Chapter 16

Money in macroeconomics

> Money buys goods and goods buy money; but goods do not buy goods.
>
> −Robert W. Clower (1967).

Up to now we have put monetary issues aside. The implicit assumption has been that the exchange of goods and services in the market economy can be carried out without friction as mere intra- or intertemporal barter. This is, of course, not realistic. At best it can provide an acceptable approximation to reality only for a limited set of macroeconomic issues. We now turn to models in which there is a demand for money. We thus turn to *monetary theory*, that is, the study of causes and consequences of the fact that a large part of the exchange of goods and services in the real world is mediated through the use of money.

16.1 What is money?

16.1.1 The concept of money

In economics *money* is defined as an asset (a store of value) which functions as a generally accepted medium of exchange, i.e., it can be used directly to buy *any* good or service offered for sale in the economy. Bitcoins may also be a medium of exchange, but are not *generally* accepted and are therefore not money. A note of IOU (a bill of exchange) may be a medium of exchange, but is not *generally* accepted and is therefore not money. Moreover, the extent to which an IOU is acceptable in exchange depends on the general state in the economy. In contrast, money is characterized by being a *fully liquid asset*. An asset is *fully liquid* if it can be used instantly, unconditionally, and without any extra costs or restrictions to make payments.

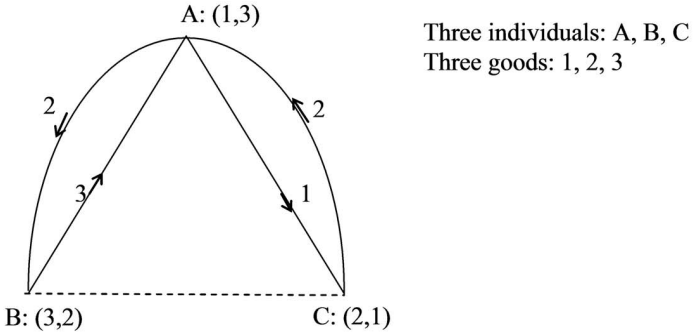

Figure 16.1: No direct exchange possible. A medium of exchange, here good 2, solves the problem (details in text).

Generally, liquidity should be conceived as a matter of degree so that an asset has a higher or lower degree of liquidity depending on the extent to which it can easily be exchanged for money. By "easily" we mean "immediately, conveniently, and cheaply". So an asset's *liquidity* is the *ease* with which the asset can be *converted into money or be used directly for making payments.* Where to draw the line between "money" and "non-money assets" depends on what is appropriate for the problem at hand. In the list below of different monetary aggregates (Section 16.2), M_1 corresponds most closely to the traditional definition of money. Defined as currency in circulation plus demand deposits held by the non-bank public in commercial banks, M_1 embraces all under "normal circumstances" (i.e., beyond financial crises) fully liquid assets in the hands of the non-bank public.[1]

The reason that a market economy uses money is that money facilitates trade enormously, thereby reducing transaction costs. Money helps an economy to avoid the need for a "double coincidence of wants". The classical way of illustrating this is by the *exchange triangle* in Fig. 16.1. The individuals A, B, and C are endowed with one unit of the goods 1, 3, and 2, respectively. But A, B, and C want to consume 3, 2, and 1, respectively. Thus, no direct exchange is possible between two individuals each wanting to consume the other's good. There is a *lack of double coincidence of wants.* The problem can be solved by indirect exchange where A exchanges good 1 for good 2 with C and then, in the next step, uses good 2 in an exchange for good 3 with B. Here good 2 serves as a medium of exchange. If good 2 becomes widely used and accepted as a medium of exchange, it is money. Extending the example to a situation with n goods, we have that exchange without money (i.e., barter) requires $n(n-1)/2$ markets ("trading spots"). Exchange with money, in the form of modern "paper money",

[1]The term "means of payment" is by some used as synonymous with "money", by others as including also media of exchange with slightly lower liquidity.

requires only n markets.

16.1.2 Historical remarks

In the past, ordinary commodities, such as seashells, rice, cocoa, precious metals etc., served as money. That is, commodities that were easily divisible, handy to carry, immutable, and involved low costs of storage and transportation could end up being used as money. This form of money is called *commodity money*. Applying ordinary goods as a medium of exchange is costly, however, because these goods have alternative uses. A more efficient way to trade is by using currency, i.e., coins and notes in circulation with little or no intrinsic value, or pieces of paper, checks, representing claims on such currency. Regulation by a central authority (the state or the central bank) has been of key importance in bringing about this transition into the modern payment system.

Coins, notes, pieces of paper like checks, and electronic signals from smart phones to accounts in a bank have no intrinsic value. Yet they may be generally accepted media of exchange, in which case we refer to them as *paper money*. By having these pieces of paper or electronic signals circulating and the real goods moving only once, from initial producer to final consumer, the trading costs in terms of time and effort are minimized.

In the industrialized countries these paper monies were in the last third of the nineteenth century and until the outbreak of the First World War *backed* through the gold standard. And under the Bretton-Woods agreement, 1947-71, the currencies of the developed Western countries outside the United States were convertible into US dollars at a fixed exchange rate (or rather an exchange rate which is adjustable only under specific circumstances); and US dollar reserves of these countries were (in principle) convertible into gold by the United States at a fixed price (though in practice with some discouragement from the United States).

This indirect gold-exchange standard broke down in 1971-73, and nowadays money in most countries is *unbacked* paper money (including electronic entries in bank accounts). This feature of modern money makes its valuation very different from that of other assets. A piece of paper money in a modern payments system has no worth at all to an individual unless she *expects* other economic agents to value it in the next instant. There is an *inherent circularity* in the acceptance of paper money. Hence the viability of a paper money system is very much dependent on adequate juridical institutions as well as confidence in the ability and willingness of the government and central bank to conduct policies that sustain the purchasing power of the currency. One elementary juridical institution is that of "legal tender", a status which is conferred to certain kinds of money.

An example is the law that a money debt can always be settled by currency and a tax always be paid by currency. A medium of exchange whose market value derives entirely from its legal tender status is called *fiat money* (because the value exists through "fiat", a ruler's declaration). In view of the absence of intrinsic value, maintaining the exchange value of fiat money over time, that is, avoiding high or fluctuating inflation, is one of the central tasks of monetary policy.

16.1.3 The functions of money

The following three functions are sometimes considered to be the definitional characteristics of money:

1. It is a generally accepted medium of exchange.
2. It is a store of value.
3. It serves as a unit of account in which prices are quoted and books kept (the *numeraire*).

On can argue, however, that the last function is on a different footing compared to the two others. Thus, we should make a distinction between the functions that money *necessarily* performs, according to our definition above, and the functions that money *usually* performs. Property 1 and 2 certainly belong to the essential characteristics of money. By its role as a device for making transactions money helps an economy to avoid the need for a double coincidence of wants. In order to perform this role, money *must* be a store of value, i.e., a device that transfers and maintains value over time. The reason that people are willing to exchange their goods for pieces of paper is exactly that these can later be used to purchase other goods. As a store of value, however, money is *dominated* by other stores of value such as bonds and shares that pay a higher rate of return. When nevertheless there is a demand for money, it is due to the *liquidity* of this store of value, that is, its service as a generally accepted medium of exchange.

Property 3, however, is not an indispensable function of money as we have defined it. Though the money unit is usually used as the unit of account in which prices are quoted, this function of money is conceptually distinct from the other two functions and has sometimes been distinct in practice. During times of high inflation, foreign currency has been used as a unit of account, whereas the local money continued to be used as the medium of exchange. During the German hyperinflation of 1922-23 US dollars were the unit of account used in parts of the economy, whereas the mark was the medium of exchange; and during the Russian hyperinflation in the middle of the 1990s again US dollars were often the unit of account, but the rouble was still the medium of exchange.

This is not to say that it is of little importance that money *usually* serves as numeraire. Indeed, this function of money plays an important role for the short-run macroeconomic effects of changes in the money supply. These effects are due to *nominal rigidities*, that is, the fact that prices, usually denominated in money, of most goods and services generally adjust only sluggishly (they are not traded in auction markets).

16.2 The money supply

The money supply is the total amount of money available in an economy at a particular point in time (a stock). As noted above, where to draw the line between assets that should be counted as money and those that should not, depends on the context.

16.2.1 Different measures of the money stock

Usually the money stock in an economy is measured as one of the following alternative *monetary aggregates*:

- M_0, i.e., the *monetary base*, alternatively called *base money, central bank money,* or *high-powered money.* The monetary base is defined as fully liquid claims on the central bank held by the private sector, that is, currency (coins and notes) in circulation plus *bank reserves*. The latter consist of demand deposits held by the commercial banks in the central bank plus currency in the "vaults" of these banks.[2] This monetary aggregate is under the direct control of the central bank and is changed through *open-market operations*, that is, through the central bank trading bonds, usually short-term government bonds, with the private sector. But clearly the monetary base is an imperfect measure of the liquidity in the private sector.

- M_1, defined as *currency in circulation* plus *demand deposits* held by the non-bank general public *in commercial banks*. Currency in circulation is currency held by the general public (households and non-bank firms). The demand deposits are also called *checking accounts* because they are deposits on which checks can be written and payment cards (debit cards) be used. M_1 does not include currency held by commercial banks and demand deposits held by commercial banks in the central bank. But currency in

[2] The commercial banks are usually part of the private sector and by law it is generally only the commercial banks that are allowed to have demand deposits in the central bank – the "banks' bank".

circulation, usually the *major* part of M_0, *is* included in M_1. Most importantly, the commercial banks use a portion of the funds received from depositors to make interest-bearing loans. Through this *bank lending,* M_1 is generally substantially larger than M_0.

The measure M_1 is one measure intended to reflect the quantity of assets serving as media of exchange in the hands of the non-bank part of the private sector. Broader measures of the money stock include:

- $M_2 = M_1$ plus savings accounts and small-denomination time deposits (say below € 100,000) that can easily be converted into a checkable account, although with a penalty. These claims are not instantly liquid, but they are close to.

- $M_3 = M_2$ plus large-denomination time-deposits (say above € 100,000).[3]

As we move down the list, the liquidity of the added assets decreases, while their interest yield increases.[4] Currency is of course fully liquid and earns zero interest. Along with currency, the demand deposits in the commercial banks are normally fully liquid, at least as long as they are guaranteed by a governmental deposit insurance (although normally only up to a certain maximum per account). The interest earned on these demand deposits is usually low or even nil (at least for "small" depositors) and is often ignored in simple theoretical models. When in macroeconomic texts the term "money supply" is used, normally M_1 or M_2 is meant, although part of M_2 is not directly usable as a means of payment and therefore not money in the strict meaning.

A related and theoretically important, simple classification of money types is the following:

1. *Outside money* = money that on net is an asset of the private sector.

2. *Inside money* = money that is not net wealth of the private sector.

Clearly M_0 is *outside money.* Most money in modern economies is *inside money*, however. Deposits at the commercial banks is an example of inside money. These deposits are an asset to their holders, but a liability of the banks.

[3] In casual notation, $M_1 \subset M_2 \subset M_3$, but $M_0 \nsubseteq M_1$ since only a part of M_0 belongs to M_1.

[4] This could be an argument for weighing the different components of a monetary aggregate by their degree of liquidity (see Barnett, 1980, and Spindt, 1985).

Payment cards versus credit cards Does it make sense to include the amounts that people are allowed to charge by using their *credit cards* in the concept of "broad money"? No, this would imply *double counting*. Actually *you* do not pay when you use a credit card at the store. It is the company issuing the credit card that pays to the store (shortly after you made your purchases). You postpone your payment until you receive your monthly bill from the credit card company. That is, the credit card company does the payment for you and gives credit *to you*. It is otherwise with a *payment card* (debet card) where the amount for which you buy is instantly charged your electronic account in the bank.

16.2.2 The money multiplier

Bank lending is the channel through which the monetary base expands to an effective money supply, the "money stock", considerably larger than the monetary base. The excess of the deposits of the non-bank part of the private sector over *bank reserves* ("vault cash" and demand deposits in the central bank) is lent out in the form of bank loans or used to buy government or corporate bonds. The non-bank public then deposits a fraction of these loans on checking accounts. Next, the banks lend out a fraction of these and so on. This process is named the *money multiplier process*. And the ratio of the "money stock", measured as M_1, say, to the monetary base is called the *money multiplier*.

Let

$$
\begin{aligned}
CUR &= \text{currency in circulation (= held by the non-bank general public),}\\
DEP &= \text{demand deposits held by the non-bank general public,}\\
\frac{CUR}{DEP} &= cd, \text{ the desired currency-deposit ratio,}\\
RES &= \text{bank reserves = currency held by the commercial banks}\\
&\quad \text{("vault cash") plus their demand deposits in the central bank,}\\
\frac{RES}{DEP} &= rd, \text{ the desired reserve-deposit ratio} \geq \text{ the required reserve-deposit ratio.}
\end{aligned}
$$

Notice that the currency-deposit ratio, cd, is chosen by the non-bank public, whereas the reserve-deposit ratio, rd, refers to the behavior of commercial banks. In many countries there is a minimum reserve-deposit ratio required by law to ensure a minimum liquidity buffer to forestall "bank runs" (situations where many depositors, fearing that their bank will be unable to repay their deposits in full and on time, simultaneously try to withdraw their deposits). On top of the minimum reserve-deposit ratio the banks may hold "excess reserves" depending on their assessment of their lending risks and need for liquidity.

We may express the money multiplier in terms of cd and rd. First, note that

$$M_1 = CUR + DEP = (cd + 1)DEP, \tag{16.1}$$

where DEP is related to the monetary base, $M_{0,}$ through

$$M_0 = CUR + RES = cdDEP + rdDEP = (cd + rd)DEP.$$

Then, substituting into (16.1) gives

$$M_1 = \frac{cd + 1}{cd + rd} M_0 = mmM_0, \tag{16.2}$$

where $mm = (cd + 1)/(cd + rd)$ is the *money multiplier*.

As a not unrealistic example consider $cd \approx 0.7$ and $rd \approx 0.07$. Then we get $mm \approx 2.2$. When broader measures of money supply are considered, then, of course, a larger money multiplier arises. It should be kept in mind that both cd and rd, and therefore also mm, are neither constant nor exogenous from the point of view of monetary models. They are highly endogenous and depend on many things, including the degree of liquidity, risk, and expected returns on alternative assets − from the banks' perspective as well as the customers'. In the longer run, cd and rd are affected by the evolution of payment technologies.

To some extent it is therefore a matter of simple identities and not particularly informative, when we say that, given M_0 and the currency-deposit ratio, the money supply is smaller, the larger is the reserve-deposit ratio. Similarly, since the latter ratio is usually considerably smaller than one, the money supply is also smaller the larger is the currency-deposit ratio. Nevertheless, the money multiplier turns out to be fairly stable under "normal circumstances". But not always. During 1929-33, in the early part of the Great Depression, the money multiplier in the US fell sharply. Although M_0 increased by 15% during the four-year period, liquidity (M_1) declined by 27%.[5] Depositors became nervous about their bank's health and began to withdraw their deposits (thereby increasing cd) and this forced the banks to hold more reserves (thereby increasing rd). There is general agreement that this banking panic contributed to the depression and the ensuing deflation.

There is another way of interpreting the money multiplier. By definition of cd, we have $CUR = cdDEP$. Let cm denote the non-bank public's desired *currency-money ratio*, i.e., $cm = CUR/M_1$. Suppose cm is a constant. Then

$$CUR = cmM_1 = cm(cd + 1)DEP. \qquad \text{(by (16.1))}$$

[5] Blanchard (2003).

It follows that $cm = cd/(cd+1)$ and $1-cm = 1/(cd+1)$. Combining this with (16.2) yields

$$M_1 = \frac{1}{\frac{cd}{cd+1} + rd\frac{1}{cd+1}} M_0 = \frac{M_0}{cm + rd(1-cm)} = \frac{1}{1-(1-rd)(1-cm)} M_0 = mmM_0. \tag{16.3}$$

The way the central bank is able to control the monetary base is through *open-market operations*. In its traditional form, *outright open-market operations*, the central bank trades short-term government bonds with the banks. When the central bank buys a government bond from a bank, it takes over a loan from the bank to the government, thereby in effect increasing the monetary base as if lending to the bank. The aim may be to sustain a desired level of M_1 or a desired level of the short-term interest rate or, in an open economy, a desired exchange rate vis-a-vis other currencies. The central bank may alternatively increase the monetary base through a *repurchase agreement*, which is another form of open-market operation, see below.

To obtain a perhaps more intuitive understanding of the money multiplier and the way commercial banks "create money", let us take a *dynamic perspective*. Suppose the central bank increases M_0 by the amount ΔM_0 through purchasing bonds in the market. This is the first round. The seller of the bonds deposits the fraction $1-cm$ of the proceeds on a checking account in her bank and keeps the rest as cash. The bank keeps the fraction rd of $(1-cm)\Delta M_0$ as reserves and provides bank loans or buys bonds in the market with the rest. This is the second round. Thus, in the first round money supply is increased by ΔM_0; in the second round it is further increased by $(1-rd)(1-cm)\Delta M_0$; in the third round further by $(1-rd)^2(1-cm)^2\Delta M_0$, etc.[6] In the end, the total increase in money supply is

$$\begin{aligned} \Delta M_1 &= \Delta M_0 + (1-rd)(1-cm)\Delta M_0 + (1-rd)^2(1-cm)^2\Delta M_0 + ... \\ &= \frac{1}{1-(1-rd)(1-cm)}\Delta M_0 = mm\Delta M_0. \end{aligned}$$

The second last equality comes from the rule for the sum of an infinite geometric series with quotient in absolute value less than one. The conclusion is that the money supply is increased mm times the increase in the monetary base.

16.3 Money demand

Explaining in a precise way how paper money gets purchasing power and how holding money - the "demand for money" in economists' traditional language -

[6] For simplicity, we assume here that cm and rd are constant.

is determined, is a complicated task and not our endeavour here. Suffice it to say that:

- In the presence of sequential trades and the absence of complete information and complete markets, there is a need for a generally accepted medium of exchange — *money.*

- The demand for money, by which we usually mean the quantity of money willingly held by the non-bank public, should be seen as part of a broader *portfolio decision* by which economic agents allocate their financial wealth to different existing assets, including money, and liabilities. The portfolio decision involves a balanced consideration of *after-tax expected return*, *risk*, and *liquidity.*

Money is demanded primarily because of its liquidity service in transactions. Money holding therefore depends on the *amount of transactions* households and firms plan to carry out with money in the near future. Money holding also depends on the *need for flexibility* in spending when there is *uncertainty*: it is appropriate to have ready liquidity in case favorable shopping opportunities should turn up and to have a buffer in case of ill-foreseen adverse events. Keynes (1936, p. 170 ff.) also emphasized the *speculative motive*, i.e., the liquidity demand induced when speculators believe they will know "better than the market" that a fall in the price of bonds, equity shares, or foreign currency will happen very soon.

Generally money earns no interest at all or at least less interest than other assets. Therefore money holding involves a trade-off between the need for liquidity and the wish for interest yield.

The incorporation of a somewhat micro-founded money demand in macromodels is often based on one or another kind of short-cut:

- The *cash-in-advance constraint* (also called the *Clower constraint*).[7] Generally, households' purchases of nondurable consumption goods are in every short period paid for by money held at the beginning of the period. With the cash-in-advance constraint it is simply postulated that to be able to carry out most transactions, you *must* hold money in advance. In continuous time models the household holds a stock of money which is an increasing function of the desired level of consumption per time unit and a decreasing function of the opportunity cost of holding money.

[7] After the American monetary theorist Robert Clower (1967). A better name for the constraint would be "money-in-advance constraint", since by "cash" is usually meant currency.

- The *shopping-costs* approach. Here the liquidity services of money are modelled as reducing shopping time or other kinds of non-pecuniary or pecuniary shopping costs. The shopping time needed to purchase a given level of consumption, c_t, is decreasing in real money holdings and increasing in c_t.

- The *money-in-the-utility function* approach. Here, the indirect utility that money provides through reducing non-pecuniary as well as pecuniary transaction costs is modelled as if the economic agents obtain utility directly from holding money. This will be our approach in the next chapter.

- The *money-in-the-production-function* approach. Here money facilitates the firms' transactions, making the provision of the necessary inputs easier. After all, typically around a third of the aggregate money stock is held by firms.

16.4 What is then the "money market"?

In macroeconomic theory, by the "money market" is usually meant an imaginary market place where at any moment the available aggregate stock of money (supply) "meets" the aggregate desired money holding (demand). Equilibrium in this market is presented by an equation saying that the supply equals the demand in the sense of the amount of money willingly held by the general public. Note that we talk about supply and demand in terms of *stocks* (amounts at a given point in time), not flows. To be specific, let the money supply in focus be money in the sense of M_1 (currency in circulation plus demand deposits in the banks) and let P denote the general price level in the economy (say the GDP deflator). At the demand side, let the aggregate demand for real money balances be represented by the function $L(Y, i)$, where $L_Y > 0$ and $L_i < 0$ ("L" for liquidity demand). The level of aggregate economic activity, Y, enters as an argument because it is an (approximate) indicator of the volume of transactions in the near future for which money is needed. The second argument, i, in the liquidity demand function is some index for the *short-term nominal interest rate* which reflects the opportunity cost of holding money instead of interest-bearing short-term financial claims that are close substitutes to money, i.e., have high relatively high but not full liquidity. We may think of interest-bearing time-deposits that are easily convertible into money, although at a penalty. Or i could be the interest rate on short-term government bonds ("treasury bills") or the interbank rate, see below.[8]

[8] To simplify, in (16.4) we assume that none of the components in the monetary aggregate considered earns interest. In practice demand deposits may earn a small nominal interest. In

So money market equilibrium is present if

$$M_1 = PL(Y, i). \tag{16.4}$$

One of the issues in monetary theory is to account for how this stock equilibrium is brought about. During the history of economic thought there has been different views about which of the variables M_1, P, Y, and i is the equilibrating variable such that the available stock of money becomes willingly held by the agents. Presuming that the central bank somehow controls M_1, classical (pre-Keynesian) monetary theory has P as the equilibrating variable. In Keynes' monetary theory (now mainstream), however, it is i which has this role while the general price level for goods and services is considered sticky in the short run. It will be the bond price, and hence i, which responds.– and establishes the equilibrium (16.4) very fast. Popular specifications of the function L include $L(Y, i) = Y^{\alpha} i^{-\beta}$ (constant elasticity of money demand with respect to i) and $L(Y, i) = Y^{\alpha} e^{-\beta i}$ (constant semi-elasticity of money demand with respect to i), where α and β are positive constants.

One may alternatively think of the "money market" in a more narrow sense, however. We may translate (16.4) into a description of demand and supply for *base money* (currency plus bank reserves in the central bank):

$$M_0 = \frac{P}{mm} L(Y, i), \tag{16.5}$$

where mm is the money multiplier. The right-hand side of this equation reflects that the demand for M_1 via the actions of commercial banks is transformed into a demand for base money.[9] If the general public wants to hold more money, the demand for bank loans rises and when granted, deposits expand. Then the banks try to increase their reserves to maintain the required (or in any case desired) reserve-deposit ratio. A bank that finds it has too little reserves will want to borrow reserves from other banks in what is known as the *interbank market,* often on a day-to-day basis. But the immediate situation is one of excess demand for bank reserves, and if its supply is not increased by the central bank, the interest rate in the interbank market, the *interbank rate,* rises. Then the interest rates on other short-term financial assets (short-term government bonds, time-deposits accounts, commercial paper, etc.) tend to move in the same direction because all these assets compete with each other. Assets offering higher-than-average rate of return will attract funds from assets offering lower-than-average rate of return, thereby roughly averaging out.

this case, i would indicate the excess of the short-term interest rate over this rate.

[9] Although the money multiplier tends to depend positively on i as well as other interest rates, this aspect is unimportant for the discussion below and is ignored in the notation in (16.5).

The "narrow" money market considered in (16.5) is a compact description of what is in the financial market statistics, and by the practitioners, called the "money market". This is the collective name for markets where trade in short-term debt-instruments (time to maturity less than one year). The agents trading in these markets include the central bank, the commercial banks, mortgage credit institutions, and other financial institutions. From a logical point of view a more appropriate collective name than "money market" would be "short-term bond market" or "near-money market". This would be in line with the usual way we use the term "market", namely as a "place" where a certain type of goods or assets are traded *for* money. Moreover, speaking of a "short-term bond market" corresponds well to the standard collective name for the markets for financial assets with maturity of *more* than one year, namely the "capital market" (where "capital" is synonymous with longer-term bonds and equity).

Anyway, in this book we maintain the usual term "money market" for the abstract market place where the aggregate supply of money "meets" the aggregate demand for money. As to what kind of money is in focus, "narrow" or "broad", further specification is always to be added.

Monetary policy and open-market operations

In recent decades the short-term interest rate has become the *main* monetary policy tool of the leading central banks in the world. In recent decades leading central banks, for instance both the Federal Reserve System of the US, the Fed, and the European Central Bank, the ECB, has increasingly focused on the short-term nominal interest rate as their policy tool. These central banks *announce* a *target level* for the chosen *policy interest rate* and then adjusts the monetary base through open-market operations such that the policy interest rate ends up very close to the announced target.

To understand the mechanism let us first imagine that the policy interest rate is the annualized interest rate, i_g, on one-month government bonds. Suppose the payoff is 1 euro at the *maturity date* and that there is no payoff between the *issue date* and the maturity date. Let p be the market price (in euros) of the bond at the issue date. The implicit monthly interest rate, x, is then the solution to the equation $v = (1+x)^{-1}$, i.e.,

$$x = p^{-1} - 1.$$

Translated into an annual interest rate, this amounts to $i_g = (1+x)^{12} - 1 = p^{-12} - 1$ per year. With $p = 0.9975$, we get $i_g = 0.03049$ per year.[10]

[10] With continuous compounding we have $p = e^{-i_g/12}$ so that $i_g = 12 \ln p^{-1} = 0.03004$ when $p = 0.9975$.

Now, suppose the central bank finds that i_g is too high and therefore enters the market to buy a substantial amount of these bonds from the private sector. To find sellers a higher price of the bonds must be offered. The bond price, p, is thus driven up, and the rate i_g thereby lowered – until the available stocks of bonds and money in their new proportion are willingly held. In practice this adjustment of p, and hence i_g, to a new equilibrium level takes place fast. If the resulting i_g is not as low as the target value, the central bank continues its buying bonds for base money until it is.

In fact, for both the Fed and the ECB the chosen policy interest rate for which they announce a target value is not short-term government bonds but the interbank rate. Even so, the procedure to obtain that rate is still some form of open-market operations where government bonds are traded with the private sector. Because of the competition between different short-term assets in the financial markets, other interest rates, *including the interbank rate*, say i, will also be affected in a downward direction. The central bank continues its trading until the injection of base money has brought the interbank rate down to the announced target level. The interbank market is in the US called the Federal Funds market, and the interest rate.in this market is called the *Federal Funds Rate.*[11] Similarly, the ECB announces a certain target value for its quite similar policy rate called EONIA (Euro Overnight Index Average).

The aim of controlling the policy rate may be to stimulate or dampen the general level of economic activity, and the purpose of this may be controlling inflation, unemployment, or the foreign exchange rate. In this context what really matters is the interest rate households and firms have to pay when they borrow, the "bank lending rate"or the "corporate bond rate". Because of the higher risk involved, these rates tend to exceed the interbank rate by a substantial amount, known as the *interest spread*. In a financial crisis this spread may soar.

Repurchase agreement and repo rate Nowadays a lot of open market operations are carried out in the form of *repurchase agreements, repos* in brief. The central bank announces a specific interest rate at which it is willing to buy short-term government bonds from a commercial bank with the agreement that the bank buys back the bonds after a week, say, at a pre-agreed price such that the implied annualized interest rate on this loan equals the announced interest rate, the *repo rate*. This government bond serves as a collateral in the sense that if the bank defaults, the central bank has the bond.

In a *reverse repo* the buy and buy back roles of the two parties are reversed.

[11] In spite of its name, the Federal Funds Rate is not an interest rate charged by the U.S. central bank but a weighted average of the short-term interest rates commercial banks in the U.S. charge each other on overnight loans on an uncollateral basis.

The zero lower bound on the nominal interest rate In recessions, when the central bank attempts to stimulate aggregate demand by lowering the policy rate, i, it may reach a point where no further lowering is possible no matter how much money supply is increased. This point is attained when $i = 0$, the "zero lower bound". Agents would prefer holding money at zero interest rather than short-term bonds at negative interest. That is, the "=" in the equilibrium condition (16.4), or its equivalent, (16.5), should be replaced by "$\geq$" or, equivalently, $L(Y, i)$ should at $i = 0$ be interpreted as a "set-valued function". Strictly speaking the lower bound is slightly below zero because the alternative to holding bonds is holding money which gives zero interest but involves costs of storing, insuring, and transporting.

Monetary policy and the implications of the zero lower bound (or the slightly less than zero lower bound) are explored later in this book.

16.5 Key questions in monetary theory and policy

Some of the central questions in monetary theory and policy are:

1. How, and through what channels, do changes in the *level* of the money supply (in the M_0 sense, say), or the *growth rate* of the money supply affect (a) the real variables in the economy (resource allocation), and (b) the price level and the rate of inflation?

2. How do the effects of money supply movements depend on whether they occur through open-market operations or through the financing of budget deficits?

3. How do the effects depend on the state of the economy with respect to capacity utilization?

4. How can monetary policy be designed to stabilize the purchasing power of money and optimize the liquidity services to the inhabitants?

5. How can monetary policy be designed to stabilize the economy and "smooth" business cycle fluctuations?

6. Do rational expectations rule out persistent real effects of changes in the money supply?

7. Is hyperinflation always the result of an immense growth in the money supply or can hyperinflation be generated by self-fulfilling expectations?

8. What kind of regulation of commercial banks is conducive to a smooth functioning of the credit system and reduced risk of a financial crisis?

As an approach to some of these issues, we will in the next chapter consider a neoclassical monetary model by Sidrauski (1967). In this model money enters as a separate argument in the utility function. The model has been applied to the study of long-run aspects like the issues 1, 4, and 7 above. The model is less appropriate, however, for short- and medium-run issues such as 3, 5, and 8 in the list. These issues are dealt with in later chapters.

16.6 Literature notes

In the *Arrow-Debreu model*, the basic microeconomic general equilibrium model, there is assumed to exist a *complete set of markets*. That is, there is a market for each "contingent commodity", by which is meant that there are as many markets as there are possible combinations of physical characteristics of goods, dates of delivery, and "states of nature" that may prevail. In such an fictional world any agent knows for sure the consequences of the choices made. All trades can be made once for all and there will thus be no need for any money holding (Arrow and Hahn, 1971).

For the case of incomplete markets, Kiyotaki and Wright (JPE, 1989) and Trejos and Wright (JMCB, 1993) develop a microeconomic theory of how intrinsically valueless notes can obtain the role as a generally accepted means of exchange.

For a detailed account of the different ways of modelling money demand in macroeconomics, the reader is referred to, e.g., Walsh (2003). Concerning "money in the production function", see Mankiw and Summers (1986).

16.7 Exercises