Chapter 4:
The Neoclassical Model with Money
Econ206 - Francesc Ortega
Outline

1. What is money?
2. The nominal interest rate. Fisher’s equation.
3. The complete neoclassical model.
4. The determinants of the price level.
5. The supply of money.

Reading: Chapter 4 (Mankiw 6e or 7e) and chapter 19 (ch18 in 6e)
Functions

- The stock of assets that can be used to make transactions.
- Functions
  1. **Store of value**. It allows us to transfer wealth from the present to the future (provided inflation not exorbitant).
  2. **Unit of account**. Used to quote prices and debts.
  3. **Medium of exchange**. What we use to purchase goods and services. Fully liquid.
A quick monetary history of the world

1. In all societies sooner or later **commodity money** appears. These are types of money with intrinsic value. Examples: gold, silver, cigarettes. The shortcoming is that commodity money is highly impractical. People shave the coins! Need to weigh coins in every transaction.

2. At some point the government mints coins of known purity and weight. Easy to recognize if they have been shaved.

3. Next government replaces coins by **gold certificates**.

4. **Fiat money**. Today’s $20 bills have that value only because the government says so. We trust that other people will accept them for that value. Usually fine except in cases of political instability or hyperinflation.
A problem with fiat money: Seigniorage

- In a fiat money economy, the government has the monopoly on printing money.
- People trust the nominal value on the bills.
- Tempting to print money to pay for government purchases. Almost zero printing cost but get goods and services in exchange!
- Printing money to finance expenditure revenue is like an inflation tax (also called seigniorage). As we will see, printing money creates inflation, which reduces the real value of people’s savings. So it’s like a tax.
- Read in the book how the American revolution was paid for.
The nominal interest rate

- The nominal interest rate \(i\) is the rate of return in USD of a one-year riskless bond. Let \(P_B\) be the price of the bond promising \(R\) in one year. The rate of return is then

\[
i = 100 \frac{R - P_B}{P_B} \%
\]

- The real interest rate \(r\) is the rate of return in **units of goods** (purchasing power) associated to a one-year riskless bond.
- The simple neoclassical model only pins down the real interest rate. What is the equilibrium nominal interest rate?
Fisher’s equation

Definition

• Given $r_t$ and the expectation of next year’s price level we can determine the nominal interest rate $i_t$.

$$i_t = r_t + E\pi_{t+1}$$

• where $\pi_{t+1}$ is the actual rate of inflation between periods $t$ and $t + 1$. Obviously, not known in period $t$.

• $E\pi_{t+1} = \frac{P_{t+1}^e}{P_t} - 1$ is the expected rate of inflation between periods $t$ and $t + 1$ as of $t$. Known in period $t$.

• Can change frequently in response to news about the future. Lately Bernanke’s Fed is trying out ways to influence this expectation as a new tool of monetary policy.
Plenty of data on the nominal interest rate. Just look in the newspaper. But what is the current real interest rate today?

Fisher’s equation can be used: \( r_t = i_t - E\pi_{t+1} \).

Note that this calculation requires data on expectations on future inflation. Obtained surveying consumers (U of M Inflation Expectation)
Inflation expectations

University of Michigan Inflation Expectation

- Source: Survey Research Center: University of Michigan
- Based on Surveys of Consumers
- Frequency: Monthly
- Observation Range: 1978-01 to 2010-07 (as of August 13, 2010)
- Specifically, they report the Median expected price change next 12 months, Survey of Consumers.
Inflation expectations II

• Another way to measure the real interest rate is by looking at the returns of Inflation-Protected Securities.

• Using these data, expectations on inflation are often estimated (in Wall street) as the difference between the yields of Treasury notes ($i_t$) and of (5-year) Treasury Inflation-Protected Securities ($r_t$).

• Excerpt from Bloomberg News (06/22/2010):

"Investors anticipate an inflation rate of 1.69 percent in the next five years, compared with 2.01 percent on April 28, according to the gap between five-year Treasuries and Treasury Inflation-Protected Securities."
Expected versus Actual Inflation

Which one matters for nominal interest rates?

- We know that increases in **expected** inflation $E\pi_{t+1}$ will lead to higher nominal interest rates one-for-one.
- Do increases in **actual** inflation $\pi_{t+1}$ "lead to" higher nominal interest rates one-for-one?
- This is not a direct implication of Fisher’s equation. It is an empirical question whether this holds or not.
- Evidence shows there is a **systematic although not perfect relationship**.
- Sometimes changes in inflation are unexpected! In those cases $E\pi_{t+1} \neq \pi_{t+1}$. 

Usually $i_t$ and $\pi_t$ co-move

Over time evidence

U.S. inflation and nominal interest rates, 1960-2009

nominal interest rate

inflation rate
Countries with high $\pi_t$ tend to have high $i_t$

Cross-country evidence

Inflation and nominal interest rates across countries

Nominal interest rate (percent, logarithmic scale)

Inflation rate (percent, logarithmic scale)
The Money demand

- Given savings, families need to do a simple portfolio choice.
- Two assets: money (perfect liquidity) and riskless bonds (pays nominal interest but fully illiquid).

\[ Y - T = C + S^P \]
\[ PS^P = M + B \]

- The optimal portfolio choice gives rise to the demand for real money balances:

\[ \frac{M^d}{P} = L(Y, i) = L(Y, r + \pi^e) \]

- Increasing in \( Y \) (money is used for transactions)
- Decreasing in \( i \) (opportunity cost of holding money)
- Take expected inflation as given
The Market for Real Money Balances

- The quantity of money in the economy is controlled by the Fed. Let money be $\bar{M}^s$.
- Supply of RMB: $\frac{\bar{M}^s}{P}$
- Demand of RMB: $\frac{M^d}{P} = L(Y, r + \pi^e)$
- Graph with real interest rate as the relevant price. Increases in Y shift the demand to the right. Increases in expected inflation shift it to the left.
Equilibrium in the complete model

- A vector of prices and quantities such that supply equals demand in all markets:
  1. Factor markets
  2. Output market
  3. Loans market
  4. Market for real money balances
Steps to find the equilibrium

1. Market clearing in factor markets delivers $\bar{Y} = F(\bar{K}, \bar{L})$ and $(W/P)^*, (R/P)^*$.

2. Market clearing in the loans (or output) market delivers $r^*$: $I(r) = S(r, \bar{Y})$. Use Fisher’s equation can compute $i^*$.

3. (new) Market clearing for real money balances determines $P^*$. Now we can talk about inflation and determine nominal (dollar) wages.
Equilibrium in Complete Neoclassical Model

Step 1: \( Y^*, \left( \frac{W}{P} \right)^*, \left( \frac{R}{P} \right)^* \)

\( \frac{W}{P} \)

\( \frac{W}{P} \)

\( MPL(K, L) \)

\( \frac{R}{P} \)

\( MPK(k, L) \)

\( Y \)

\( Y^* = \bar{Y} \)

\( F(K, L) \)
Step 2: \( C^A \)

\[ S(r, Y) = S_p + S_g \]

\[ I(r, R_t) \]

Units of production
Outline

- What is money?
- Nominal rate
- Complete model
- Price level
- The money supply
- Bailouts and regulations

Step 3: \( p^* \)

\[ \frac{\bar{M}_s}{p^*} \]

\[ L(y, r + \pi e) \]
Determinants of the price level

- We now have a (basic) theory of the price level
- As we shall see next, today’s price level will increase in response to
  1. An increase in the current money supply.
  2. An increase in today’s expectations about future inflation.
A history of price levels

Tom Sargent
The neutrality of money

- Suppose the Fed raises $M^s$ (e.g. through an open market operation).
- Find the new equilibrium following the three earlier steps.
- **Key**: Real income and real interest rate remain constant. Thus the equilibrium quantity of RMB demanded is unchanged at $L(Y^*, r^* + \pi^e)$.
- Therefore market clearing in market for RMB requires a proportional increase in the price level, with no effect on real variables.
Increase in money supply: \( \bar{M}_o \to \bar{M}_i > \bar{M}_o \)

\[ \frac{\bar{M}_o}{P_o^*} = \frac{\bar{M}_i}{P_i^*} \]

\( E_0 = E_1 \)

\( F \): Initial equilibrium.

\( F \): Not an equilibrium. Excess supply given \( P_i^* \).

\( E_1 \): Final equilibrium (\( P_i > P_i^* \)).
The neutrality of money

- Graphically, in the RMB market, if the price level remains constant there will be an excess supply. So price level must increase to clear the market.
- In short, increases in money supply lead to one-for-one increases in inflation.
The neutrality of money

Example

• Suppose that initially the economy is in equilibrium with money supply \( M^s_A = 10 \), price level \( P^A = 1 \), and a quantity of RMB demanded of \( L^A = 10 \).

• Now suppose that there is a 5% increase in the money supply so that \( M^s_B = 10.5 \).

• Note that the equilibrium demand for RMB is unchanged! Make sure you see this.

\[
\frac{M^s_A}{P^A} = 10 = \frac{M^s_B}{P^B} \\
\frac{P^B}{P^A} = \frac{M^s_B}{M^s_A} \\
g^P = g^{M^s}
\]

• Hence, an increase in prices (inflation) of 5%.
Money and inflation

What do the data say?

- In the long run, inflation and money growth are positively related, as the theory predicts. Also across countries.
- But not in the short run. In fact, negative correlation in short run.
- This does not mean that an increase in the money supply will *cause* inflation in the short run.
- It’s an estimation bias due to **reverse causality**: when inflation is rising the Fed cuts back on the money supply. Generates spurious relationship.
Over time

U.S. inflation and money growth, 1960-2009

- Inflation rate
- M2 growth rate
Cross-country

International data on inflation and money growth

Inflation rate (percent, logarithmic scale)

Money supply growth (percent, logarithmic scale)
Increases in future expected inflation

• Suppose the Fed announces that next year it will increase the money supply. Based on our theory we expect the price level next year to be higher than it would have been otherwise.

• As a result, we expect a higher inflation rate for next year ($\pi^e$).

• A bit surprisingly, this leads to a higher current price level and inflation rate.
Outline

What is money?  Nominal rate  Complete model  Price level  The money supply  Bailouts and regulations

\[ \text{INCREASE IN INFLATION EXPECTATIONS} \left( \bar{\pi}_2 > \bar{\pi}_0 \right) \]

\[ L \left( \bar{\pi}_0, \bar{\pi}^\pi \right) \]

\[ L \left( \bar{\pi}_2, \bar{\pi}^\pi \right) \]

\[ M/P \]

\[ E_0 : \text{Initial Equilibrium} \]

\[ E_1 : \text{Final Equilibrium} \]

Observe that \( \bar{\pi}_1 > \bar{\pi}_0 \).
Increases in future expected inflation

The argument

- As we know, changes in expected inflation do not affect the equilibrium real income and real interest rate.
- By Fisher’s equation, the current nominal interest rate will increase. Shifts down the demand for RMB.
- So the price level must increase to bring back market clearing. That is, inflation today!
Example (revised)

- Suppose $\bar{Y} = 100$, $r^* = 0.05$, and $L = (Y/100) - 2(r + \pi^e)$.
- Expected inflation $\pi^e$ is initially zero but it increases to 10%. The money supply remains constant.
  1. Compute the initial initial price level $P_0$ and nominal interest rate $i_0$ (with zero expected inflation).
  2. Compute the final price level $P_1$ and nominal interest rate $i_1$ (with expected inflation 10%).
  3. Compute the percent increase in the price level.
  4. Compute the change in the nominal interest rate.
Example: Solution

Compute the initial initial price level $P_0$ and nominal interest rate $i_0$ (with zero expected inflation).

\[
L(\overline{Y}, r_0 - \pi_0^e) = 1 - 0.1 = 0.9
\]

\[
\frac{M^s}{P_0} = 0.9
\]

\[
P_0 = \frac{10M^s}{9}
\]

\[
i_0 = r_0 + \pi_0^e = 5\%
\]
Example: Solution

- Compute the final price level $P_1$ and nominal interest rate $i_1$ (with expected inflation 10%).

\[
L(\bar{Y}, r_0 - \pi_1^e) = 1 - 0.3 = 0.7
\]

\[
\frac{M^s}{P_1} = 0.7
\]

\[
P_1 = \frac{10M^s}{7}
\]

\[
i_1 = r_1 + \pi_1^e = 15\%
\]

- The percent change in the price level is

\[
g^P = \frac{P_1}{P_0} - 1 = \frac{9}{7} - 1 = \frac{2}{7} = 28.57\%.
\]

- The change in the nominal interest rate is

\[
\Delta i = \Delta r + \Delta \pi^e = \Delta \pi^e = 0.10.
\]
The quantity theory of money

- Particular case of our model. Suppose $L(Y) = \nu \bar{Y}$, with $\nu > 0$.
- As before, equilibrium price level pinned down by the market for real money balances:

$$P^* = \frac{M^s}{\nu \bar{Y}}$$

- Note that money is neutral here too.
- Effect of expected inflation on the current price level is missing here.
The money supply

- Decisions on the money supply are called monetary policy.
- The money supply equals currency plus demand (checking account) deposits: $M = C + D$
- Since the money supply includes demand deposits, the banking system plays an important role. In fact deposits are about 10 times larger than currency.
- Depending on the types of deposits included (checking, savings, etc), we have several money aggregates (M1, M2, M3, and so on).
Why are banks bailed out?

Occupy Wall Street?

- From 1929 to 1933 over 9,000 banks closed
- As a result the money supply fell by 28%
- This drop in the money supply contributed to the severity of the Great Depression. In a nutshell, this drastic liquidity loss took down the market for loans, which kills investment.
- This is why the US administration made large (and generous) emergency loans to banks in the recent economic and financial crisis. In Europe again with current sovereign default risk in Euro area.
Monetary policy instruments

- The Fed controls the currency in circulation through **Open Market Operations** (public debt market).
  - Buying bonds increases C in circulation
  - Selling bonds reduces C in circulation
- The Fed controls the quantity of deposits through the **reserve ratio** (rr): \( \frac{R}{D} \geq rr \).
Money supply: the role of banks

- Scenario 1: No banks
- Scenario 2: 100-percent reserve banking ($rr = 1$). Banks hold all reserves equal to their deposits.
- Scenario 3: Fractional-reserve banking ($rr < 1$). Banks’ reserves cover only a fraction of the deposits.
- In all scenarios, we assume $C = 1000$. 
No banks

- Obviously, no bank deposits. That is, $D = 0$
- Hence the money supply is equal to the currency in circulation: $M^s = C = 1000$
100-percent reserve banking

• Banks accept deposits but do not make loans ($rr = 1$). Like safe boxes.
• Suppose currency in circulation is $C = 1000$. This cash is owned by Mr 1 who deposits it in Firstbank.
• Firstbank assets: Reserves = 1000.
• Firstbank liabilities: Deposits = 1000.
• Hence the money supply is currency in circulation plus bank deposits. In this example, $M^s = C + D = 0 + 1,000$.
• Note that it is the **same** money supply as in the no-banks scenario.
Banks have an incentive to give out loans (e.g. mortgages). They charge higher interest on loans than interest they pay for deposits.

But banks required to keep some reserves, in case depositors want to withdraw funds. Assume \( rr = 0.20 \).

What is Firstbank going to do with its $1000 in reserves? It will give out as much in cash loans as it can (to Mr. 2). Let’s see Firstbank’s balance sheet now.

Mr. 2 will deposit his cash in Secondbank.
<table>
<thead>
<tr>
<th>Assets</th>
<th>Firstbank</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>R=1,000</td>
<td></td>
<td>D=1,000</td>
</tr>
<tr>
<td>R=200</td>
<td></td>
<td>D=1,000</td>
</tr>
<tr>
<td>L=800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M = C + D</td>
<td>800 + 1,000</td>
<td></td>
</tr>
<tr>
<td>Assets</td>
<td>Secondbank</td>
<td>Liabilities</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>R=$800</td>
<td></td>
<td>D=$800</td>
</tr>
<tr>
<td>R=$160</td>
<td></td>
<td>D=$800</td>
</tr>
<tr>
<td>L=$640</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M = C + D</td>
<td>640 + 1,800</td>
<td></td>
</tr>
</tbody>
</table>
Money supply with fractional-reserve banking

- Note that at each step the increase in the money supply is smaller.
- The total money supply is

\[ M^s = 1000 + (1 - rr)1000 + (1 - rr)^21000 + \ldots \]

\[ = \frac{1000}{rr} \]

\[ = mm1000 \]

- \( mm = \frac{1}{rr} \) is the money multiplier.
- With \( rr = 0.2 \) then \( mm = 5 \).
Banks are creating liquidity, not wealth

- Giving out a loan changes the structure of the liabilities of Firstbank, but not its net worth (zero).
- Another way to see this is by looking at individual’s wealth. Consider individuals $j = 1, 2, 3...$ and define $wealth(j) = assets(j) - liabilities(j)$.

\[
\begin{align*}
wealth(1) &= 1000 - 0 = 1000 \\
wealth(2) &= 800 - 800 = 0 \\
wealth(3) &= 640 - 640 = 0
\end{align*}
\]

- Sum of all individual wealth=1000.
Liquidity versus solvency problems

- **Liquidity crisis**: if all depositors to Firstbank ask for their money, bank cannot pay them immediately (reserves<deposits). First it needs to collect the loans it made.

- **Solvency crisis**: if the loans given by Firstbank go awry (cannot be repaid). Then bank can’t satisfy its liability with the depositors.
The nature of the problem

- In 2006 a big part of banks’ loans were mortgages. Some of the banks reserves were in currency but others in mortgage-backed securities (bundles of mortgages held at other institutions). Large exposure to housing price risk.
- Between 2006 and 2008 housing prices fell after a long period of continued increase. As a result many mortgage holders went underwater and decided to default (value house < mortgage).
- As banks’ assets fell, they had to reduce deposits, which reduces liquidity (money supply) and credit.
- To make matters worse banks dumped the foreclosed properties in the market. House prices spiralled further triggering more defaults and bank losses.
The bailout

- On top of this the supposedly safe mortgage-backed securities lost value dramatically (contained unknown amounts of sub-prime mortgages). As a result many banks went nearly bankrupt (assets<liabilities).
- The government had to spend over $300 billion helping banks out (TARP).
- Fortunately, most of the emergency loans have been repaid and taxpayers have recovered their money. This saved the banking system and was very cost effective.
- See TARP entry on Wikipedia.
Reforming the system

1. "Too big to fail." Because banks play a central role in the economy (providing liquidity and credit) the government cannot afford to let big banks fail. New measures intended to limit the size of banks.

2. "Moral hazard." Banks’ deposits are insured (FDIC), which introduces an incentive to excessive risk-taking in their asset portfolios. New regulations to limit the riskiness of the assets in deposit institutions. Implies banks have to shed their investment-banking branches.

3. "Vulnerable banks." Banks will need to build a "conservation buffer" (larger reserves) and to increase their equity (i.e. borrow less from other institutions).