Monetary Macroeconomics

Lecture 7:
Central Banking and the Money Supply

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How Does the Central Bank Control the Money Supply?

Monetary authority may wish to regulate money-creating institutions (i.e. banks) in order to control the total stock of money or to enhance revenue from seigniorage.

Three tools commonly used by central banks:

- Reserve requirements
- Loans to banks
- Exchange of money for interest-bearing debt

Reserve Requirements

The governments force people to hold fiat money by requiring financial intermediaries to hold a legally specified fraction of their deposits in the form of fiat money.

Hence reserve requirements are the amount of funds that a depository institution must hold in reserve against specified deposit liabilities.

In the US, this is held either as cash in their vault or as deposits with the Federal Reserve Bank.

In Switzerland the reserve requirement ratio is currently 2.5%.

Reserve Requirements Across Countries

Country	Reserve Requirement
Mexico	None/compulsory deposits
Eurozone	2%
Latvia	3%
Chile	4.5%
China	7%
Bulgaria	8%
Burundi	8.5%
Hungary	8.75%
Ghana	9%
USA	10%
Zambia	17.5%
Croatia	19%
Tajikistan	20%
Suriname	35%
Jordan	80%

Source: Survey conducted in Sept 2003 among CBC participants at the Study Center Gerzensee

Monetary Aggregates

There are several measures of money: M1, M2, M3, and M4.

M0 = monetary base (currency)

M1 = M0 +checking account deposits (highly liquid). This is the narrowest measure of money.

M2 = M1 + time deposits + saving deposits

M3 = M2 + repurchase agreements + money market fund shares and money market paper + debt securities issued with maturity up to 2 years

These definitions can change from country to country! There is no universally accepted method of defining these measures.

You can find data on the Swiss monetary aggregates at

www.snb.ch

and

www.data.snb.ch

Central Bank Lending

If the banks find themselves unexpectedly short of fiat money and cannot meet the reserve requirements, they can borrow from the Central Bank.

In the US the interest rate charged by the Federal Reserve Bank is called the **discount rate**.

The banks can also borrow from each other. The interest rate they charge to other banks is called the **federal funds rate** in the US.

It is determined by the market. It has been always more volatile than the discount rate. But the Fed announces a target value for this interest rate and conducts open market operations to meet this target.

Open Market Operations

A purchase or sale of an interest-paying asset by the monetary authority is called an open market operation.

So the central bank becomes a financial intermediary itself!

Open market operations are sales and purchases of (usually) government securities in the open market.

Open market purchases expand reserves and the monetary base, thereby raising the money supply and lowering the short-term interest rate.

Open market sales shrink reserves and the monetary base, lowering the money supply and raising short-term interest rates.

This is the primary way a central bank generates changes in the monetary base and hence in the money supply.

For example, in the US, open market operations involve government bonds, rather than private bonds, mortgages, shares in firms, and so on. That is because the Fed does not hold these types of private obligations.

Advantages of OMO

The central bank has control of the volume – effect on the monteary base is much more certain than on reserves.

OMO are flexible and precise.

OMO are easily reversed. Counteract mistakes.

OMO can be quickly implemented.

General Trends

Recently, there has been greater importance of OMO as a tool for monetary policy.

Reserve requirements have declined worldwide.

There has been less reliance on the discount window.

In Switzerland

The Swiss National Bank implements its monetary policy by influencing interest rates on the money market.

It sets a target range for the three-month
Libor, the economically most significant money market rate for Swiss franc investments.

LIBOR stands for the London Interbank Offered Rate and is the rate of interest at which banks borrow funds from other banks, in marketable size, in the London interbank market.

The SNB influences the three-month Libor mainly through short-term **repo transactions** (repurchase agreements), its chief monetary policy instrument.

It can prevent an undesirable rise in the three-month Libor rate by supplying the banks with additional liquidity through repo operations at lower repo rates (creating liquidity).

Conversely, by injecting less liquidity or increasing repo rates the National Bank induces an upward interest rate movement (absorbing liquidity).

Repo rates cannot be directly compared with the Libor.

As a rule, the three-month Libor is **higher** for two reasons. First, the Libor refers to an unsecured loan, whereas the repo rate is the price for a loan backed by securities. The Libor thus contains a credit risk premium. Second, maturities for repo transactions are usually shorter than three months and therefore have a lower maturity premium than the three-month Libor.

If a bank urgently needs liquidity which cannot be obtained in the money market, it may receive an advance against securities (**Saron loan (Swiss Average Rate Overnight)**) from the SNB.

A "Saron loan", however, is limited to the amount of collateral provided in the form of securities and granted only at the official rate.

The SNB sets the conditions of its standing facilities regarding its intra-day facility and short-term liquidity financing facility. These facilities are not a permanent source of refinancing.

Link Between Money Supply and Interest Rates

The central banks do not control the interest rates directly. They can target interest rates, but they use other instruments to hit the targets, such as open market operations.

Open market operations adjust the supply of reserves in the banking system so that the central bank can achieve a target interest rate.

Two Contradictory Views

1. Liquidity Effect

According to this view, money demand is a decreasing function of the nominal interest rate because the interest rate is the opportunity cost of holding cash (liquidity).

So a decrease in the supply of money must cause interest rates to increase in order to keep the money market in equilibrium.

2. Fisher Effect

The Fisher equation states that the nominal interest rate equals the real interest rate plus the expected rate of inflation (Fisher 1896).

$$R_{t+1} = r_{t+1} + E[\pi_{t+1}]$$

If monetary policy does not affect the real interest rate, then the Fisher equation implies that higher nominal interest rates are associated with higher rates of inflation.

Since in the long run, high inflation rates are associated with high money growth rates, the Fisher equation suggests that

Money supply $\uparrow \Rightarrow E(\pi) \uparrow \Rightarrow$ nominal interest rates $\uparrow$.

Thus the interest rate could react to a *monetary expansion* by increasing or decreasing!

Liquidity Effect $\downarrow$

Fisher Effect [Inflationary Expectations] $\uparrow$

Price and Income Effects $\uparrow$

Ultimately, the answer is quantitative! We need to measure the impact of an increase in money supply on interest rates and the impact might be different in short and long-term (*dynamics*).

Dynamics of Interest Rate Adjustment

The liquidity effect is likely to be short term.

The income and price effects are likely to be longer term (sticky prices, adjustment costs).

Inflationary expectations may be slow or quick to adjust (speed may depend on past inflationary experiences).

How do interest rates react over time to a one-time surprise monetary expansion?

We need to find the *impulse response function*.

First we estimate the dynamic relationship between money supply and interest rates using VAR (Vector Autoregression).

$$i_t = \alpha_1 + \beta_{11} i_{t-1} + \beta_{12} \Delta m_{t-1} + u_t$$

$$\Delta m_t = \alpha_2 + \beta_{21} i_{t-1} + \beta_{22} \Delta m_{t-1} + e_t$$

Note: Money supply is first-differenced to ensure stationarity.

First estimate those equations with the available data. Then let $u_t = 0$, and let $e_t = \sigma$ only for one t and zero afterwards. Then calculate i_t for each t and draw its graph (this is the impulse response function).

What does the international evidence say?

Lastrapes (1998) documents that for most OECD countries: Initial effect: monetary expansion $\Rightarrow$ interest rates decrease.

Consistent with *slow* updating of inflationary expectations

Halabí and Lastrapes (2002) show that for Chile, a country with a recent history of high inflation: Initial effect: monetary expansion $\Rightarrow$ interest rates increase.

Consistent with *fast* updating of inflationary expectations!

Lastrapes (1998), "International Evidence on Equity Prices, Interest Rates, and Money," *Journal of International Money and Finance*, Vol. 17, No. 3.

Halabí and Lastrapes (2002), "Estimating the Liquidity Effect in Post-Reform Chile: Do Inflationary Expectations Matter?" *Journal of International Money and Finance*, Vol. 22, No. 6.

An OLG Model with Financial Intermediation

Consider an OLG model where the agents live for 3 periods.

There are two assets available as we had last time: Illiquid capital and liquid fiat money.

Money supply grows at rate $z > 1$, and the initial middle-aged begin with the stock of fiat money.

Let $X > \left(\frac{n}{z}\right)^2$, that is the rate of return on fiat money for two periods is lower than the rate of return on capital.

Hence there is role for financial intermediation.

Assume that the intermediation of capital is costless and competitive.

For each good deposited at the bank, the bank is required to hold fiat money worth γ goods. The rest, $(1-\gamma)$, can be invested in capital.

Denote the aggregate deposit at the bank as H.

A bank's balance sheet looks like:

Assets		Liabilities	
Reserves	γH	Deposits	H
Interest-bearing Assets	$(1-\gamma)H$	Net Worth	0
Total Assets	H	Total Liabilities	H

Who Demands Money in this Economy?

Only the banks!

Because the young can have deposit accounts in the banks which give a higher rate of return. So they do not want to hold fiat money!

So the demand for money is

$$N_t h_t p_t \gamma = M_t$$

where h_t is the real value of the deposit by a young person, $N_t h_t p_t$ is the monetary value of the aggregate deposits at the bank and γ is the reserve requirement ratio.

Seigniorage

The real seigniorage revenue in period t is

$$\frac{M_t - M_{t-1}}{p_t} = \frac{M_t - \frac{1}{z}M_t}{p_t}$$
$$= \left(1 - \frac{1}{z}\right)\frac{M_t}{p_t}$$
$$= \left(1 - \frac{1}{z}\right)N_t h_t \gamma$$

If γ increases, then seigniorage revenue increases!

Real Output

The real output in period t is the sum of the endowments of the young, the return on capital invested two periods ago, and return on deposits at the bank from two periods ago.

$$GNP_t = \underbrace{N_t y}_{\substack{\text{aggregate}\\\text{endowment}}} + \underbrace{N_{t-2} X k_{t-2}}_{\substack{\text{return on capital}\\\text{privately invested in } t-2}} + \underbrace{N_{t-2} X (1-\gamma) h_{t-2}}_{\substack{\text{return on intermediated}\\\text{capital invested in } t-2}}$$

If γ increases, then the real output falls!

Note that M_t has no such direct affect on the real output.

Intuition Why the Real Output Falls when the Reserve Requirement Ratio increases

An increase in reserve requirements increases the cost of intermediating. Thus it leads to less financial intermediation. Less intermediated capital implies less real output!

Rate of Return on Deposits

Denote the one-period gross real rate of return on deposits as r^*.

Recall that we had assumed that the banks are perfectly competitive. So they make zero profits, hence the interest rate they give to the depositors is equal to what they can earn.

Thus

$$r^* = \gamma\left(\frac{n}{z}\right) + (1-\gamma)\sqrt{X}$$

Denote the one-period return on capital with $\sqrt{X} = x$

So

$$r^* = \gamma \frac{n}{z} + x - \gamma x$$
$$= x - \gamma\Big(x - \frac{n}{z}\Big)$$

Recall that $X > \left(\frac{n}{z}\right)^2$. Hence the term in the parentheses is positive.

If γ increases, then r^* decreases.

If z increases, then r^* decreases.

Effect of Reserve Requirement on Utility

A higher reserve requirement lowers the utility of future generations by forcing them (indirectly) to hold more of the asset with the lower rate of return!

If γ increases, then the welfare (utility) of future generations decrease.

Back to Our OLG Model

Denote M_t the stock of fiat money, so M_t is the monetary base.

Let $(M1)_t$ be the total nominal stock of deposits at banks in period t. In this model there is no fiat money held outside of the banks.

$$M_t = \gamma (M1)_t$$

So we have

$$(M1)_t = \underbrace{\frac{1}{\gamma}}_{\text{money multiplier}} \underbrace{M_t}_{\text{high-powered money}}$$

Note that when γ increases, then $(M1)_t$ decreases.

Is the Model Still Consistent with the Quantity Theory of Money?

Recall that

$$p_t = \frac{M_t}{N_t \gamma h_t}$$

So

$$p_t = \frac{\gamma (M1)_t}{N_t \gamma h_t} = \frac{(M1)_t}{N_t h_t}$$

The model is consistent wit the Quantity Theory of Money. If $M1$ increases, then p increases proportionally — assuming that $N_t h_t$ remains unchanged!

What is the Effect of an Increase in $(M1)_t$ on Seigniorage and Real Output?

The answer depends on the means by which $(M1)_t$ is changed!

Suppose that γ decreases. Then the real output would go up and the seigniorage revenue would decrease.

If, on the other hand, M_t increases, then the seigniorage revenue would increase. But the real output would not be affected.

Hence it might be better not to look at $M1$ when we think about monetary policy.

Central Bank Lending in the OLG Model

Assume that δ is the fraction of a bank's reserves that can be financed by loans from the central bank.

A bank with deposits H and reserves of γH is entitled to borrow $\delta\gamma H$ from the central bank.

Let Γ_t^B represent the total nominal amount of borrowed reserves. And M_t is the stock of fiat money that has not been borrowed from the central bank (nonborrowed reserves)

So

$$\delta = \frac{\Gamma_t^B}{\Gamma_t^B + M_t}$$

(borrowed reserves as a fraction of all reserves)

A profit maximizing bank would acquire additional interest-bearing assets using the central bank loans.

So the balance sheet of the bank looks like:

Assets		Liabilities	
Reserves	γH	Deposits	H
Interest-bearing A.	$\delta\gamma H + (1-\gamma)H$	Loans from the CB	$\delta\gamma H$
		Net Worth	0
Total Assets	$H + \delta\gamma H$	Total Liabilities	$H + \delta\gamma H$

The demand for fiat money comes from the reserve requirement again, which may now be satisfied from a combination of borrowed and nonborrowed reserves.

$$p_t \underbrace{\gamma N_t h_t}_{\text{required reserves}} = p_t \underbrace{\delta \gamma N_t h_t}_{\text{borrowed reserves}} + \underbrace{M_t}_{\text{monetary value of nonborrowed reserves}}$$

Hence the price level is

$$p_t = \frac{M_t}{(1-\delta)\gamma N_t h_t}$$

Note that the price level is higher with the introduction of central bank lending.

By supplying some of the reserves needed to meet the reserve requirement, central bank lending essentially lowers the reserve requirement from γ to $\gamma(1-\delta)$.

Central bank lending also expands intermediated investment.

The total money supply is also affected.

$$\gamma(M1)_t = \delta\gamma(M1)_t + M_t$$

So $(M1)_t = \frac{M_t}{\gamma(1-\delta)}$.

What is the Rate of Return on Deposits?

Let ψ be the real gross rate of return on central bank loans.

The total rate of return that the bank receives on its assets is equal to $\gamma(n/z)+[1-\gamma(1-\delta)]x$. And the bank has to pay interest on the loan of $\delta\gamma$.

Hence the real rate of return on deposits is:

$$r^* = \gamma\frac{n}{z} + [1-\gamma(1-\delta)]x - \psi\delta\gamma$$

Furthermore, if $\psi = x$, then

$$r^* = \gamma\frac{n}{z} + (1-\gamma)x$$

So the rate of return is unaffected by central bank lending.