Money

Two basic questions:

1. Modern economies use money. Why?
2. How/why do changes in the amount of money affect nominal and real variables in the economy?

Uses/functions of money: (1) Unit of account: contracts are usually denominated in terms of money.
(2) Store of value: money allows consumers to trade current goods for future goods.
(3) Medium of exchange: facilitates transactions.
Non-monetary transactions require barter: one good or service is exchanged directly for another.

Requires a *double coincidence of wants*: each party must want what other has.

Other objects, like stocks and bonds, can be store of value and medium of exchange. Can dominate as store of value since they give a positive rate of return.

But stocks and bonds are not efficient in exchange:

1. Agents not well-informed about the exact value of stocks.
2. It is not always easy to sell these assets. (Liquidity)

Money very efficient in exchange. Facilitates specialization.

In absence of regular money, other objects appear as media of exchange (cigarettes in POW camps).
Types of money

Cowry shells

Ancient Greek coins, ca 700 BC

Stone money of the island of Yap
Most modern money is **fiat**. It is inherently useless. Valuable only because others value it.

In contrast, earlier money was **commodity** money. Explicitly backed by gold or silver.

How do we measure the money supply?

Distinguishing what to count as money is more difficult because of financial innovation. Different measures depending on how broad.

Monetary base (M0): currency and bank reserves
M1 and Its Currency Component

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- **M1**: $M_0 +$ traveller’s checks, demand deposits (non-interest checking), checkable deposits (may earn interest). Closest to our theoretical description of money.

- **M2**: $M_1 +$ additional assets which less like money. Savings deposits, money market accounts, small time deposits.

- Most US currency held outside US. In 1999, currency averaged $1800 per person, but average personal is $100. Some held by business, and underground (criminal) economy. But over half of US currency is held outside US.

- “Dollarization” of many especially Latin American countries where US $ is unofficial currency for transactions.
M2 and M1

Real M2 Money Stock
Real M1 Money Stock

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Williams Economics 312
Central bank (US: Federal Reserve, European Central Bank, Bank of England, etc.) regulates money supply.

Changes in money supply take place through open market operations. The purchase and sale of securities, typically government bonds.

Increases money supply by buying financial assets from the public. Exchanges money for assets, putting more money in hands of public. Decreases money supply by selling assets.
Chart 1

Outright Holdings of Domestic Assets in the SOMA
Daily Values, 2007 - 2010

- Treasury Securities
- Agency Debt
- MBS

Source: FRBNY
Federal Reserve Balance Sheet

Federal Reserve Assets (Uses of Funds)

Currency Swaps
Agency Debt & MBS
Lending to Nonbank Credit Markets
Short-Term lending to Financials
Other
Treasuries

Source: Federal Reserve Board

through Jun 19, 2013
Up to now all our models have been real: focusing on determinants of quantities produced. Numeraire was units of consumption goods.

In monetary models, money is the natural numeraire.

- \( P \) is the current price level (price of goods in units of money)
- \( P' \) is the future price level.

The inflation rate \( \pi \) is the growth rate of the price level:

\[
\pi = \frac{P' - P}{P}.
\]

A nominal bond costs $1 today, pays $1 + R in the future.

A real bond costs 1 good today, pays 1 + r in the future.

How are inflation, nominal, and real interest rates related?
The Fisher Equation

Consider the following sequence of transactions:

- Take one unit of goods, buy \( P \) units of money.
- Sell \( P \) units of money for \( P \) nominal bonds.
- Wait until the future period, getting \( P(1 + R) \) units of money.
- Take \( P(1 + R) \) units of money, buy \( \frac{P(1+R)}{P'} \) units of goods.

This replicates purchasing a real bond.

In the absence of arbitrage:

\[
1 + r = \frac{P}{P'} (1 + R) = \frac{1 + R}{1 + \pi},
\]

Equivalently:

\[
r = R - \pi - r\pi \approx R - \pi
\]

\( r = R - \pi \) is the Fisher equation.
Inflation and Interest Rates

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Now add money to our basic model.

Assume households hold money to buy “cash goods”. Households save by holding bonds.

What determines money demand?

- Overall demand for goods in the current period.
- Opportunity cost of holding money (nominal rate $R$).
In modern economies goods buy money and money buys goods, but goods don’t buy goods.
And because goods don’t buy goods, a medium of exchange that serves to aid the process of transacting will have value.
The demand for money is then determined by the nature of the economy’s transactions technology.
Cash-in-advance (CIA) models require that money balances be held to finance certain types of purchases; without money, these purchases cannot be made.
Other related models model “transaction services” as being produced with money and time.
Household Problem: Timing

- At the start of the period, the household has two assets: Money $M^-$ and nominal bonds $B^-$.  
- Household consists of two members, a worker and a shopper.  
- Worker supplies labor to firm, earns wage.  
- Shopper takes $M^-$ to store and purchases cash goods. Also purchases credit goods.  
- At the end of the period household members pool resources, rebalance portfolio of assets.
Importance of Timing Assumptions

- Lucas (1982). Agents allocate their portfolio between cash and other assets at the start of each period, after observing any current shocks but prior to purchasing goods.

- If there is a positive opportunity cost of holding money, agents hold just enough to finance their desired level of consumption.

- We follow Svensson (1985), where the goods market opens first. Agents have available for spending only the cash carried over from the previous period.

- If there is uncertainty, an agent may find that she is holding cash balances that are too low to finance her desired spending level. Or she may be left with more cash than she needs, thereby forgoing interest income.

- We focus on a model with certainty, so the distinctions are less important.
Household Decisions

• Household chooses leisure \( l \) (or labor \( h - l \))
• Consumption:
  • Cash goods \( C^m \) (must be purchased with money).
  • Credit goods \( C^c \).
• Savings: Money \( M^d \). Bonds \( B^d \).
• Pays real taxes \( T \) and earns real dividends \( x \).
• The household has standard preferences over current and future leisure and consumption of both the cash and credit goods:

\[ U(C^m, C^c, C^{m'}, C^{c'}, l, l') = u(C^m, C^c, l) + \beta u(C^{m'}, C^{c'}, l') \]

• The household faces cash-in-advance (CIA) constraints:

\[ PC^m \leq M^– \text{ and } P' C^{m'} \leq M^d \]

If the nominal interest rate is positive, these constraints bind.

• The household also faces nominal budget constraints:

\[ PC^m + PC^c + B^d + M^d = M^– + (1 + R^–) B^– + P w(h - l) + P(x - T) \]

\[ P' C^{m'} + P' C^{c'} = M^d + (1 + R) B^d + P' w'(h - l') + P'(x' - T') , \]
Eliminate $M^−$ and $M^d$ from the budget constraint using CIA:

\[
PC^c + B^d + P'C^{m'} = (1 + R^−)B^− + Pw(h - l) + P(x - T)
\]

\[
P'C^{c'} = (1 + R)B^d + P'w'(h - l') + P'(x' - T'),
\]

Combine to get a single intertemporal budget constraint:

\[
C^c + \frac{P'C^{c'}}{P(1 + R)} + \frac{P'}{P}C^{m'} = \frac{(1 + R^−)B^−}{P}
\]

\[
+ w(h - l) + x - T + \frac{P'}{P} \cdot \frac{w'(h - l') + (x' - T')}{1 + R}
\]

Recall $P'/P = 1 + \pi$ and $1 + r = \frac{1 + R}{1 + \pi}$. 
Household’s Decision Problem

- The intertemporal budget constraint becomes

\[ C^c + \frac{C^{c'}}{1 + r} + (1 + \pi)C^{m'} = \frac{(1 + R^-)B^-}{P} \]

\[ + w(h - l) + x - T + \frac{w'(h - l') + (x' - T')}{1 + r} \]

\[ \max_{C^c, l, C^{m'}, C^{c'}, l'} u(C^{m}, C^c, l) + \beta u(C^{m'}, C^{c'}, l') \]

- \[ u_{C^c} = \lambda \]
- \[ u_l = \lambda w \]
- \[ \beta u_{C^{m'}} = \lambda (1 + \pi) \]
- \[ \beta u_{C^{c'}} = \lambda \frac{1}{1 + r} \]
- \[ \beta u_{l'} = \lambda \frac{w'}{1 + r} \]
Optimality Conditions

First order conditions give:

\[
\begin{align*}
MRS_{l,c} &= w \text{ (as before)} \\
MRS_{l',c'} &= w' \text{ (as before)} \\
MRS_{c,c'} &= 1 + r \text{ (real interest rate)} \\
MRS_{c',cm'} &= \frac{1}{(1 + r)(1 + \pi)} = \frac{1}{1 + R} \text{ (nominal interest rate)}
\end{align*}
\]

From CIA, \(M^d/P' = cm'\) so get implicit money demand from last equation.
Firms and Government

- Firms: Unchanged from real intertemporal model. Optimality conditions as before:

\[ MPN = w, \ MPK = r \]

- Government: Combine fiscal and monetary policy.
- Pay for real spending \( G \) and nominal debt \((1 + R^-)B^-\) by:
  - Raising taxes \( T \).
  - Issuing more debt \( B \).
  - Increasing the money supply \( M - M^- \).
- Government budget constraint:

\[ PG + (1 + R^-)B^- = PT + B + M - M^- \]
The Money Market

- All factors in the real intertemporal model still present.
- In addition, there is also another market, the money market.
- Recall real money demand $M^d/P'$ determined by:

$$MRS_{C^{c'}, C^{m'}} = \frac{1}{1 + R}$$

- Consumption decisions depend on permanent income, so does real money demand. $M^d$ also depends on current nominal interest rates.
- Shifting forward one period, write as:

$$\frac{M^d}{P} = L(Y, Y', R)$$

- Money demand $L$ is increasing in $Y$, decreasing in $R \approx r + \pi$. 
Nominal money supply is fixed, $M^s = M$.
The price level adjusts to clear the money market:

$$M = PL(Y, Y', R).$$

Note that the model is “recursive”: solve for the price level last. The other variables determined by the real markets (goods, labor, capital).
Figure 10.5 The Current Money Market in the Monetary Intertemporal Model

\[ M^d = PL(Y, r + i) \]

\[ P^* \]

\[ P \]

\[ M^s \]

\[ M^d, M^s \]
A One-Time Increase in the Money Supply

- $M = M_1$ until the current period. Then there is an unanticipated, permanent increase to $M_2$.
- Government budget constraint:
  \[ PG + (1 + R^-)B^- = PT + B + M - M^-. \]
- $M - M^- = M_2 - M_1 > 0$. What else adjusts?
  - $R^-$ and $B^-$ are predetermined.
  - We typically treat $G$ as fixed.
  - Tax cut or equivalently a “helicopter drop”: directly transfer the new money to households in lump some fashion.
  - Open market purchase of bonds.

- Note that printing money does not create wealth. Money, like bonds, is a liability of the government.
Equilibrium Effects of $M^s \uparrow$

- Nothing on the real side of the economy changes.
- This is the classical dichotomy.
- The price level increases proportionately.

$$M = PL(Y, Y', R).$$

- The real money supply $M/P$ is left unchanged.
- Money is neutral: no effects on real side, only prices.
- Money here effectively pins down units of measurement.
Figure 10.8  The Effects of a Level Increase in $M$—The Neutrality of Money
A Change in the Growth Rate of Money

- An increase in the money supply raises prices.
- An increase in money supply growth raises inflation as prices continue to rise.
- Suppose $M' = (1 + m)M$.
- $M = PL(Y, R)$ and $M' = P'L(Y', R')$.
- Suppose the real economy is the same in every period ($Y = Y'$, $R = R'$):

$$\frac{M'}{M} = \frac{P'}{P} \Rightarrow 1 + m = 1 + \pi \Rightarrow m = \pi$$

- Inflation due growth in money supply.
- But increase in money growth may have real effects. (We’ll return to this later.)
Quantity Theory of Money

- **Velocity** of money is a measure of how quickly money changes hands. Basic **quantity theory** equation:

  \[ MV = PY \]

- Serves as definition of \( V = PY/M = Y/L(Y, R) \).
- **Quantity theory** or **monetarism** says that velocity is stable, so changes in \( M^s \) lead to changes in nominal income \( PY \).
- Problems: Increased financial innovation led to shifts in money demand, hence changes in velocity. Made implementation of policy difficult and led to volatility.
M1 Velocity: 1959-2013

Source: Federal Reserve Bank of St. Louis

Velocity of M1 Money Stock

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Figure 10.17 Central Bank Does Not Observe the Price Level Response to a Shift in Demand for Money