Lecture notes:
Money in modern economies

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1 Money and banking[1]

1.1 Money

Money is one of the fundamental inventions of mankind, and quite an ancient one: it goes back at least to 9,000 BC, when cattle came to be used as the oldest of all known forms of money. Nowadays, money has become central to the workings of modern economies ... but what counts as money, exactly?

The simplest way of defining money is through the functions it performs. Money has **three important functions**; money is:

- a **medium of exchange**: it is accepted in exchange for goods for the sole reason that it can in turn be traded for other goods;
- a **store of value**: it is an asset (the most liquid one), since it allows to trade current goods for future goods;
- a **unit of account**: all contracts are denominated in terms of money.

The distinguishing economic feature of money is its medium-of-exchange role: money eliminates the need of a *double coincidence of wants*, and allows trades when credit transactions are impossible. Adam Smith saw it as an essential part of moving from a *subsistence economy*, typically based on barter,[2] to an *exchange economy*. Money can be seen as a social institution that provides a solution to the problem of a lack of trust.

Money has circulated in many forms:

[1] This Section follows the exposition in McLeay, Radia, and Thomas (2014b) quite closely.

[2] Barter requires a double coincidence of wants: one must have what the other person wants, and vice versa. This is not always possible, and generally implies a lot of inconvenience: money overcomes these difficulties. Fig. 1 reproduces an illustration from *Harper's Weekly* (January 17, 1874, p. 61), showing a man engaging in barter: the lad is offering chickens in exchange for his yearly newspaper subscription. Source: Wikipedia.

Figure 1: Two men engaging in barter.

- **Commodity money**: objects that have value in themselves as well as value in their use as money (e.g. gold coins). Fig. 2 shows two examples of early commodity money: on the left, an *okpoho*, the traditional commodity money in West Africa until the 1940s; on the right, Japanese commodity money in use before the 8th century AD: arrowheads, rice grains and gold powder.

Figure 2: Examples of commodity money. Source: Wikipedia.

- **Representative money**: any type of money that has face value greater than its value as material substance. Fig. 3 represents a Yapese Rai, i.e. a large, circular stone disk carved out of limestone and used as money on the island of Yap. Some remarkable examples of representative money are:
  - **Commodity-backed money**: a claim on a commodity, for example gold or silver certificates. Fig. 4 shows a $50 U.S. gold certificate.
  - **Fiat money**: money that is *"... created and issued by the State, but is not convertible by law into anything other than itself, and has no fixed value in terms of an objective standard."* (J.M. Keynes). Fig. 5 reproduces some Yuan dynasty banknotes, the earliest known fiat money, introduce by the very founder of the dynasty, Kublai Khan[3].

[3]"All these pieces of paper are issued with as much solemnity and authority as if they were of pure gold or silver... and indeed everybody takes them readily, for wheresoever a person may go throughout

Figure 3: Yapese stone money (Rai). Source: Wikipedia.

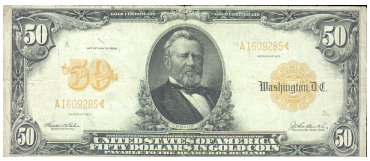

Figure 4: U.S. gold certificate. Source: public domain.

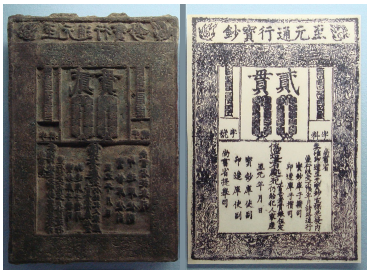

Figure 5: Yuan dynasty banknotes. Source: Wikipedia.

1.2 The financial system

1.2.1 The Central Bank

The **Central Bank** (*CB*) is the authority responsible for policies that affect a country's supply of money and credit. The history of central banking goes back at least to the seventeenth century, to the founding of the first *CB*, the *Swedish Riksbank*.[4] Early *CB*s helped fund the government's debt, and they slowly came to serve as *banks for bankers*, becoming the **lenders of last resort** for the financial system.[5] In modern economies, *CB*s are concerned with **monetary policy** and **financial stability**.[6] In the words of Jeffers (2010):

> "The central bank, as lender of last resort, helps ensure systemic stability. In general, what is meant by that is stability of both the banking sector and the financial markets, not only the stock markets, but also and specifically the payment systems. In order to carry out this mission, the *CB* must use preventive measures as well as measures aimed at helping to overcome a crisis when it occurs. In such a case, the *CB* must above all insure that liquidity is available or very quickly restored, because that is what stabilizes the financial system."

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the Great Kaan's dominions he shall find these pieces of paper current, and shall be able to transact all sales and purchases of goods by means of them just as well as if they were coins of pure gold." Marco Polo, *Il Milione*, c. 1300.

[4] For a brief history of central banks, see Bordo (2007).

[5] "A lender of last resort is an institution, usually a country's central bank, that offers loans to banks or other eligible institutions that are experiencing financial difficulty or are considered highly risky or near collapse. In the United States, the Federal Reserve acts as the lender of last resort to institutions that do not have any other means of borrowing and whose failure to obtain credit would dramatically affect the economy." Source: Investopedia.

[6] The *European Central Bank* (*ECB*) claims that "monetary policy concerns the decisions taken by central banks to influence the cost and availability of money in an economy." Furthermore, the *ECB* believes that "financial stability is a state whereby the build-up of *systemic risk* is prevented. Systemic risk can best be described as the risk that the provision of necessary financial products and services by the financial system will be impaired to a point where economic growth and welfare may be materially affected."

Fiat money is typically issued by the *CB*, and is recorded as a liability in the *CB*'s **balance sheet**. Although the *CB* is formally in debt to the holder of its money, that debt can only be repaid in more fiat money. Hence, fiat money is just a special form of an *I-Owe-yoU* (*IOU*), a **financial asset**,[7] which is useful in exchange because it is an *IOU* that everyone trusts. As any other financial asset, the net aggregate supply of money is zero (in a closed economy, see Fig. 6)! In other words, money is a financial asset for the public, and a liability for the *CB*: at the aggregate level the two positions cancel out.

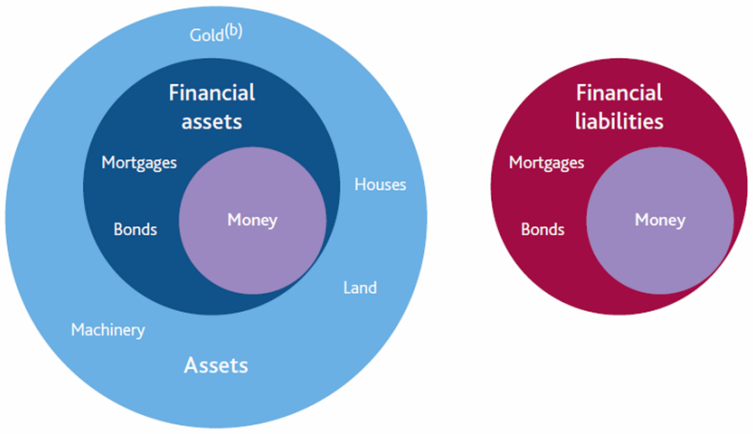


Figure 6: Money as a financial asset. Source: McLeay, Radia, and Thomas (2014b).

In modern economies, not only the *CB*, but also the **commercial banking system** creates fiat money; more precisely:

- The *CB* is the only issuer of **base money** (or narrow money)
- The banking system is the main creator of **broad money**

Base money, or "central bank money," comprises *IOUs* from the *CB*; i.e. fully liquid claims on the central bank held by the private sector:

- **Currency** (an *IOU* to the public)
- **Central bank reserves** (*IOUs* from the *CB* to commercial banks, to be discussed later)

Broad money can be thought of as the money that the private sector has available for transactions, and comprises:[8]

- **Currency** in the hands of the public, available for transaction purposes
- **Bank deposits** (*IOUs* from commercial banks to the public)

[7] A *financial asset* is a non-physical asset whose value is derived from a contractual claim.

[8] The empirical counterparts to the theoretical concepts of narrow and broad money are the respectively the *monetary aggregates* known as $M0$ and $M1$.

Base money is important because it is by virtue of their position as the only issuer of base money that *CBs* can implement **monetary policy**. Furthermore, base money is **legal tender** (i.e. the medium of payment recognized by the legal system to be valid for meeting a financial obligation),[9] while bank deposits aren't (see Fig. 7). During **financial crises**, when doubts arise about the liquidity of commercial bank money, this distinction may become quite relevant!

Figure 7: U.S. Legal tender. Source: public domain.

1.2.2 Commercial banks

Commercial banks need to hold some currency to meet frequent deposit withdrawals and other outflows. But to use banknotes to carry out this large volume of transactions would be extremely cumbersome! So banks are allowed to hold a different type of *IOU* from the *CB*, known as **central bank reserves**. Reserves are a useful medium of exchange for banks: if one bank wants to make a payment to another, the *CB* will adjust their reserves balances accordingly.

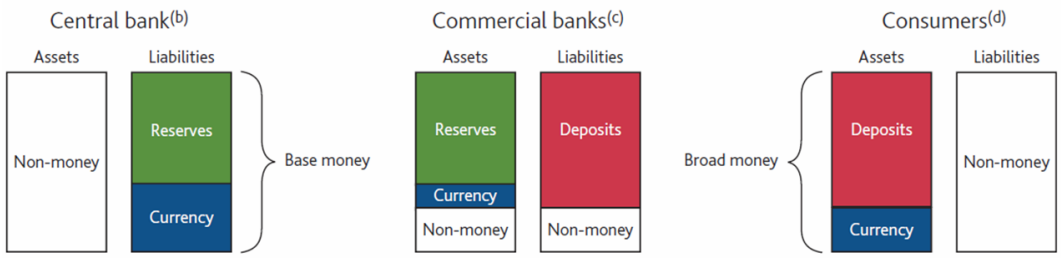


Figure 8: Balance sheets of different types of money holders and issuers. Source: McLeay, Radia, and Thomas (2014b).

In many jurisdictions, *CBs* implement their monetary policy and defend the stability of the financial system by setting the:

[9] According to the European Commission, *legal tender* does provide for the following key elements: *(i)* mandatory acceptance (unless explicitly agreed otherwise) *(ii)* legally recognized means for repaying a debt, i.e. with a discharging effect *(iii)* at face value, with no levying of additional fees permitted (as is the case, for example, with credit cards).

- **Required reserve ratio**: a minimum (reserve + vault cash) / deposits ratio for some categories of deposits. Currently, practical implementations vary significantly across countries: in the U.S. the ratio varies from zero to 10%, depending on the size of banks liabilities, while in the Eurozone the ratio dropped to 1% in 2012. Canada, the U.K., New Zealand, Australia, Sweden and Hong Kong have no reserve requirements. Bank reserves in excess of the reserve requirement are called **excess reserves**.

- **Interest rate on reserves**: in recent years, many *CB*s began paying interest on excess reserve balances as well as required reserves. Some *CB*s, as the *ECB*, have paid negative interest, in effect taxing banks for exceeding their reserve requirements, as an expansionary monetary policy measure.

- **Capital adequacy ratio,** also know as *Capital to Risk (Weighted) Assets Ratio*: a minimum equity / risk-weighted credit exposures ratio, used to protect depositors and promote stability of the financial system.[10]

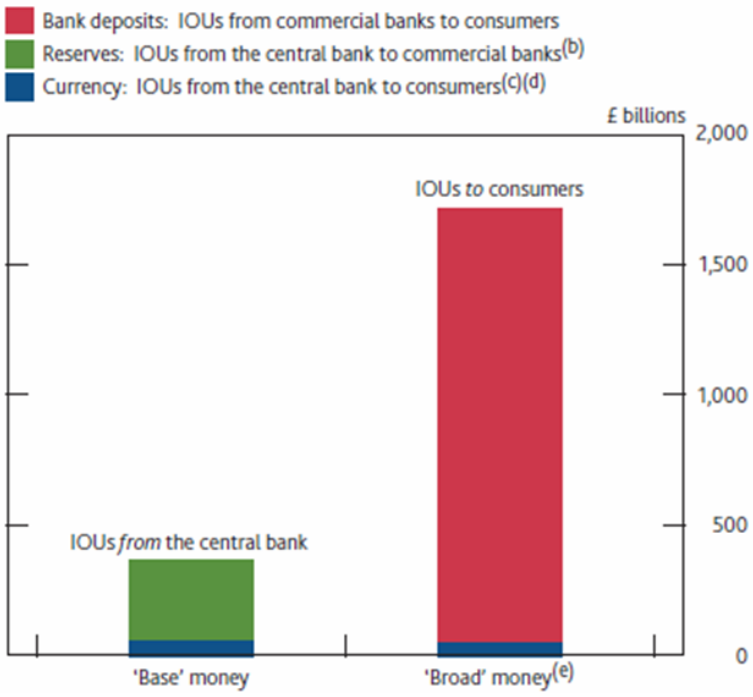


Figure 9: Amounts of money in circulation (in the UK, 2013). Source: McLeay, Radia, and Thomas (2014b).

Fig. 9 summarizes the composition of money supply in the U.K.: bank reserves are the main component of base money, while deposits are the main component of broad money;

[10] *Capital Adequacy Ratio* (*CAR*) is the ratio of a bank's capital in relation to its risk weighted assets. *CB*s do impose limits on the *CAR* in order to prevent commercial banks from taking excess leverage and becoming insolvent in the process. The risk weighted assets take into account credit risk, market risk and operational risk. The *Basel III* norms stipulated a capital to risk weighted assets of 8%.

currency plays a very minor role in both aggregates. Fig. 10, instead, focuses on the U.S., and reports the *St. Louis Adj. Monetary Base*, a measure of base money, and *M2*, a measure of broad money, on the left, and excess reserves of depository institutions on the right. The sharp increase in base money from 2008 onward, due to a unprecedented increase in excess reserves, is a byproduct of the unconventional monetary policy implemented by the *FED* in order to fight the Great Recession of 2008-2010. More on this will follow.

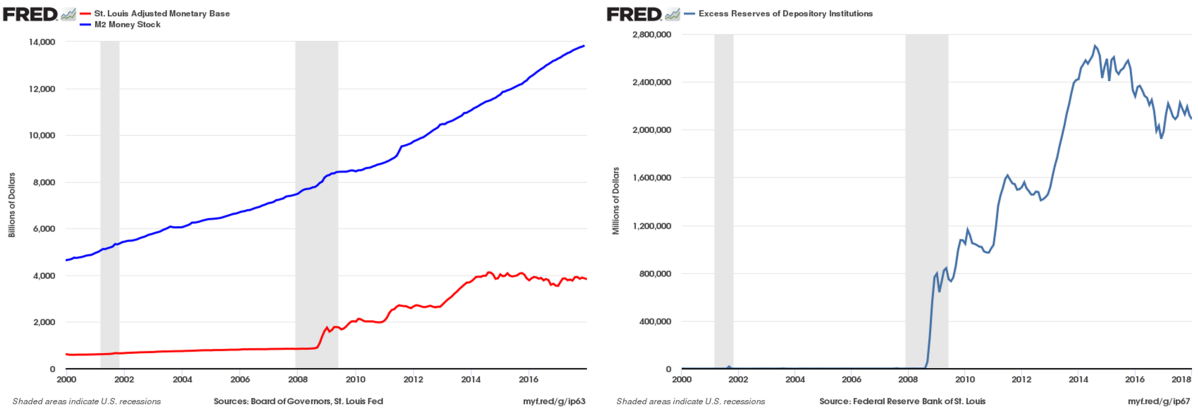


Figure 10: Base money and broad money (left), and excess reserves of depository institutions (right) in the U.S. Source: FRED2.

2 The demand for money

We will now examine the determinants of the **demand for money** (in broad sense) expressed by the private sector (households + firms). Suppose that your **financial wealth** can be hold in two financial assets: **money** and **bonds**.

- **Money** pays no interest, but can be used for transactions.
- **Bonds** pay a positive nominal interest rate, $i > 0$, but cannot be used for transactions.

Assume furthermore that trading in bonds involves **transaction costs**. How should your financial wealth be allocated between money and bonds? This is a **portfolio allocation problem**! If transaction costs are high enough, a diversified portfolio is the natural outcome, i.e. optimal portfolios contain both money and bonds.

At the individual level, the optimal portfolio depends upon:

- your level of transactions: you will want to have enough money on hand to avoid having to sell bonds and incur in transaction costs;
- the interest rate: the higher the interest rate, the higher the incentive to hold bonds.

The **aggregate demand for money** is the sum of all the individual demands, and is denoted by M^d. The aggregate level of transactions can be considered roughly proportional to nominal GDP level; hence:

$$M^d \left(\underset{(+)}{€Y}, \underset{(-)}{i} \right) = €Y \cdot L(i).$$

The demand for money, M^d, depends negatively on the interest rate, since the latter represent the opportunity cost of holding money.

Fig. 11 shows the effect on the demand for money of an increase in nominal GDP, for given interest rate: the money demand schedule simply shifts to the right, so that, for each interest rate, the demand for money is now higher.

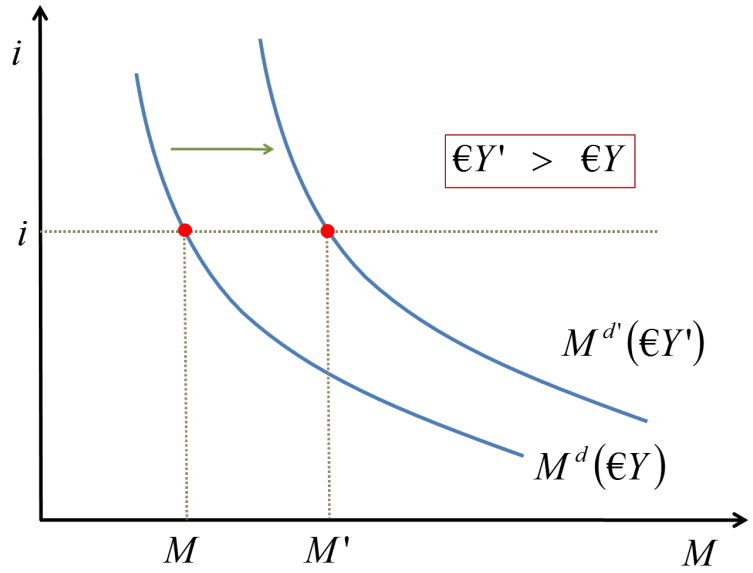


Figure 11: Money demand.

3 The supply of base money

The supply of base money is firmly in the hands of the *CB*. To better understand how the *CB* is able to easily change the amount of money in the hands of the public, let's consider the ***CB*'s balance sheet**. The assets of the *CB* are the bonds it holds in its portfolio, while its liabilities are the stock of currency and reserves:

***CB*'s Balance Sheet**			
Assets		***Liabilities***	
Bonds	10	Currency	2
		Reserves	8

The *CB* can change the supply of money by buying or selling securities in the bond market: those actions are called **Open Market Operations** (*OMO*s).

For the sake of simplicity, let's ignore the commercial banking system, set the stock of reserves to zero, and assume that the *CB* engages in trade directly with households and firms. The essential role of the banking system in the supply of broad money will be discussed later in some detail. In general, *OMO*s lead to equal changes in the *CB*'s assets and liabilities:

- If the *CB* **buys** government securities in the open market from an individual seller in exchange for currency, the supply of base money **increases**.
- Conversely, if the *CB* **sells** government securities to an individual buyer in exchange for currency, the supply of base money **decreases**.

Consider our initial balance sheet, and the following examples:

Assets		***Liabilities***	
Bonds	10	Currency	10
		Reserves	0

If the *CB* buys €5 worth of bonds, the amount of bonds it holds its higher by €5, and so is the amount of currency in the economy; this is called an **expansionary** *OMO*, since it expands the supply of money:

Assets		***Liabilities***	
Bonds	15	Currency	15
		Reserves	0

If, instead, the *CB* sells €5 worth of bonds, the amount of currency in the economy is decreasing; this is called a **contractionary** *OMO*:

Assets		***Liabilities***	
Bonds	5	Currency	5
		Reserves	0

4 The equilibrium interest rate (I)

Again, for the sake of simplicity, ignore the commercial banking system, and assume that currency is the only form of money in the economy. As previously discussed, the supply of currency is firmly in the hand of the *CB*, and is controlled via *OMO*s.

Suppose the *CB* decides to supply a **fixed amount of currency**, so that:

$$M^s = \overline{M} > 0.$$

Equilibrium in financial markets requires that **money supply equals money demand**. This equilibrium condition, labeled (for obvious reasons!) the ***LM* curve**, boils down to:

$$\overline{M} = €Y \cdot L(i).$$

Fig. 12 shows how to graphically determine the equilibrium interest rate. Note that money supply is depicted as a vertical line: being fixed, it does not depend on the interest rate.

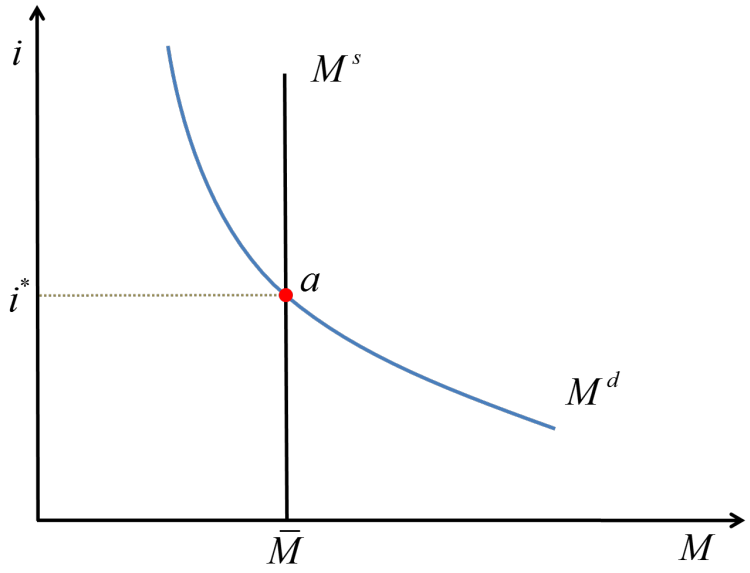


Figure 12: The equilibrium interest rate.

4.1 Effects of an increase in nominal income

An increase in $€Y$ increases in turn the level of transactions, and therefore the demand for money, for given i. At the initial interest rate, there is an excess demand for money, $M^d > M^s$; in order to decrease the amount of money people want to hold, an increase in the interest rate becomes necessary:

- People try to sell bonds in exchange for currency, but this drives down the price of bonds.[11]
- The drop in the price of bonds drives the interest rate up.

Hence, an increase in $€Y$ implies an increase in the equilibrium interest rate, while M remains unchanged, being determined by the *CB*. Fig. 13 graphically depicts this adjustment process.

4.2 Effects of an increase in the supply of money

An increase in the stock of currency implies that $M^s > M^d$ at the initial interest rate i. In order to increase the amount of money people want to hold, a decrease in the interest rate becomes necessary:

[11] Appendix A provides a short exposition of the relationship between the interest rate and the price of bonds.

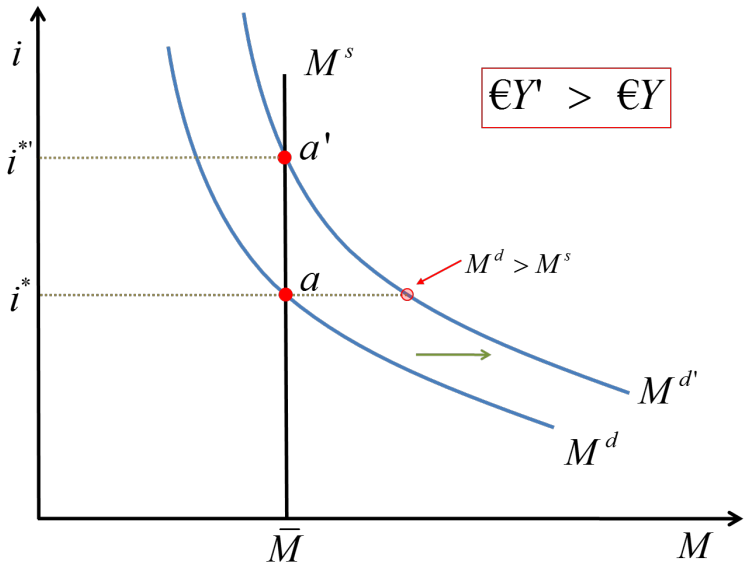


Figure 13: Effects of an increase in nominal income.

- People try to buy bonds in exchange for currency, but this drives up the price of bonds.
- The increase in the price of bonds drives the interest rate down.

Hence, the increase in M^s implies a decrease in the equilibrium interest rate and a contemporaneous increase in the stock of currency.

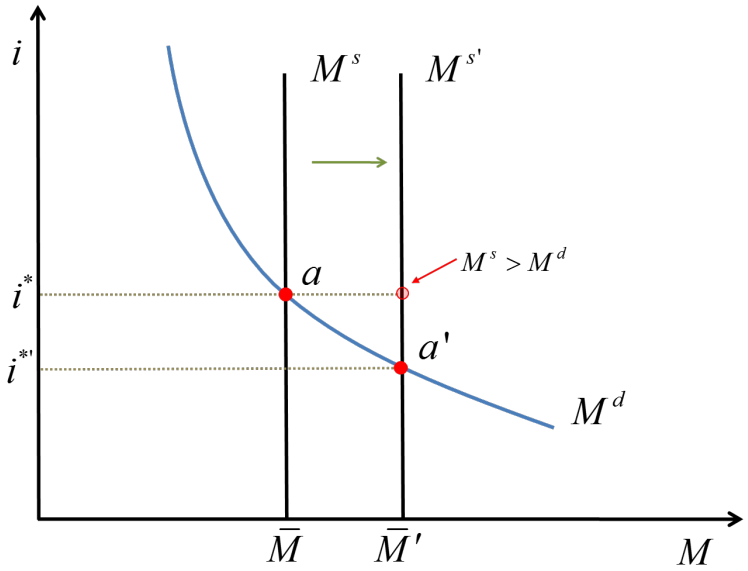


Figure 14: An increase in money supply.

5 Banking and money supply

It is now time to focus on the role of the commercial banking system as a key player in the market for money. We already anticipated that the banking system is the main creator of broad money, in the form of short-term checkable deposits. Furthermore, we noted that banks need to hold some currency and central bank reserves to address the liquidity risk associated with bank deposits. Hence, the *CB* controls not only the amount of currency in the economy, but also the stock of reserves. In the following, we will emphasize the role of banks as financial intermediaries in the process of money creation. Appendix B presents a short characterization of financial intermediation.

5.1 The supply of broad money[12]

In modern economies (i.e. in the presence of fiat money), the "creation" of broad money is essentially in the hands of the banking sector.

Being financial intermediaries, **banks supply loans on demand, creating in the process new deposits**, and finance those loans with existing deposits or by short-term borrowing on the interbank market. Intuitively, the idea is that "*lending creates deposits*", and therefore broad money:

- Banks create money, in the form of deposits, by making new loans (or by purchasing securities from the non-bank private sector).
- The amount of deposits influences the amount of desired reserves, which is then supplied on demand by the *CB* (at a price!).

5.1.1 The adventures of Banco Bocconiano

In order to understand how a bank ends up issuing broad money, let's follow the life of a newly established bank, called **Banco Bocconiano (*BB*)**; assume that the initial shareholders' equity amounts to €20.[13] On the first day of operations, the balance sheet looks like the following:

Assets		***Liabilities***	
CB Reserves	10	Equity	20
Cash	10		

[12] This Section has been heavily influenced by McLeay, Radia, and Thomas (2014a) and Deutsche Bundesbank 2017.

[13] In accounting, *equity* is the difference between the value of the assets and the value of the liabilities of something owned, i.e. the net assets. Alternatively, equity can also refer to the capital stock of a corporation.

Day one: the journey begins The first costumer opens a checking account and deposits €5 cash and €5 worth of checks drawn on other banks; this increases *BB*'s liabilities by €10. *BB* keeps the cash in its vault and clears the checks, getting the corresponding amount credited on its reserve account with the *CB*:

Assets		***Liabilities***	
CB Reserves	15	Equity	20
Cash	15	**Deposits**	**10**

Note that the banking transaction described above left the supply of broad money completely unaffected! Consider the €5 worth of cash that changed hands, from the customer to the bank: the potential increase in broad money implied by the newly created deposit is sterilized by the decrease in the amount of currency in the hands of the public, which is the only one that counts as broad money; in turn, the €5 worth of checks credited to *BB*'s reserve account is, at the same time, debited to the issuing bank's reserve account, leaving the total amount of reserves, and therefore of broad money, unaltered.

Day two: new broad money is born! The second customer is willing to open a checking account and sell a €5 worth of government securities. *BB* buys the securities and credits the customer's checking account with the equivalent value:

Assets		***Liabilities***	
CB Reserves	15	Equity	20
Cash	15	**Deposits**	**15**
Securities	**5**		

Note that this purchase created a new item on the assets side, securities, and an increase in deposits, on the liabilities side. As a matter of fact, these new liabilities (€5) are newly created money! **Buying (and selling) securities from the non-bank private sector affects the money supply**.

Day three: success arrives Our bank is surprisingly successful: many customers apply for mortgages, and *BB* grants €45 worth of new loans. Once the loans have been granted, the principal amounts are credited on checking accounts opened with *BB* itself:

Assets		***Liabilities***	
CB Reserves	15	Equity	20
Cash	15	**Deposits**	**60**
Securities	5		
Mortgages	**45**		

Note that the provision of loans created a new item on the assets side, mortgages, and an increase in deposits, on the liabilities side. Again, these new liabilities are money! **Bank lending increases the supply of broad money**, as effectively depicted in Fig. 15.

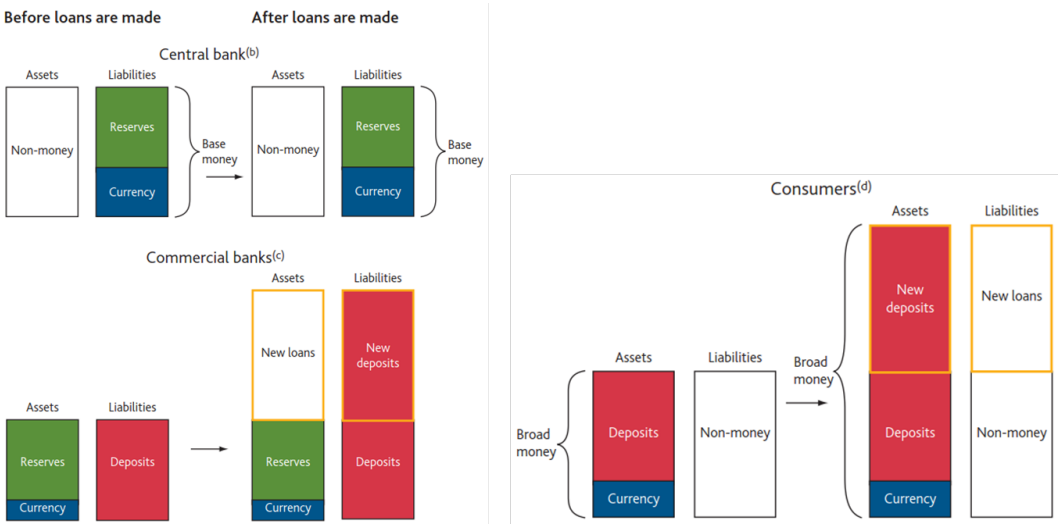


Figure 15: Money creation by the banking sector making additional loans. Source: McLeay, Radia, and Thomas (2014a).

Day four: liquidity risk raises its ugly head Clearly, the customers are allowed to withdraw at will from their checking accounts, and this creates a **liquidity risk** for the bank.[14] To address this risk, *BB* aims at keeping a 10% reserve ratio, and therefore considers the current reserves (€15 cash + €15 *CB* reserves) more than adequate. However, the demand for mortgages is continuously increasing! The bank grants a further €340 worth of new loans, crediting the principal amounts on checking deposits and therefore further increasing the money supply:

Assets		***Liabilities***	
CB Reserves	15	Equity	20
Cash	15	**Deposits**	**400**
Securities	5		
Mortgages	**385**		

Suddenly, reserves become inadequate, given the desired 10% ratio (€30 < €40): our bank needs at least €10 worth of additional reserves!

Day five: looking for additional reserves The easiest way to finance this increase in reserves is to relay on new deposits, since many customers end up being savers, not borrowers (recall that, after all, our bank is a financial intermediary!). In case additional deposits are slow in coming, *BB* may borrow short-term directly from the *ECB* at the official **refinancing rate**, using the €5 worth of securities as **collateral**.[15] The *CB* grants

[14] *Liquidity risk* is the risk stemming from the lack of marketability of an investment that cannot be bought or sold quickly enough to prevent or minimize a loss. If withdrawals in a given day are larger that existing reserves (cash + *CB* reserves), and this cannot be *ex-ante* excluded, *BB* may find it very difficult to quickly sell its securities, or access other forms of short-term financing, with such a short notice.

[15] *Collateral* is an asset that a borrower offers as a way for a lender to secure the loan. If the borrower stops making the promised loan payments, the lender can seize the collateral to recoup its losses.

the short-term collateralized loan, and credits €5 worth of additional reserves on *BB*'s reserve account. The remaining €5 are borrowed on the **unsecured interbank market** at the **interbank rate**,[16] and again credited on *BB*'s reserve account. This refinancing operation implies an increase in reserves, on the asset side, and creates new items on the liabilities side:

Assets		***Liabilities***	
***CB* Reserves**	**25**	Equity	20
Cash	15	Deposits	400
Securities	5	***CB* Refinancing**	**5**
Mortgages	385	**Uns. Borrowing**	**5**

Note that, while *BB*'s reserves increase by €10, the **total quantity of reserves** in the banking system increases by €5 only: the short-term loan granted by the *CB* does increase total reserves, while the €5 borrowed on the interbank market increase *BB*'s reserves, but decrease the lending bank's reserves. This is a very important point: the quantity of reserves is determined by the *CB*'s actions: an individual bank can increase its own reserves by borrowing them from other banks, but these does not change the total level of reserves in the banking system.

5.1.2 Summary

We learned that:

- When banks buy (and sell) securities from the non-bank private sector they affect the supply of money.
- Bank lending increases the supply of money.
- At the same time, bank lending increases deposits, and the connected risk of unexpected withdrawals, raising the demand for *CB* reserves.

Hence, the need to borrow short-term in order to reach the desired reserve ratio **makes lending and purchasing securities a costly activity**, over and above the pure **credit risk**,[17] and actually **limits the supply of broad money**!

Hence, **there are strong forces that limit money creation through lending**:

- Market forces constrain lending because individual banks have to lend profitably, and therefore the **demand for lending** plays a key role.

[16] "The interbank lending market is a market in which banks extend loans to one another for a specified term. Most interbank loans are for maturities of one week or less, the majority being overnight. Such loans are made at the interbank rate (also called the overnight rate if the term of the loan is overnight)." Source: Wikipedia.

[17] *Credit risk* refers to the risk that a borrower may not repay a loan and that the lender may lose the principal of the loan or the interest associated with it.

- **Additional loans increase liquidity and credit risks**, and therefore increase respectively the need for reserves and the size of the default premium.

Monetary policy can be considered the ultimate constraint on money creation:

- Being the monopoly provider of base money, the *CB* controls the **price of reserves** (directly and indirectly by controlling the interest rate on short-term money markets).
- By controlling the price of reserves, and setting the required reserve and capital adequacy ratios, the *CB* indirectly controls the supply of broad money.

6 The equilibrium interest rate (II)

The previous analysis suggests that, while the *CB* has full control on base money, the control on broad money is only indirect, and is exerted by controlling the price of reserves.

Hence, in a world without commercial banks, the *CB* would control the supply of currency, and let the interest rate be determined in equilibrium. In world characterized by a well-functioning commercial banking system, instead, the *CB* would find it much easier to control the interest rate (i.e. the price of additional reserves) and let the **money supply equate endogenously the money demand**.

The ***LM* curve**, in this case, boils down to the following relationship:

$$i = \bar{i}.$$

At this point, you may wonder whether the price of reserves, i.e. the short-term interest rate on interbank markets, was somehow related to the interest rate on riskless bonds or not. After all, the demand of money depends on the return of riskless bonds, not on the price of reserves. Fig. 16 reassuringly shows that the two rates are typically strictly related.

7 Interest rates and risk premia

Until now, we framed our discussion of money demand in terms of a very simple portfolio allocation problem: money vs. riskless bonds. However, our analysis of the supply of broad money already hinted at the existence of a variety of other financial assets - securities and mortgage loans in particular - that populate a commercial bank's balance sheets. The goal of this Section is to explain, as simply as possible, how the single "interest rate" which was the subject of the previous analysis, i.e. the interest rate on short-term riskless bonds and/or the interest on short-term liquidity on the interbank market, turns out to be linked in equilibrium to a large number of other rates of return. In particular, we are interested

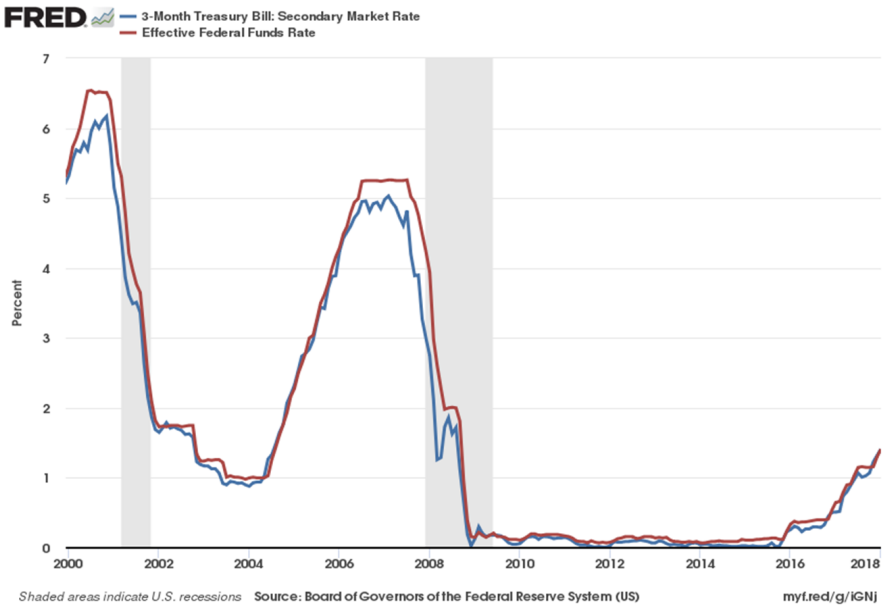


Figure 16: The return on riskless bonds vs. the price of reserves. Source: *FRED*.

in the relationship between the short-term interest rate on riskless assets and the interest that borrowers - households and firms - pay on their loans.

Consider that one of the main activities of financial intermediaries is to grant loans, that is to say buying **risky securities** (granting a loan is equivalent to buying a particular type of security). Securities are characterized by their **implicit return**, **degree of risk**, and **maturity** (i.e. the length of time over which they promise payments), as summarized in Appendix B. Let's focus on the relationship between risk and return. There is a change that the debtor may not be able to repay: to compensate for this **risk of default**, investors require a **risk premium**, i.e. a positive spread between the return to a riskless bond and the return to a risky security of the same maturity. Hence, different degrees of risk and different maturities imply the existence of different interest rates in equilibrium, and those interest rates will be linked to the rate on riskless bonds.

7.1 The risk premium

In order to pin down the intuition, consider a **risk-neutral investor** who has access to two financial assets: a riskless bond, and a risky security. Let i denote the interest rate on the **riskless bond**, i^* the interest rate on the **risky security**, $x \equiv i^* - i$ the **risk premium**, and $0 < p < 1$ the **probability of default**, i.e. the probability that the risky security defaults on its promise to pay. To be indifferent between the two assets, our risk-neutral investor requires the two securities to pay the same **expected return**:

$$\underbrace{1+i}_{\text{Return of safe bond}} = \underbrace{(1-p)\cdot(1+i^*)+p\cdot 0}_{\text{Expec. return of risky security}}.$$

In words, the return on a riskless bond, $1+i$, has to be equal to the probability of absence of default, $1-p$, times the security's return in case of absence of default, $1+i+x$, plus the probability of default, p, times the security's return in case of default, 0.

We can now solve for x, obtaining the analytical expression for the **risk premium** (x would be obviously larger for a risk-averse investor!):

$$x = (1+i)\frac{p}{1-p}.$$

Unsurprisingly, the risk premium increases with p, the probability of default:

$$\frac{\partial x}{\partial p} = \frac{1+i}{(1-p)^2} > 0.$$

7.2 Banks and risk premia

An alternative version of the previous setting, which is more macroeconomic in nature, is the following. Consider a commercial bank, which is able to refinance itself at the short-term interest rate i on the interbank market (or directly from the *CB*), that grants **risky one-period mortgage loans** at the interest rate $i^* \equiv i + x$, where x denotes again the risk premium. For the sake of exposition, let us assume that: (*i*) our bank does not sustain any operational costs other than the pure opportunity cost of refinancing; (*ii*) in case of default, the bank's revenue is zero; (*iii*) the bank has no other investment opportunities. The probability that a mortgage loans becomes **non-performing** - the probability of default - is again $0 < p < 1$.

The bank's **expected profit** for each euro of loans equals:

$$\mathbb{E}(\pi) = \underbrace{(1-p)\cdot\left(1+\underbrace{i^*}_{\text{Interest on mortgage}}\right)+p\cdot 0}_{\text{Expected revenue}} - \underbrace{(1+i)}_{\text{Cost}}.$$

In words, the expected profit is equal to the expected revenue - which in turn is equal to the gross return on the mortgage, $1+i^*$, times the probability of absence of default, plus the return in case of default, 0, times the probability of default - minus the opportunity cost of the loaned resources, which boils down to the cost of the reserves needed to finance the withdrawal of the principal.

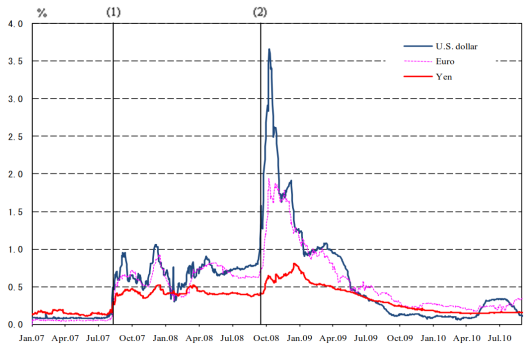
If the banking sector is **perfectly competitive**, free entry will drive expected profits down to zero, and therefore the interest rate for mortgage loans becomes:

$$\boldsymbol{i^*} = i + x = i + (1+i)\frac{p}{1-p} = \frac{i+p}{1-p} > \boldsymbol{i}\ .$$

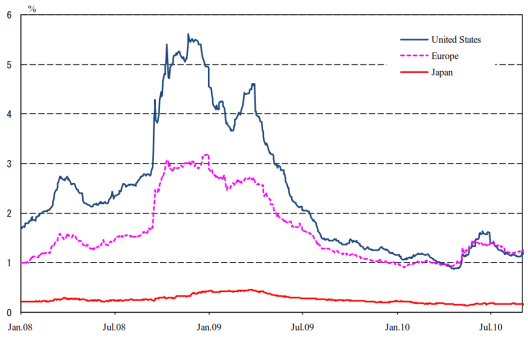
Note that, as before, $\partial i^*/\partial p > 0$. Hence, **an increase in the probability of default**

implies an increase in the rate on mortgage loans, for given policy rate. In other words, a worsening of the **creditworthiness** of their counterparties drives up the interest rates charged by banks, and therefore increase the **spread** between interest rates on loans and policy rates.

The evolution of credit conditions on the U.S. interbank market during the Great Recession is probably one of the most striking empirical example of the strict relationship between spreads and creditworthiness of counterparties. Fig. 17 provides a summary of this evidence. Fig. 17.a, in particular, plots the *LIBOR-OIS* spreads during the Great Recession for three currencies: this spread represents the difference between an interest rate with some credit risk built in (*LIBOR*) and one that is virtually risk-free (*OIS*), therefore indicating credit risk in the interbank lending market.[18] It is particularly interesting to observe the dramatic surge in the spread that followed the failure of *Lehman Brothers*: U.S. bankers evidently started to deeply mistrust their fellows! A similar dynamics can be observed in Fig. 17.a, where the spread between relatively safe corporate bonds, rated *AAA*, and slightly riskier ones, rated *BAA*, is depicted.



(a) Tension in the interbank market: LIBOR-OIS spreads (3-month).



(b) Tension in the corporate financing market: corporate bond spreads (AA-rated).

Figure 17: Tension of financial markets and spreads dynamics. Note that (1) and (2) indicate the *BNP Paribas* shock (on August 9, 2007) and the failure of *Lehman Brothers* (on September 15, 2008), respectively. Source: Bank of Japan.

8 Monetary policy

8.1 Conventional monetary policy

Prior to the Great Recession, *CB*s in advanced economies navigated calm and familiar seas. Monetary policy was conducted in a relatively predictable and systematic way,

[18] The *London Interbank Offered Rate* (*LIBOR*) is the average interest rate that banks charge each other for short-term, unsecured loans. A *Overnight Index Swap* (*OIS*) is the fair, fixed coupon for an interest rate swap in which the floating leg is linked to the short-term interest rate on the interbank market. Because the parties in a basic interest rate swap don't exchange principal, but rather the difference of the two interest streams, credit risk is a minor factor in determining the *OIS* rate.

and its transmission mechanism was reasonably well understood. As discussed above, in "normal" times the key policy instruments are short-term official interest rates, like the discount rate; monetary policy aims at driving the short-term (overnight) nominal interest rate on interbank markets (*Federal Founds rate* in the U.S.,[19] *EURIBOR* in Eurozone[20]) to a desired target level. This involved meeting the demand of base money at the target interest rate, so that monetary aggregates were by and large free to adjust. In the words of Lorenzo Bini Smaghi (keynote lecture at the *ICMB*, Geneva, 28 April 2009):

> "Nowadays, monetary policy mainly acts by setting a **target** for the **overnight interest rate** in the **interbank money market** and **adjusting the supply of central bank money** to that target through **open market operations**. ... In other words, in normal times the central bank is neither involved in direct lending to the private sector or the government, nor in outright purchases of government bonds, corporate debt or other types of debt instrument. By steering the level of the key interest rates, the central bank effectively manages the liquidity conditions in money markets and pursues its primary objective of maintaining price stability over the medium term."

To achieve this goal, the *Governing Council* of the *ECB* sets three key official interest rates for the Euro Area:

- The interest rate on the **Main Refinancing Operations** (*MRO*),[21] which provide the bulk of liquidity to the banking system, and are the practical counterpart in the Eurosystem of the previously discussed *OMOs*.
- The rate on the **deposit facility**,[22] which banks may use to make overnight deposits with the Eurosystem.
- The rate on the **marginal lending facility**,[23] which offers overnight credit to banks from the Eurosystem.

Evidently, all of them have a direct effect on the cost of reserves for the banking system. Fig. 18 shows the recent evolution of the deposit and refinancing rates: note that the deposit rate turned negative in 2014.

[19] The *Federal Funds* rate is the interest rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight.

[20] The *Euro Interbank Offered Rate* (Euribor) is a daily reference rate based on the averaged interest rates at which Eurozone banks offer to lend unsecured funds to other banks in the euro interbank market.

[21] A *Main Refinancing Operation* is a "regular open market operation executed by the Eurosystem for the purpose of providing the banking system with the amount of liquidity that the former deems to be appropriate." Source: *ECB*'s *Monetary policy glossary*.

[22] The *deposit facility* is a "standing facility of the Eurosystem which counterparties may use to make overnight deposits at a national central bank." Source: *ECB*'s *Monetary policy glossary*.

[23] The *marginal lending facility* is a "standing facility of the Eurosystem which counterparties may use to receive overnight credit from a national central bank at a pre-specified interest rate against eligible assets." Source: *ECB*'s *Monetary policy glossary*.

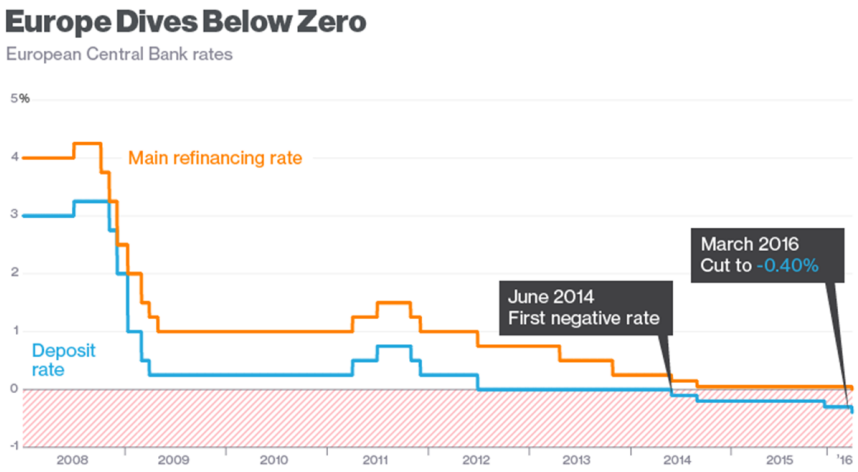


Figure 18: ECB policy rates. Source: Bloomberg.

In the U.S., the *Federal Reserve Bank* (*FED*) sets the **discount rate**, i.e. the interest rate charged to commercial banks and other depository institutions on short-term loans they receive from their regional Federal Reserve Bank's lending facility, known as the **discount window**,[24] and the interest rates on required and excess reserve balances. Furthermore, as already mentioned, the *FED* performs weekly OMOs in order to drive the *Federal Founds* rate to the desired level. Fig. 19 depicts the recent dynamics of excess reserves, the interest rate on excess reserves, and the *Federal Founds* rate in the U.S.

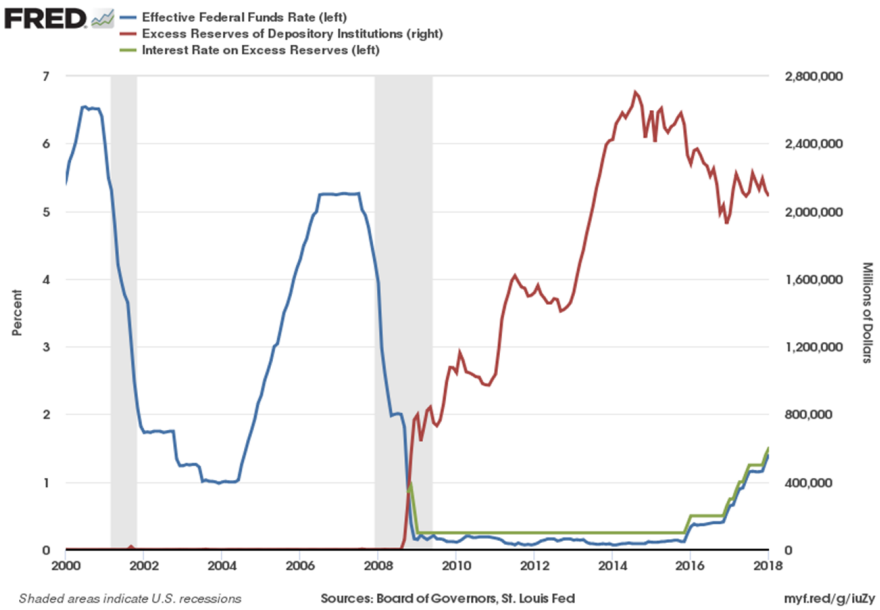


Figure 19: Excess reserves in the US, again. Source: FRED2.

[24] "The *discount window* is an instrument of monetary policy ... that allows eligible institutions to borrow money from the central bank, usually on a short-term basis, to meet temporary shortages of liquidity caused by internal or external disruptions. The term originated with the practice of sending a bank representative to a reserve bank teller window when a bank needed to borrow money" Source: Wikipedia.

Even a cursory glance at Fig. 18 and 19 reveals that the years after 2008 can hardly be considered "normal" times, and that the Great Recession of 2008-10 caused a long-lasting change in regime, as far as monetary policy is concerned.

8.2 Unconventional monetary policy[25]

The change in regime mentioned in the previous Section happened because conventional monetary policy tools proved insufficient to achieve the central bank's objective. Generally, there may be two reasons for this, as Bini Smaghi points out:

> **"First**, the economic shock is so powerful that the nominal interest rate needs to be brought **down to zero**. At that level, cutting policy rates further is not possible, so any additional monetary stimulus can be undertaken only by resorting to **unconventional monetary policy tools**. ... All of these measures have one element in common: they are designed to **improve financing conditions** beyond the very short-term interbank interest rates.
>
> **Second**, non-conventional measures may be warranted even when the policy interest rate is above zero if the monetary policy transmission process is significantly impaired. Under these circumstances, central banks have two (not necessarily mutually exclusive) alternatives, namely (i) to reduce the short term nominal interest rate even further than in normal conditions, and (ii) to act directly on the transmission process by using non-conventional measures."

The need for unconventional monetary policies eminently emerged during the recent Great Recession: Fig. 18 and 19 show that the policy rates set by the *FED* in the U.S. and by the *ECB* in the Eurozone hit the so-called **Zero Lower Bound** around the end of 2008.

Bini Smaghi effectively summarizes the main characteristics of **unconventional measures** as follows:

> "Unconventional measures can be defined as those policies that **directly target the cost and availability of external finance to banks, households and non-financial companies**. These sources of finance can be in the form of central bank liquidity, loans, fixed-income securities or equity. Since the cost of external finance is generally at a premium over the short-term interbank rate on which monetary policy normally leverages, unconventional measures may be seen as **an attempt to reduce the spreads between various forms of external finance**, thereby affecting asset prices and the flow of funds in the economy."

[25] This Section draws on McLeay, Radia, and Thomas (2014a) and Keister and McAndrews (2009).

8.2.1 Quantitative easing (*QE*)

One of the most effective tools of unconventional monetary policy is known as **Quantitative Easing**, or **large-scale asset purchases**. *QE* influences the cost of credit by affecting market conditions of assets at longer maturities, and aims at increasing the size of the *CB* balance sheet and therefore expanding its monetary liabilities. In practice, *QE* has mainly focused on buying longer-term government bonds from banks.

As it is currently understood, the transmission mechanism of *QE* relays on two channels. In Bini Smaghi's words:

> "**First**, sovereign yields serve as a benchmark for pricing riskier privately issued securities. When long-term government bonds are purchased, the yields on privately issued securities are expected to decline in parallel with those on government bonds.
>
> **Second**, if long-term interest rates were to fall, this would stimulate longer-term investments and hence aggregate demand, thereby supporting price stability."

As suggest above, to implement *QE*, a *CB* creates new base money to make large purchases of assets (mostly government bonds) from the private sector, for example from pension funds and non-financial firms. These purchases swell the size of *CB* reserves by the quantity of assets purchased—hence "quantitative" easing. Fig. 20 reports the changing size and composition of the *FED* balance sheet over the last decade.

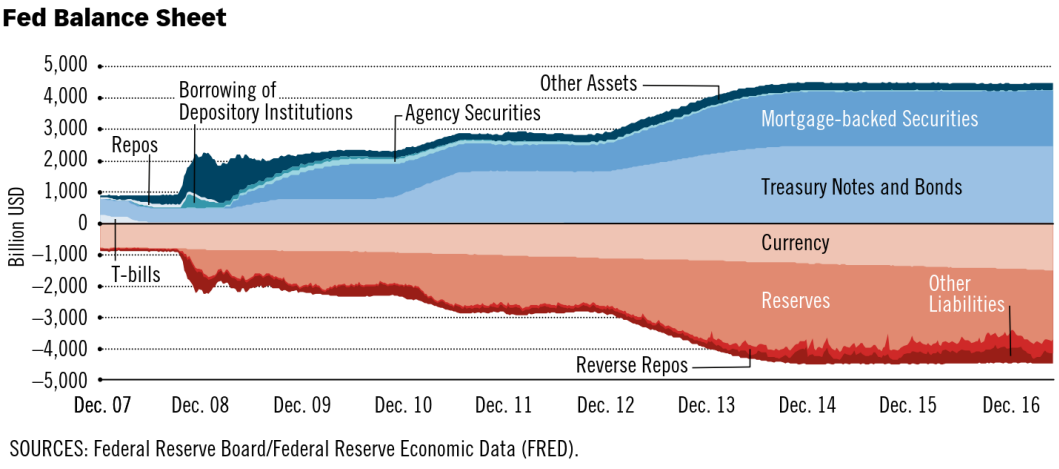


Figure 20: Evolution of the FED balance sheet. Source: Williamson.

The asset purchases are of such a scale that they push up the price of the involved assets, lowering their yields. This encourages those selling these assets to use the money they received from the sale to buy assets with a higher yield instead, like company shares and bonds. As more of these other assets are bought, their prices rise because of the increased demand. This pushes down on yields in general. The companies that have

issued these bonds or shares benefit from cheaper borrowing, encouraging them to spend and invest more. *CB*s can also buy smaller amounts of private debt (like corporate bonds): this is aimed at making it easier for companies to raise money in capital markets to invest in their business.

8.2.2 *QE* and excess reserves

It turns out that the adoption of unconventional monetary policy tools, in particular of large-scale asset purchases, is the main driver behind the massive increase in excess reserves highlighted in Fig. 10 and 19. In the words of Keister and McAndrews (2009):

> "The buildup of reserves in the U.S. banking system during the financial crisis has fueled concerns that the Federal Reserve's policies may have failed to stimulate the flow of credit in the economy: banks, it appears, are amassing funds rather than lending them out. However, a careful examination of the balance sheet effects of central bank actions shows that the high level of reserves is simply a by-product of the Fed's new lending facilities and asset purchase programs. ...
>
> The total quantity of reserves is determined almost entirely by the central bank's actions, and in no way reflects the lending behavior of banks. ... The dramatic buildup of excess reserves reflects the large scale of the Federal Reserve's policy initiatives; it conveys no information about the effects of these initiatives on bank lending or on the level of economic activity."

A simple example will clarify the issue. Consider, for the sake of exposition, the purchase of €10 billions of government bonds from a pension fund. As the pension fund does not hold a reserves account with the *CB*, the commercial bank with whom they hold a bank account is used as an intermediary. The pension fund's bank credits the pension fund's account with €10 billions of deposits in exchange for the government bonds. The balance sheets of our three actors are summarized below:

Central Bank				***Commercial Bank***				***Pension Fund***			
Assets		***Liabilities***		***Assets***		***Liabilities***		***Assets***		***Liabilities***	
Securities	+10	**Reserves**	**+10**	Reserves	+10	Deposits	+10	Deposits	+10		
								Securities	-10		

Note that the pension fund's assets do not change, while both the commercial bank and the central bank see their assets increase by €10 billions. Furthermore, note that this asset purchase by the *CB* leads to a sharp increase in reserves. However, while the *CB*'s asset purchases involved — and affected — the commercial bank's balance sheet, the primary role of this bank is as an intermediary to facilitate the transaction between the central bank and the pension fund: the €10 billions of additional reserves are simply a

by-product of this transaction. Fig. 21 depicts graphically the related changes in balance sheets discussed in the previous paragraph.

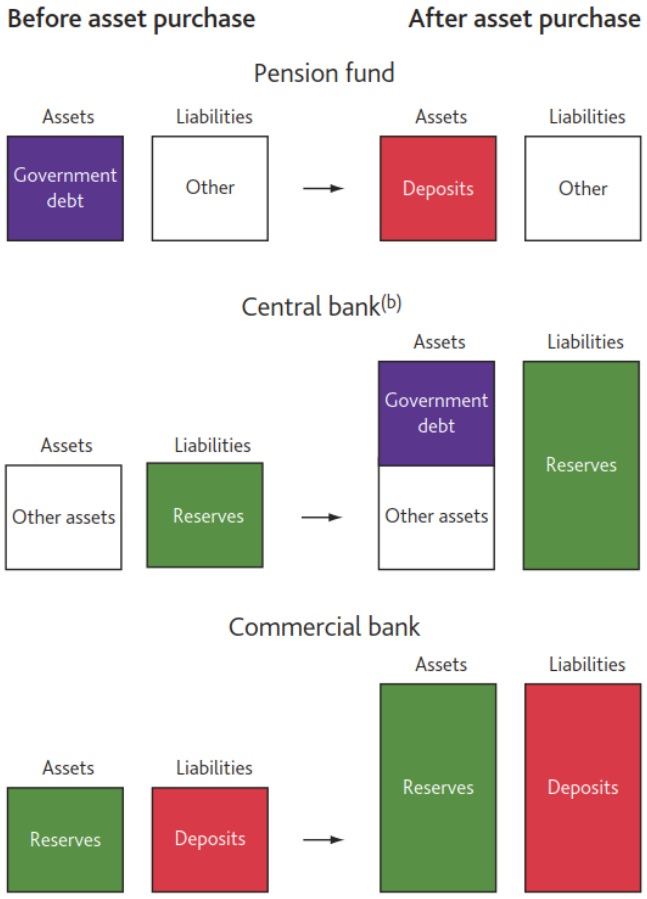


Figure 21: Impact of *QE* on balance sheets. Source: McLeay, Radia, and Thomas (2014a).

McLeay, Radia, and Thomas (2014a) do effectively state that *QE* does not directly affect the incentives for the banks to lend:

> "*QE* boosts broad money without directly leading to, or requiring, an increase in lending. ... the newly created reserves do not, by themselves, meaningfully change the incentives for the banks to create new broad money by lending. It is possible that *QE* might indirectly affect the incentives facing banks to make new loans, for example by reducing their funding costs, or by increasing the quantity of credit by boosting activity. But equally, *QE* could lead to companies repaying bank credit, if they were to issue more bonds or equity and use those funds to repay bank loans. On balance, it is therefore possible for *QE* to increase or to reduce the amount of bank lending in the economy. ... instead, *QE* works by circumventing the banking sector, aiming to increase private sector spending directly."

Keister and McAndrews (2009) highlight the importance of paying interest on reserves in

order to isolate short-term interest rates, the usual targets of monetary policy, from the effects of *QE*:

> "Paying interest on reserves breaks this link between the quantity of reserves and banks' willingness to lend. ... paying interest on reserves allows the central bank to follow a path for short-term interest rates that is independent of the level of reserves. By choosing this path appropriately, the central bank can guard against inflationary pressures even if financial conditions lead it to maintain a high level of excess reserves. ...
>
> Paying interest on reserves allows a central bank to maintain its influence over market interest rates irrespective of the quantity of reserves in the banking system. The central bank can then scale its policy initiatives according to conditions in the financial sector, while setting its target for the short-term interest rate in response to macroeconomic conditions."

9 Leverage ratios and the risk of insolvency

A carefull analisys of Fig. 17.a may lead an attentive reader to wonder why bankers lost suddenly confidence in the ability of their counterparties to repay their short-term debts.

9.1 The leverage ratio

Let us come back to our **Banco Bocconiano** (*BB*). The last time we mentioned it, its balance sheet looked like the following:

Assets		***Liabilities***	
CB Reserves	25	Equity	20
Cash	15	Deposits	400
Securities	5	*CB* Refinancing	5
Mortgages	385	Uns. Borrowing	5

Define now the **leverage ratio** as the ratio of total liabilities (= total assets!) to equity, equal in our case to 430/20 = **21.5**. The leverage ratio is the reciprocal of the **capital ratio**, obviously defined as the ratio between equity and total assets.

Fig. 22.a reports the leverage ratios for the 10 largest U.S. banks, before and after the Great Recession: *BB*'s leverage ratio seems quite reasonable in comparison.

9.2 Leverage ratios and rates of return

Suppose the expected rate of return on assets, i.e. on mortgage loan and securities in our case, is 10%, while the expected cost on liabilities, deposits + refinancing and

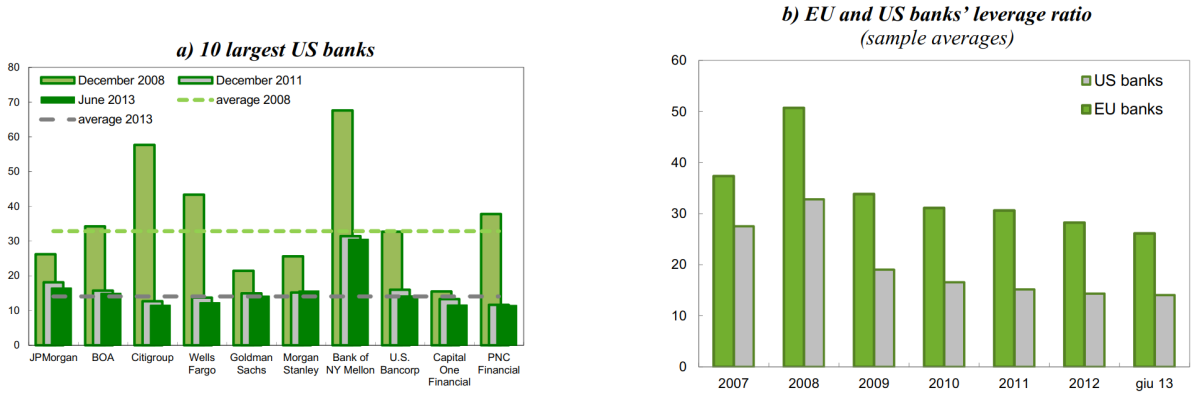


Figure 22: Leverage ratios before and after the Great Recession. Source: Bologna, Caccavaio, and Miglietta (2014).

unsecured borrowing, is 8%. The expected profit equals $0.1 \times €390 - 0.08 \times €410 = €6.2$. Given that the shareholders invested €20 in the bank, the expected return for unit of capital equals €6.2/€20 = 31%. Now suppose that the bank grants €100 of additional mortgage loans, that the expected return on those new loans remains equal to 10%, and that the required reserved are borrowed from the *CB* at the usual rate, equal to 8%. The leverage ratio increases, rising to 530/20 = **26.5**. The expected profit becomes $0.1 \times €490 - 0.08 \times €510 = €12.2$, and the expect return for unit of capital rises to €12.2/€20 = 61%. Hence, **the higher the leverage ratio, the higher the rate of return** for the shareholders!

9.3 Leverage ratios and insolvency

So why should *BB* not choose the highest possible leverage ratio? Because a high leverage ratio is **risky** for the bank! Note that equity capital can be seen as a buffer designed to absorb **unexpected write-downs** on financial assets: if capital losses exceed current equity, so that the latter turns negative, the bank becomes insolvent! If *BB*'s outstanding mortgage loans and securities amounted to €390, a write-down approximately equal to 5.1% of their value would be sufficient to drive equity towards zero, and cause insolvency. If the amount of outstanding assets increased to €490, the write-down large enough to cause insolvency drops to 4.1% of their value. In other words, **the probability to incur capital losses large enough to cause insolvency increases with the leverage ratio**!

Just to give the reader an idea of the magnitude of these potential capital losses, Fig. 23 reports write-downs and losses for some major U.S. financial institutions during the Great Recession, more precisely over the 01/2007-08/2009 period.

Total since 2007, in USD billion[a)]

	Writedown & Loss		Writedown & Loss
Banks & brokers		**Insurance companies**	
Citigroup Inc.	112.2	American International Group	101.4
Wachovia Corporation	101.9	ING Groep N.V.	17.7
Bank of America Corp.	69.6	Ambac Financial Group Inc	12.1
Merrill Lynch & Co.	55.9	Hartford Financial SVCS GRP	11.6
UBS AG	53.1	Metlife Inc	10
HSBC Holdings Plc	50.1	Prudential Financial Inc	9.2
JPMorgan Chase & Co.	49.2	Aegon NV	8.7
Washington Mutual Inc.	45.3	Swiss Re	8.3
Wells Fargo & Company	32.8	Allstate Corp	7.8
HBOS Plc	29.5	Allianz SE	7.6
Royal Bank of Scotland Group Plc	29.0	MBIA Inc	5.8
National City Corp.	25.2	Genworth Financial Inc-CL A	5.4
Barclays Plc	23.7	Other	58.8
Morgan Stanley	23.0	**Total**	264.4
Credit Suisse Group AG	19.2	**Government sponsored entities (US)**	
Deutsche Bank AG	18.7	Freddie Mac	119.6
BNP Paribas	17.0	Fannie Mae	118.3
Other	343.7	**Total**	237.9
Total	1,099.1	**GRAND TOTAL**	1,601.4

Figure 23: Major financial institutions' write-downs and credit losses (as of 13 August 2009). Source: Blundell-Wignall, Wehinger, and Slovik (2012).

9.4 Deleveraging and the credit crunch

The leverage ratio has noteworthy implications as far as the supply of credit by the banking system is concerned. For instance, suppose that *BB* learns that €10 worth of mortgage loans in its portfolio became delinquent, and is forced to write the amount down *BB*'s equity capital needs to absorb the loss, and drops to €10:

Assets		***Liabilities***	
CB Reserves	25	**Equity**	**10**
Cash	15	Deposits	400
Securities	5	*CB* Refinancing	5
Mortgages	**375**	Uns. Borrowing	5

The leverage ratio increases suddenly from 21.5 to €420/€10 = 42! The bank is still solvent, but clearly more at risk than before.

There are two ways to reduce the leverage ratio, i.e. to **deleverage**: our bank could increase the equity capital, or reduce the amount of outstanding mortgage loans. During a financial crisis, the second way is probably the only feasible one, and this implies a sharp reduction in the supply of credit to the economy, the so-called **"credit crunch"**. Fig. 24 quite effectively shows the extent of the credit crunch that affected the U.S. economy during the Great Recession.

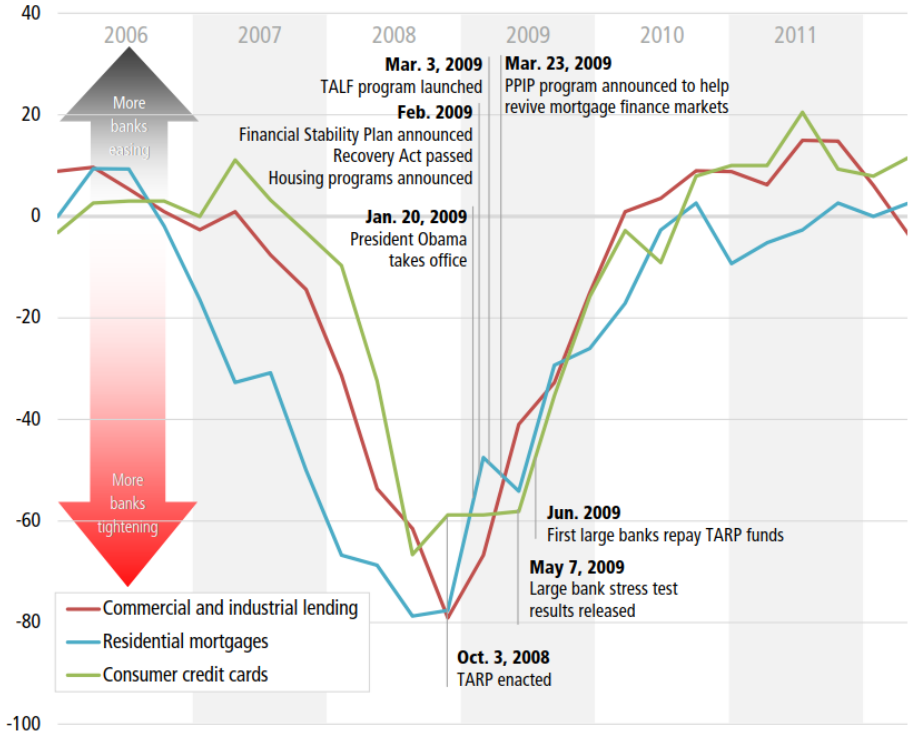


Figure 24: Net percentage of banks easing lending standards, by loan type. Source: U.S. Treasury.

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A The price of bonds

Bond markets determine bond prices, not interest rates. Consider a one-year bond that promises a payment of €100 a year from now; let the current price of such a bond be $€P_b$. If you buy the bond today and hold it for a year, the rate of return, i.e. the interest rate, is given by:

$$i = \frac{100 - €P_b}{€P_b}.$$

The higher the price of the bond, the lower the interest rate! Given the interest rate, we can recover the price:

$$€P_b = \frac{€100}{1+i}.$$

B Financial intermediation

In order to better understand the scope of financial intermediation, let's consider the main properties of financial assets:

- **Rate of return**: $r_t = (p_{t+1} + d_{t+1})/p_t – 1$; ceteris paribus, a higher return is better for the consumer.
- **Risk**: the risk that matters is the one that an asset contributes to the entire portfolio; ceteris paribus, consumers are risk averse.

- **Maturity**: the time it takes for an asset to pay off; ceteris paribus, a shorter maturity is better.
- **Liquidity**: measures how long it takes to sell an asset for its market value, and how high the transaction costs are; ceteris paribus, higher liquidity is better.

A **financial intermediary** (insurance companies, mutual founds, depository institutions, ...) is defined by the following characteristics:

- It borrows and lends to **different groups** of economic agents.
- It is **well diversified**: it trades with large groups of economic agents.
- It **transforms assets**: the properties of its liabilities are different from the properties of its assets.
- It **processes information**.

Depository institutions exists (in part) because of difficulties in getting ultimate borrowers and ultimate lenders together. A depository institution (a commercial bank, for instance):

- is specialized in **evaluating credit risk**, i.e. enjoys economies of scale in acquiring information;
- pools the founds of many lenders, reducing the replication of costs;
- is **well diversified** with respect to both its assets and liabilities;
- can therefore **transform risky, illiquid, long-maturity assets** (mortgages and loans) into relatively **safe, liquid, short-maturity liabilities** (deposits).