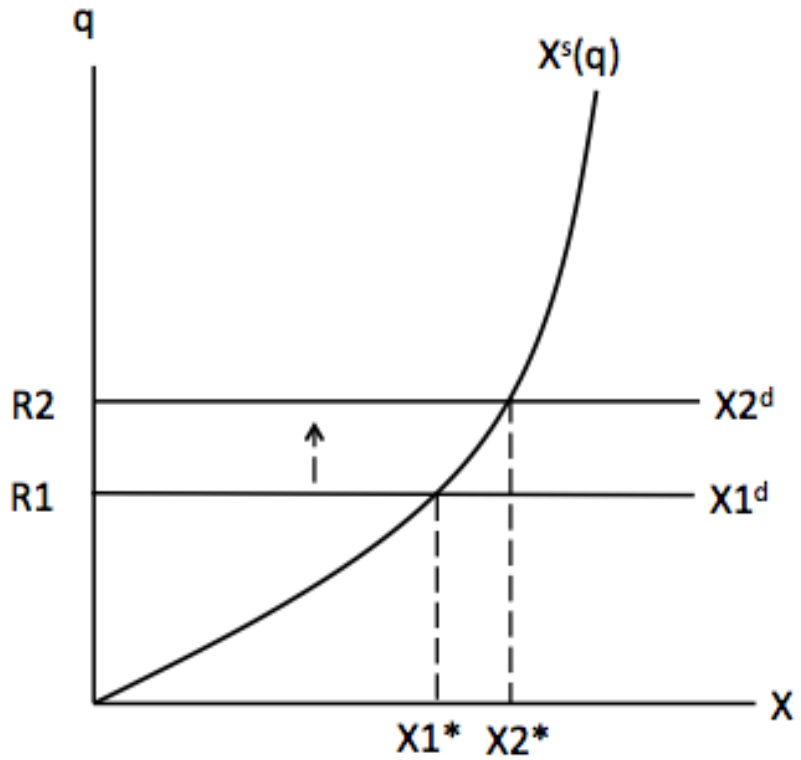
Market equilibrium

- R = equilibrium price for credit card services.
- X* = equilibrium quantity of credit card services.



X* as a function of R

- If R increases, X* will also increase.
- So X^d is a function of R, or
- X^d= X*(R) while R = q.



The nominal money demand

$$M^d = P\left[Y - X^*(R)\right]$$

$$M^d = P \times L(Y, R)$$

- The nominal demand for money is an increasing function of Y and decreasing function of R.
  - Equilibrium relationship in the bank's choices of supply and the agent's choice of currency and credit card uses.

$$M^d = PL(Y, R);\ \frac{\partial M^d}{\partial Y} > 0,\ \frac{\partial M^d}{\partial R} < 0$$

- The function is proportional to the price level.
- The consumer's and the firms' choices on the real quantity of money ($\frac{M^d}{P}$). Real money demand rises with real income (Y).
- Negative relationship with the nominal interest rate (R) — opportunity cost of holding cash.

Nominal money demand function

$$M^d = PL(Y, R)$$

as $r = R - i$

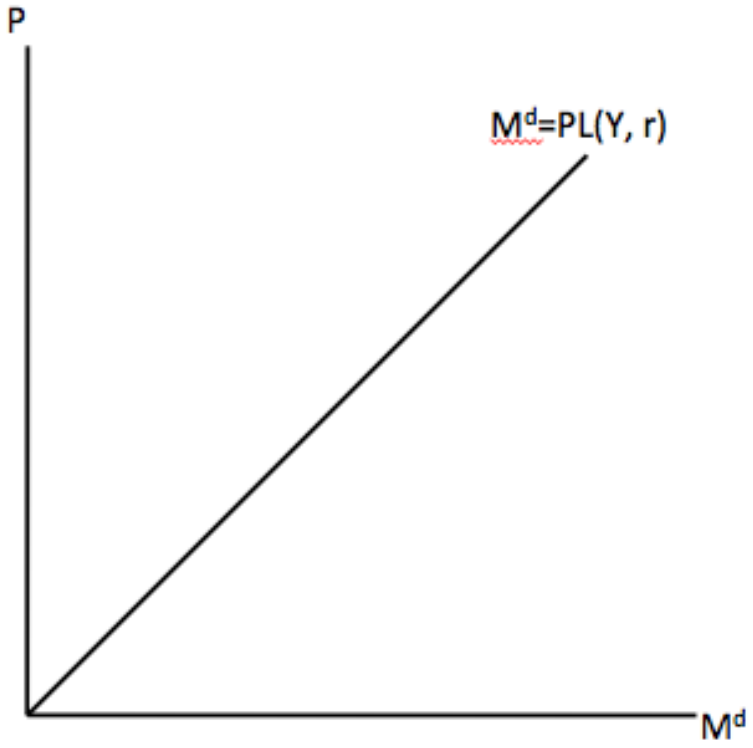
$$M^d = PL(Y, r + i)$$

$$M^d = PL(Y, r); \quad \frac{\partial M^d}{\partial Y} > 0, \ \frac{\partial M^d}{\partial r} < 0$$

when i is neglectable.

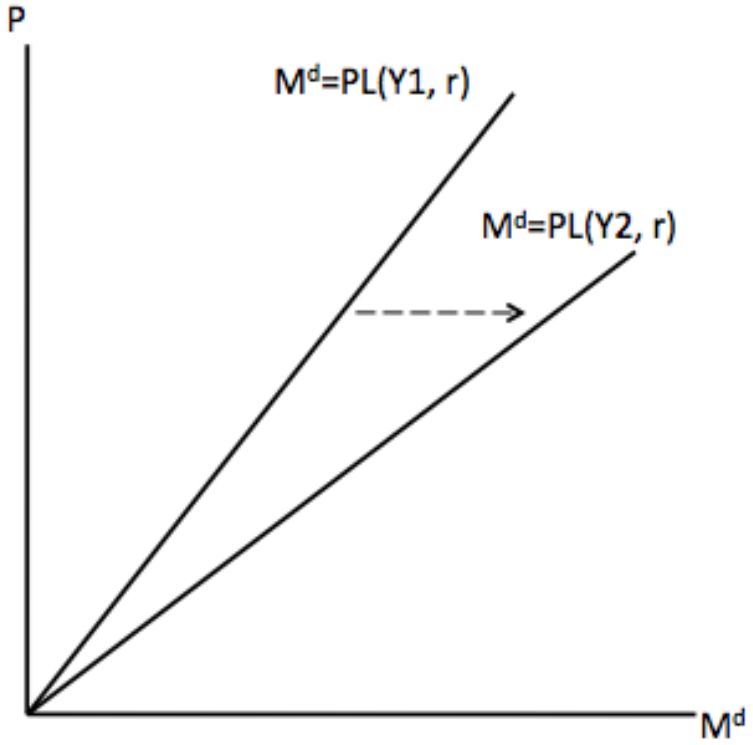
Money demand curve

- Money demand is a linear function of the price level with slope L(Y, r).



Shift in Money Demand

- An increase in Y or a decrease in r rotates the M^d curve rightwards (more money demand).



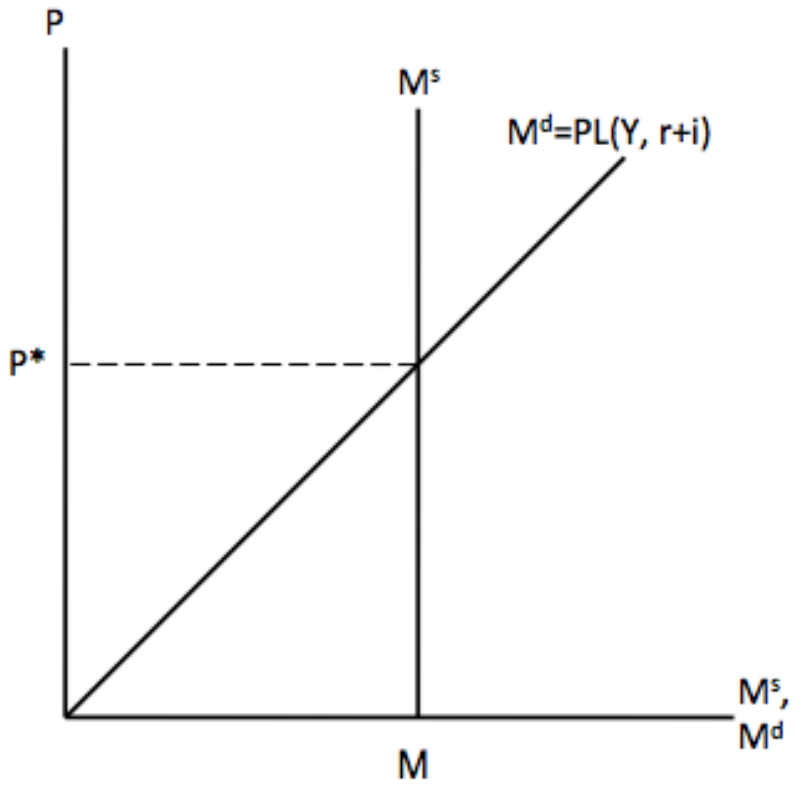
Government

- The government purchases consumption goods (PG) and pays nominal interest and principal on past bonds, (1+R^-)B^-.
- The revenue constraint consists of nominal taxes (PT), current bond issue (B) and money creation (M-M^-).

$$PG + (1 + R^-)B^- = PT + B + M - M^-$$

The money market

- The money supply (M^s) is exogenously determined by the central bank.
- $M^s = M^d$ determines the equilibrium price.

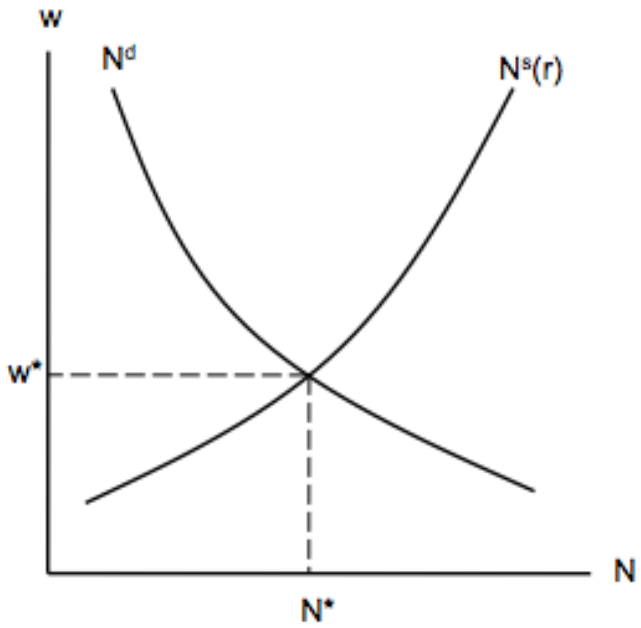


Complete monetary model

- The current labor market:
  - The real wage and employment.
- The current goods market:
  - Output demand and output supply.
- The current money market:
  - The price level; demand and supply of money.
- The credit market:
  - The real interest rate.

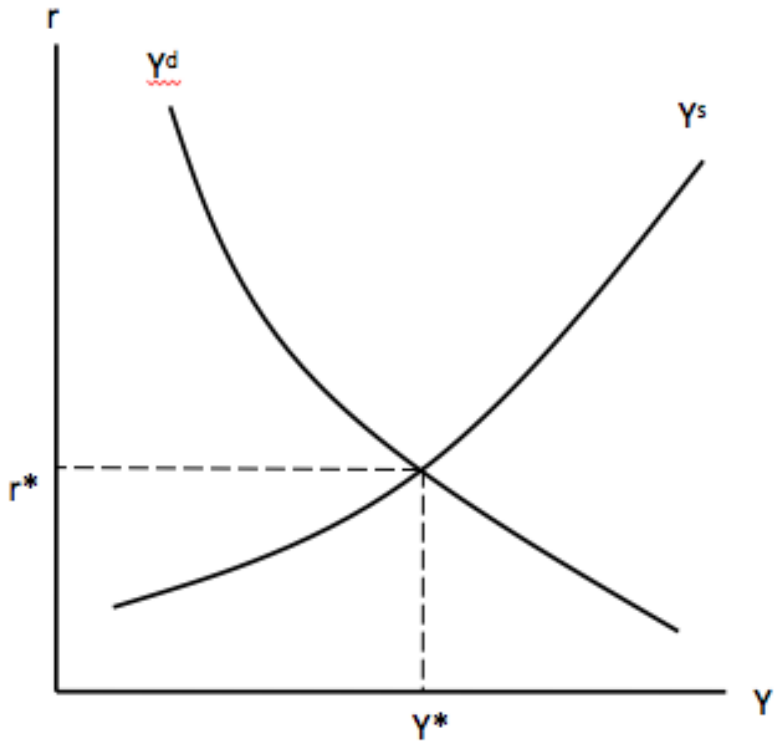
The current labor market

$$N^s = h - \ell(w)$$
$$N^d = MP_N = w$$
$$N^s(r) = N^d$$



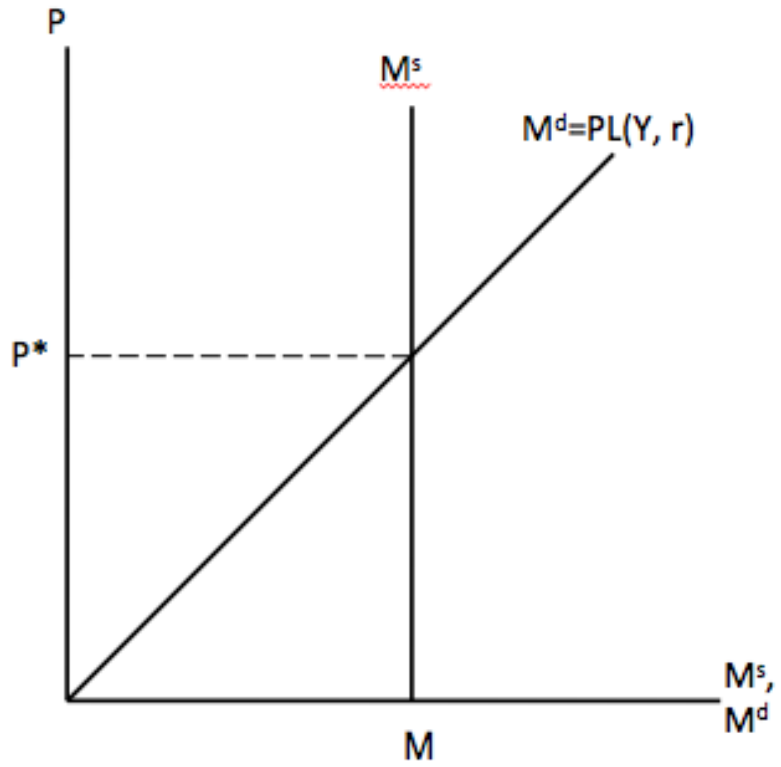
The current goods market

$$Y^s = Y(r)$$
$$Y^d = C^d(Y_d, r) + I(r) + G$$
$$Y^s = Y^d$$



The current money market

$$M^d = L(Y, r)$$
$$M^s = M$$
$$M^d = M^s$$



Competitive equilibrium

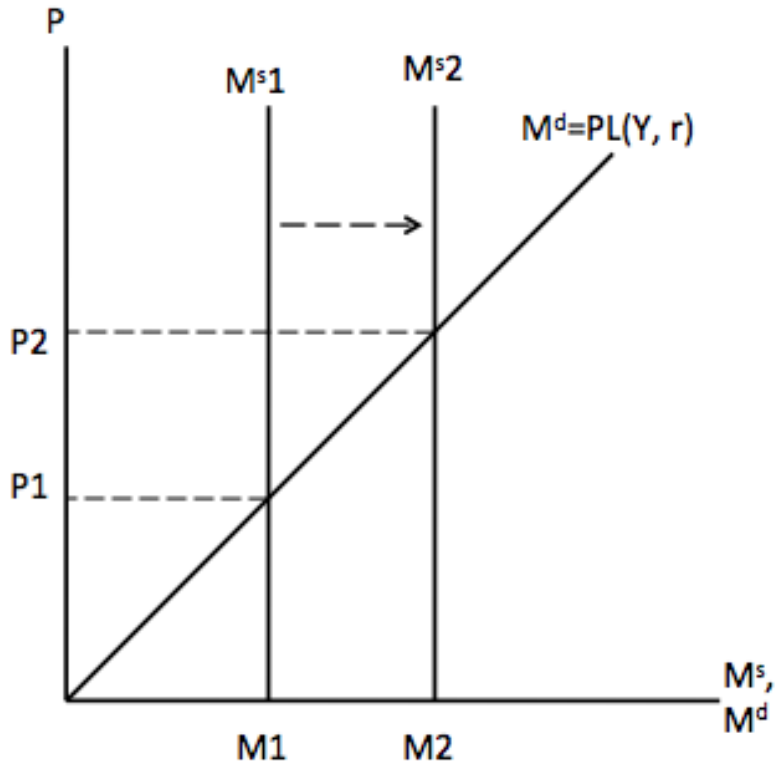
- The current goods market determines the equilibrium output (Y*).
- The credit market gives the real interest rate.
- Given r*, the current labor market determines the equilibrium real wage (w*) and employment (N*).
- Given Y* and r*, the current money market determines the price level (P*).

The Neutrality of money

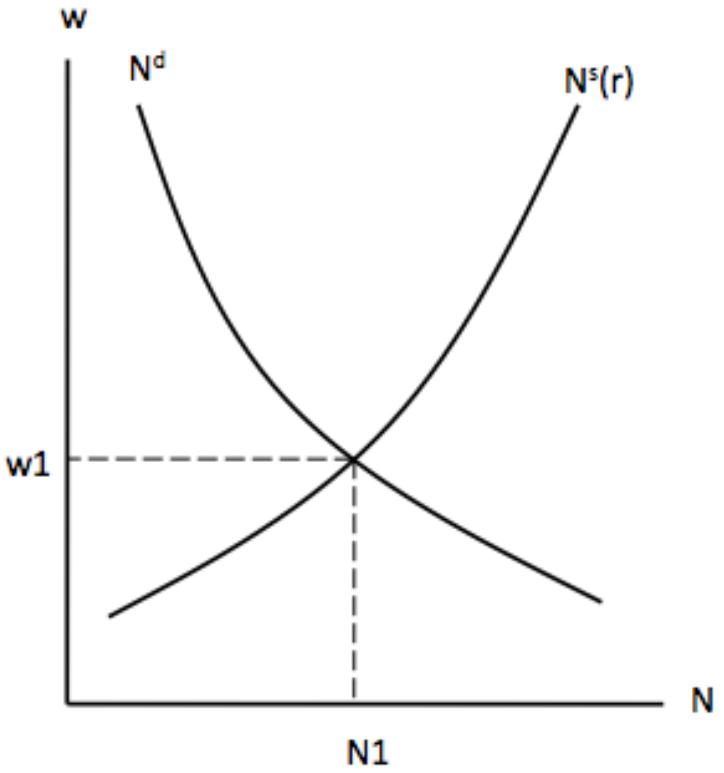
- Assume an one-time increase in the money supply: $M - M^{-} = M_2 - M_1 = \Delta M > 0$.
  - A decrease in taxes (T) increases household disposable income.
  - An open market purchase of bonds by the central bank.
  - An increase in government spending (G) financed by printing new money.
- The M^s curve shifts to the right.
  - The price level increases proportionally to ΔM.

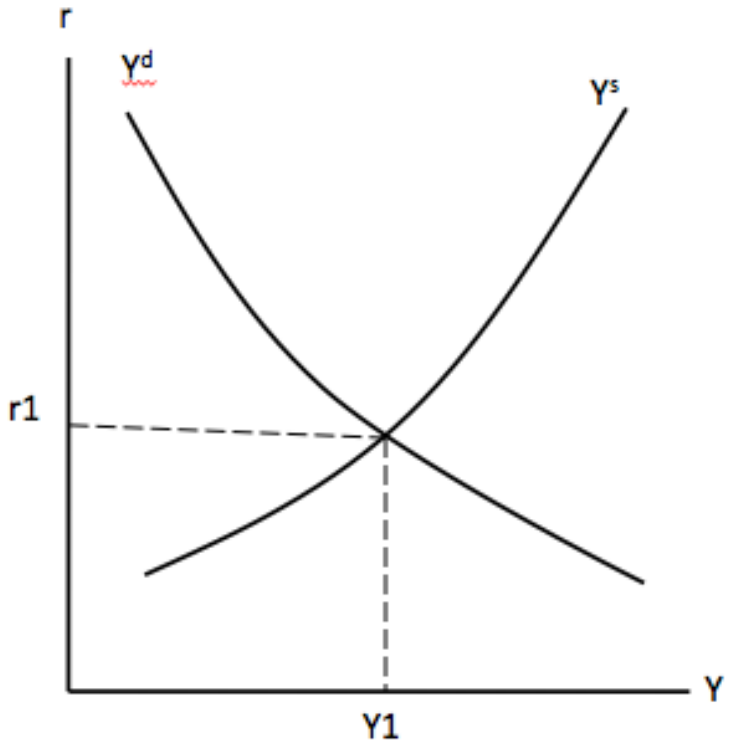
An one-time increase in Ms

- An increase in M^s from M1 to M2 causes the price to rise proportionally from P1 to P2, given Y and r.



No change in other markets





- “Suppose that the government could magically add a zero to all Federal Reserve notes. That is, suppose that overnight all $1 bill become $10 bills all $5 bills become $50 bills, and so on. It seems clear that, on the monring when everyone wakes up with their currency holdings increased by 10 times, all sellers of goods would have anticipated this change and would have increased their prices by 10 times as well, and there would be no change in aggregate economic activities.”

The classical dichotomy

- All the real variables (r*, w*, Y* and N*) remain the same.
- The real variables are separated completely from the nominal variables (M^s, M^d and P).
  - The current labor market (Ns and Nd) and the current goods market (Y^s and Y^d) are not affected.
- The real money demand is not affected:
  - $\frac{M^d}{P} = L(Y, r)$ is constant; $\Delta M = \Delta P$
  - One-time inflation until the new price is reached.

Long-run monetary neutrality

- The monetary neutrality holds in the long run.
- In the short run, money may not be neutral, depending on:
  - The method of injecting money into the economy.
  - Who receive the additional purchasing power first?

Monetary debates

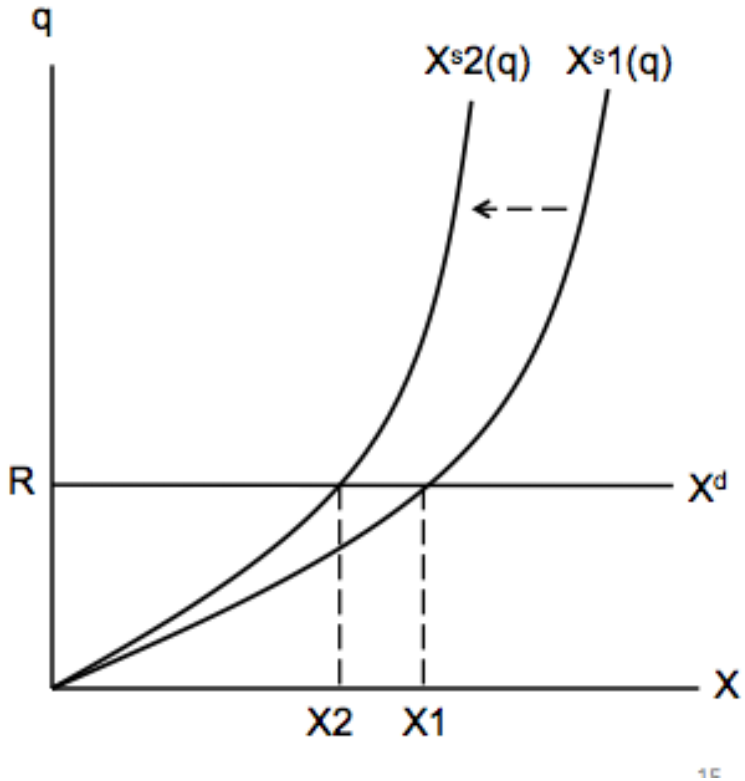
- In the long run, a money-increase has no effects on real variables.
  - Only one-time inflation and the higher price level.
- Short-run effects on real variables disappear in the long run — but how?
- What is the transmission mechanism from money to the price level?
  - The real balance effect? The wealth effect?

Shifts in money demand

- Factors that affect the supply or demand for credit card services shift the money demand curve.
- Assume the supply of credit card services shifts left:
  - Ex: communication failure between banks and retailers.
  - The amount of service decreases; the price = q.

Supply of credit card services

- The supply of credit services shifts left.
- The amount of service decreases from X1 to X2.
- The service price is still R = q.



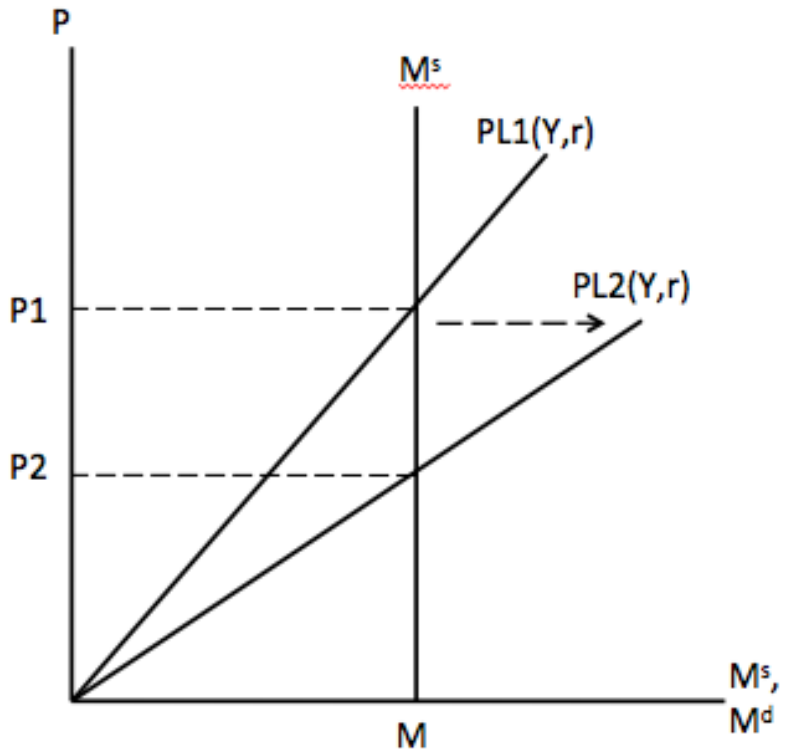
$$M^d = P\left[Y - X^*(R)\right]$$

$$M^d = P \times L(Y, R)$$

- As X decreases, money demand increases.
  - The money demand curve shifts right.
  - The price level decreases.
- No effects on other markets.

An increase in money demand

- A decrease in supply of credit card services raises the money demand.
- The price level decreases.



Changes in demand/supply of credit card services

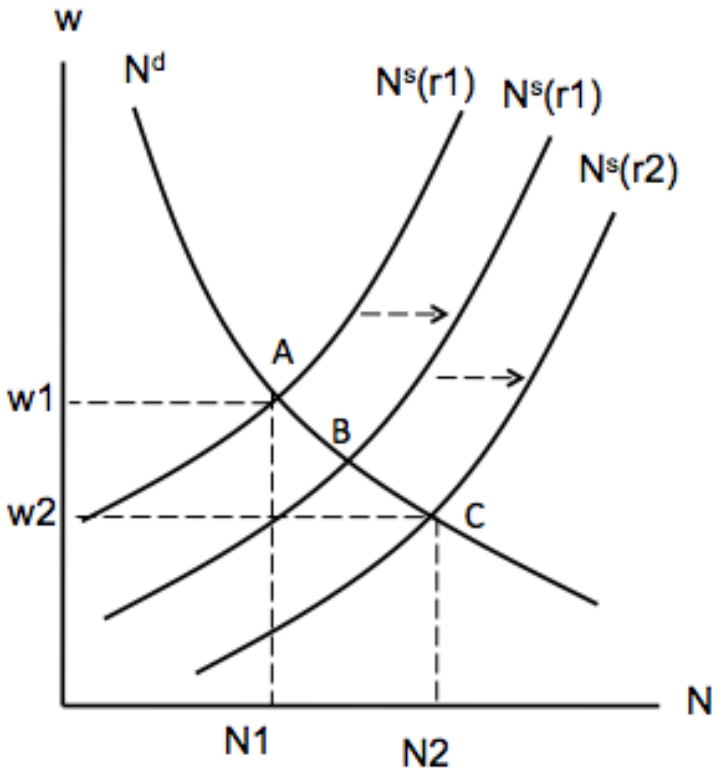
- New technology reducing the cost of banking services.
- New financial instrument reducing the bank's operating costs.
- A change in government regulations.
- A change in the perceived riskiness of banks.
- Shocks in the financial systems.

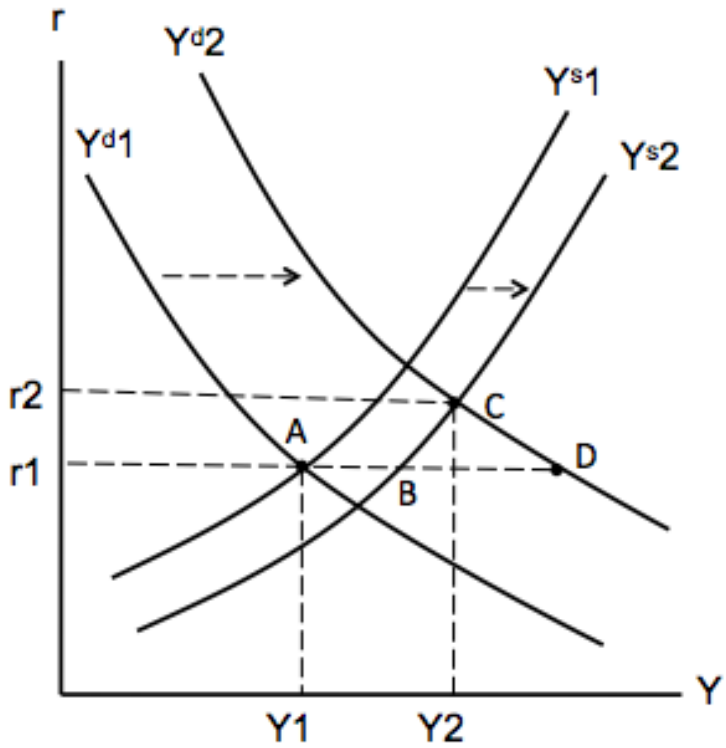
Shock experiments

1. Current government purchases increase temporarily (G);
2. Current capital stock decreases due to a natural disaster or war (K);
3. A temporary increase in current total factor productivity (z);
4. An increase in future total factor productivity (z').

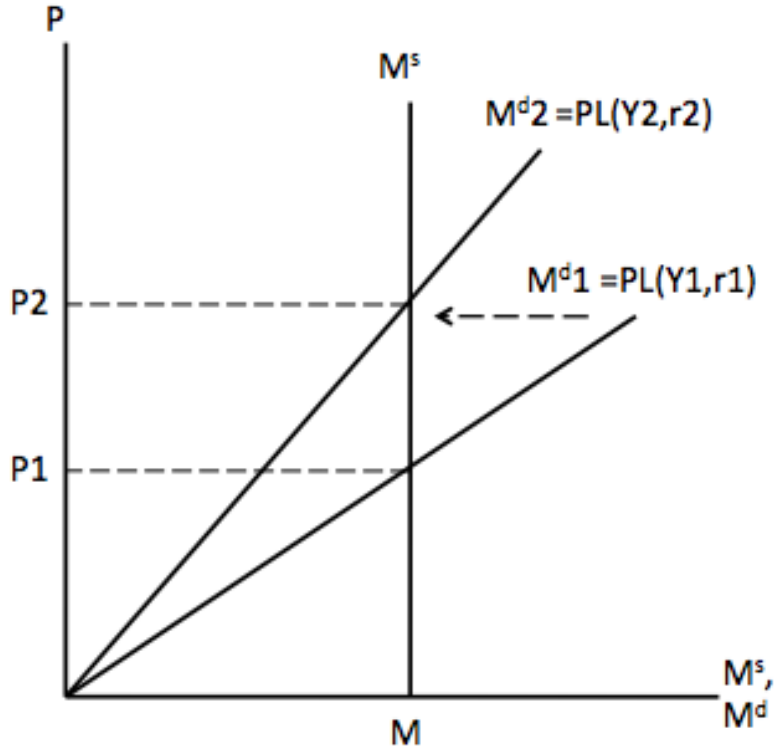
1. A temporary increase in G

- Higher lifetime taxes; lower lifetime wealth.
  - Leisure decreases; labor supply increases (Ys).
  - Current consumption decreases (Yd) .
- The G increase raises total demand for goods (Yd); higher income and real interest rate.
  - Leisure decreases and labor supply (Ns) increases.
  - Lower current consumption and investment demand.


w
N^d
$N^s(r1)$
$N^s(r1)$
$N^s(r2)$
A
B
C
w1
w2
N
N1
N2


r
Y^d2
Y^s1
Y^d1
Y^s2
r2
r1
A
B
C
D
Y
Y1
Y2

- Higher Y raises money demand but rising r decreases it.
- If the latter is strong, M^d shifts left and P rises.



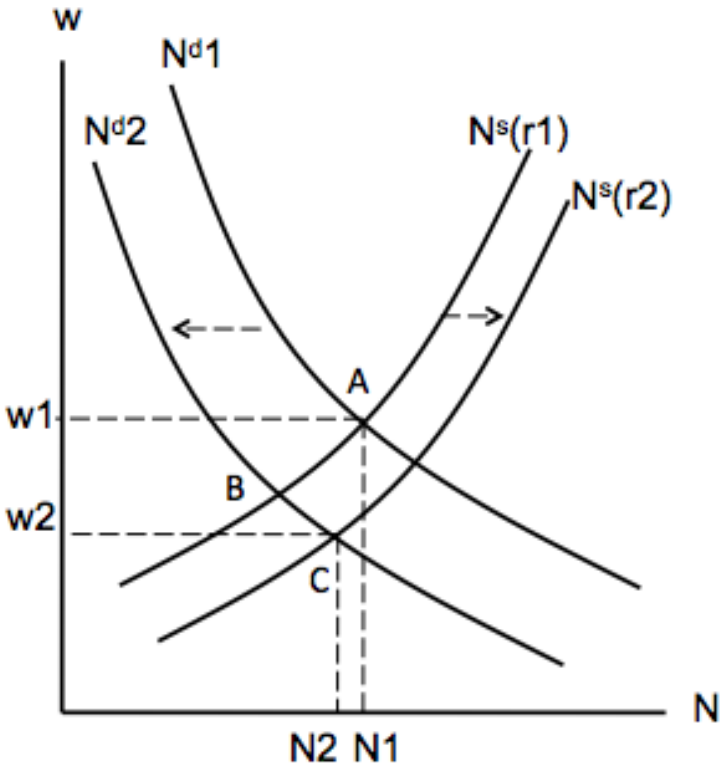
Overall effects of rising G

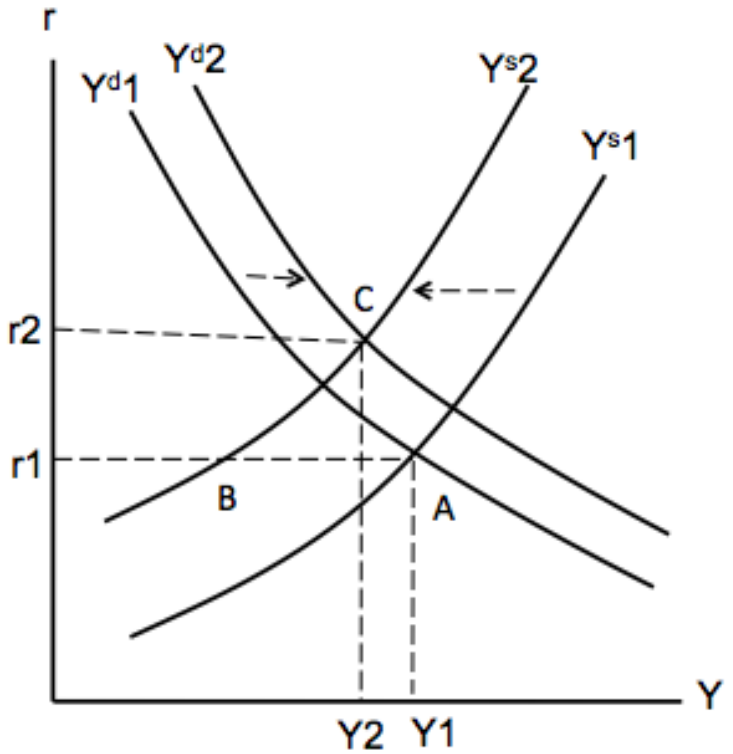
- Higher income and a higher real interest rate.
  - The effect of rising G on Y^d in the current period is stronger.
- Lower current consumption and investment.
- Higher employment and a lower real wage.
- The higher price level.

2. A decrease in current capital stock

- A lower MP_N, falling labor demand (Y^s shifts left).
- A lower K' and higher MP'_K; investment demand increases (Y^d shifts right).
  - The higher real interest rate reduces leisure (labor supply, N^S), current consumption and investment demand.
  - The real wage, employment and output fall.

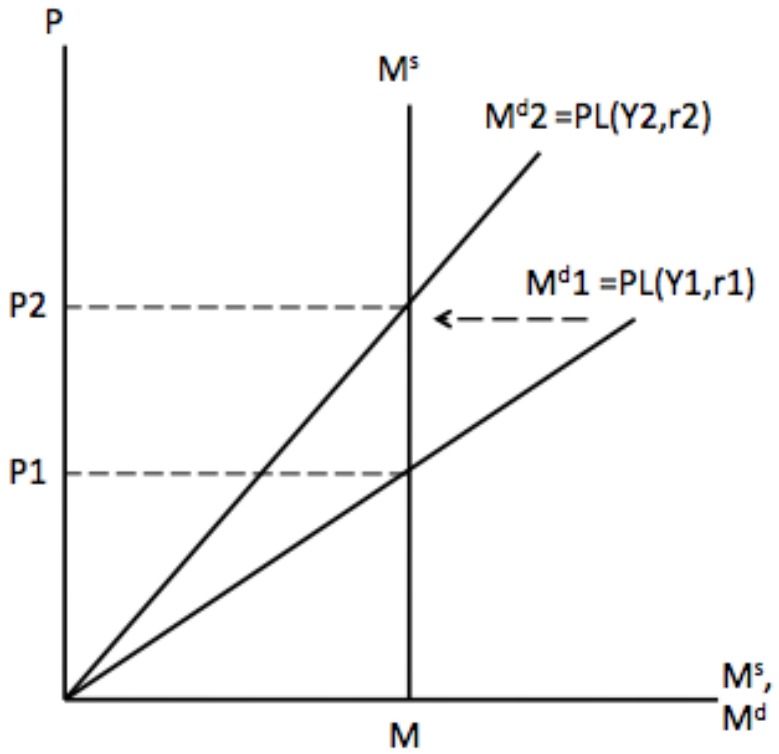
Falling K: labor and goods markets





Falling K: money market

- Lower income and higher real interest rate decrease money demand.
- The price level increases.



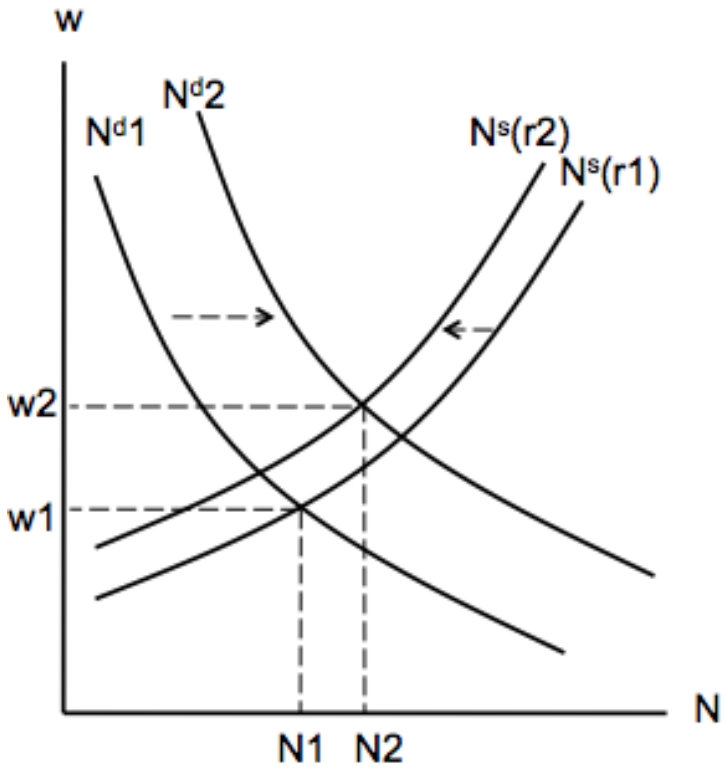
Overall effects of falling K

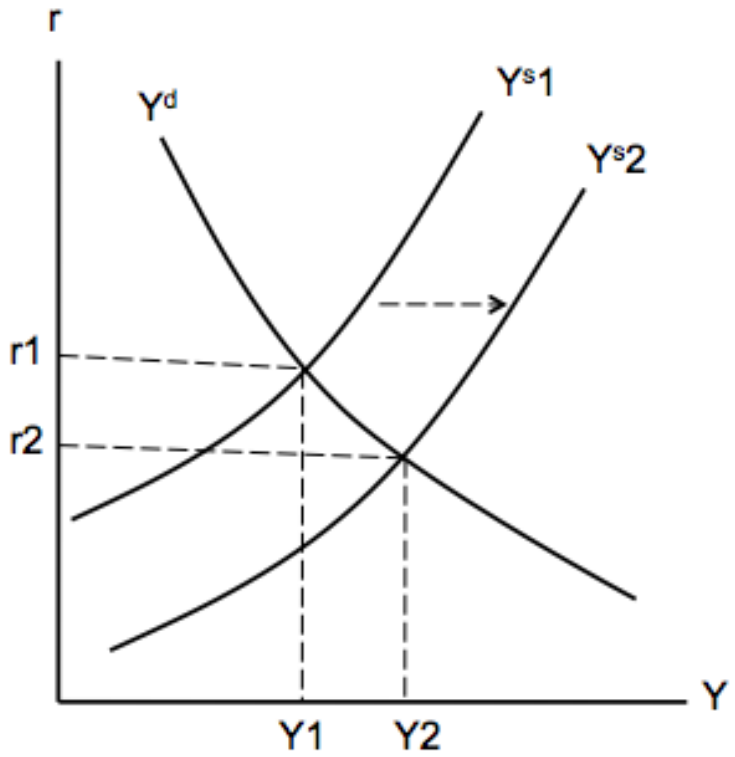
- Output and income are lower.
- The real interest rate is higher.
- Current consumption decreases; investment increases (net effect).
- Employment and the real wage decrease.
- The price level is higher.

3. An increase in current z

- Current MP_N and labor demand increase; Y^S shifts right.
- The real interest rate decreases.
- Leisure increases; labor supply (N^S) decreases.
- The real wage increases.
- Employment and output increases.
- Current consumption and investment increase.
- Higher money demand and price level.

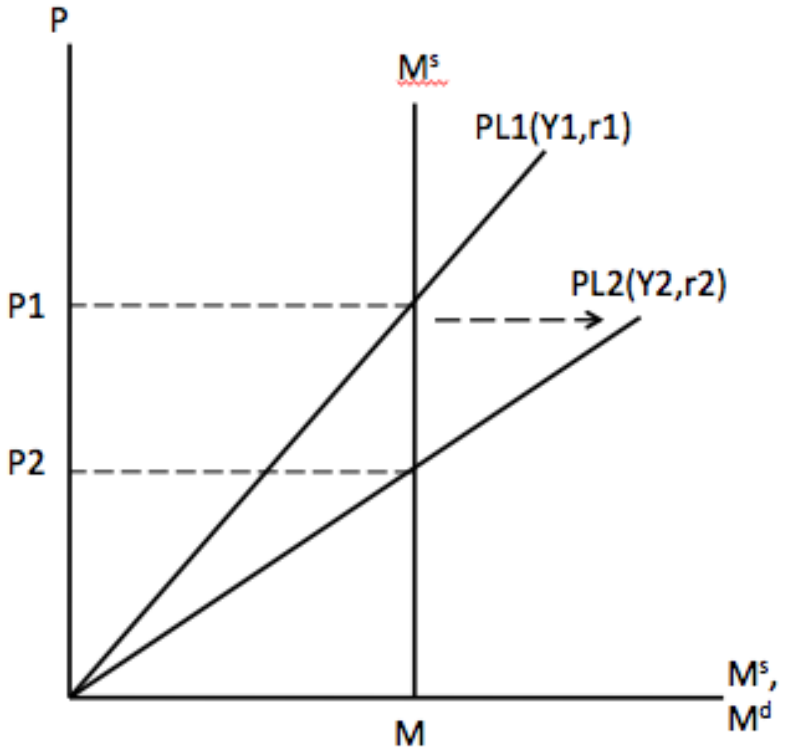
A rising z: labor and goods markets





A rising z: money market

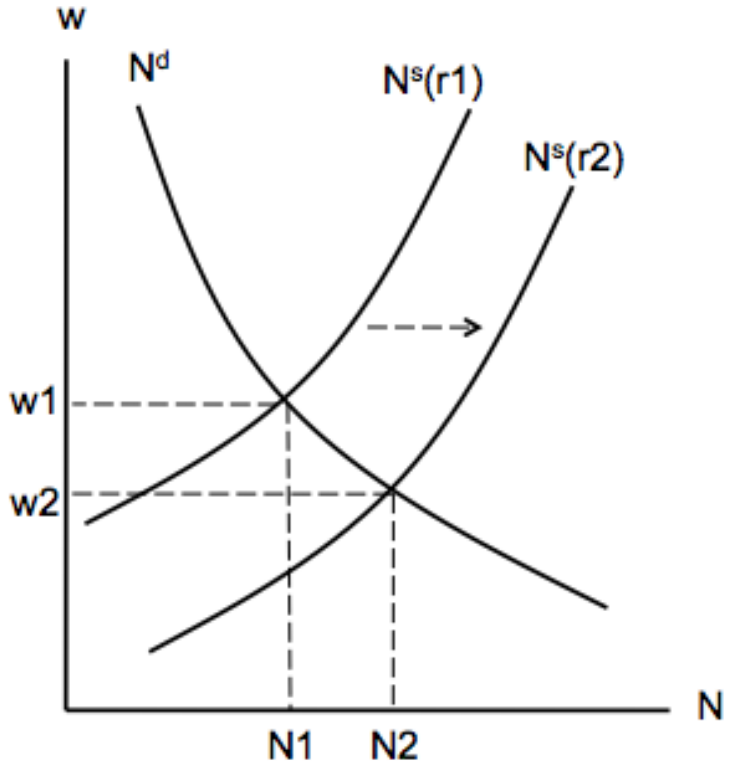
- A lower real interest rate and higher income raise money demand.
- The price level decreases.

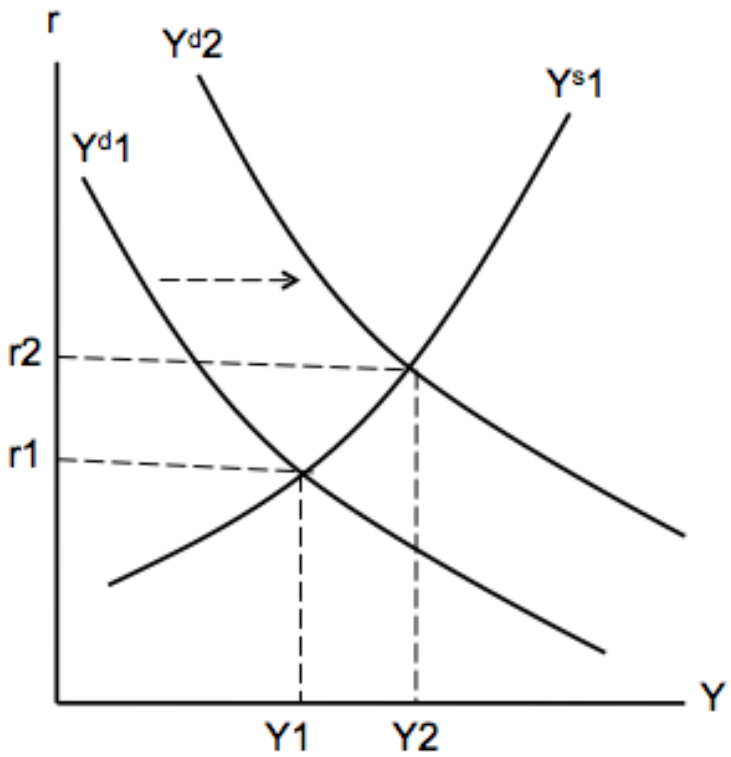


4. An increase in z'

- Higher MP'_K and investment demand; Y^d shifts right.
  - Higher output and real interest rate.
  - Lower leisure, more labor supply (N^S).
  - Employment and the real wage increase.
  - Current consumption is uncertain; investment increases (net effect).
- If M^d decreases, the price level increases.

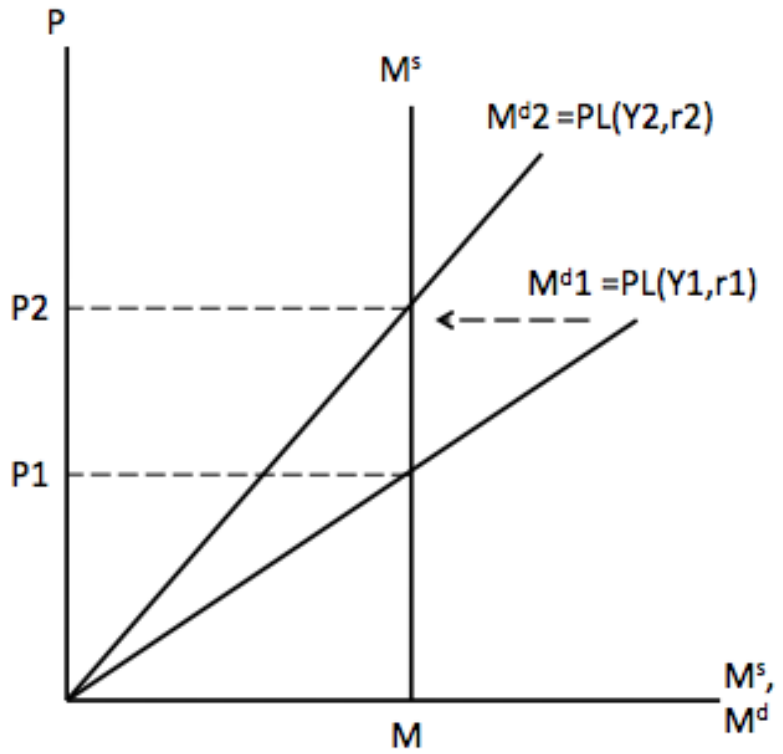
Rising z': labor and goods markets





Rising z': money market

- Higher Y raises money demand, but higher r reduces it.
- If the latter is strong, the price level increases.



Discretionary monetary policy

- Keynesians believe that the market is not efficient and too slow in adjusting to shocks
- Fiscal policy to stabilize the economy.
- **Discretionary monetary policy** by the central bank (to influence private spending).
  - Easy-money policy in times of a slowdown.
  - Tight-money policy in times of expansion.
- But the central bank never has the full information about the economy.
  - Discretionary monetary policy is difficult and costly; targets are missed most of the time.
  - Persistent high inflation in the 1970s discredited such policy.
- **Monetary policy rules** are recommended.
  - The rules for the central bank to control the money supply in response to observable variables in the economy.

The monetary policy rule

- Inflation affects consumers' welfare.
  - Price stability is preferred by consumers and firms.
- Types of monetary policy rules:
  - Money supply targeting.
  - Interest rate targeting.
  - Inflation targeting.
  - Nominal GDP (NGDP) targeting.

Money supply targeting

- Recommended by Milton Friedman in 1968.
  - The doctrine of monetarism (1970s).
- The constant money-growth rule:
  - Set a constant growth rate of some monetary aggregates (e.g., M1 or M2).
  - Popular in the 1970s and 1980s, then abandoned.
  - Missing the targets due to shocks from Md.
- Good for reducing runaway inflation.

Interest rate targeting

- The Fisher relation: R = r + i. ($R = r + \pi$; $\pi$is inflation rate)
- The central bank targets R = R*.
- If R* = r, then i = 0 (or $\pi = 0$). Good for M^d shocks.
- If R > R*, the central bank raises M growth.
- If R < R*, the central bank reduces M growth.
- Not efficient if shocks from real variables.

Inflation targeting

- The central bank sets a target inflation rate (π^*).
  - If $\pi > \pi*$, the central bank raises the nominal interest rate.
  - Short-run interest rate targeting to achieve medium-run inflation target.
- But other shocks may cause the central bank to miss the target.

Nominal GDP targeting

- The central bank sets a future path of nominal GDP growth (NGDP*).
  - Then it uses short-run targeting (e.g., interest rate targeting) to achieve the medium-run target.
  - If NGDP > NGDP*, it reduces the nominal interest rate.
  - If NGDP < NGDP*, it raises the nominal rate.

Additional for teaching

Changes in money affect different economic agents at different times and places and in different extent. This is sometimes called Cantillon Effect. If, for example, a central banks increases the quantity of money, then there's someone who receives the new money first. Who ever receives the new money fist (i.e. the government to finance fiscal deficit) has the advantage of receiving an extra amount of money that has not loose its purchasing power yet. As the new money is spent, the currency looses purchasing power as prices increase, and the last person to receive his share of the new money supply does it only after the prices has increased. This is the reason why it is said that inflation is an implicit tax to the population (in many cases to the poor or less wealthy). Some people see their income increase and others decrease, they change their consumption and this leads to changes in relative prices. What guarantees that during all this process the preferences of the individuals will not change? Are preferences engraved in stone? If this new situation the market triggers changes in subjective preferences, then the conditions of the equilibrium are

An injection of new money allows the first receiver to buy items at basically unchanged prices, while those receiving the new money later can buy only at higher prices. So, first receivers of new money benefit at the expense of later receivers ("Cantillon Effect").
Yet another complication is that in the real world, new money doesn't come in via a magical increase of currency, nor through a helicopter drop. Instead the government (or the owners of gold mines in a Rothbardian world) gets the money first, and then hands it out to its cronies. The new money then ripples out into the community. It's best to be the government, it's second-best to be the defense contractor or Wall Street banker who get sweetheart deals, it's third-best to be the fancy restaurant that caters to the Wall Street bankers, etc.

If you're running a deli in Boise, you're going to see your input prices rise before your customers are able to pay more for your sandwiches. So there will be a general redistribution of wealth to the people closest to the money spigot, every time there is a new injection of money that disturbs the price equilibrium.
Finally, to the extent that this new money comes into the economy via the credit market (as opposed to a helicopter drop or, say, running the printing press to pay the Army), then one of the prices that rise early on is the price of bonds. In other words, real interest rates are temporarily pushed down, until the new injection stops and then the price system re-equilibrates. This artificially low interest rate sets off the unsustainable boom.