9. Interest rate and central bank

1. “The” interest rate of an economy

Definition 1.1. The nominal interest rate associated with a financial asset is the rate of return of the asset.

An economy has nearly as many interest rates as financial assets. The empirical evidence suggests that all of them tend to move in parallel. It is therefore reasonable to adopt the fiction that there is a unique interest rate i in the economy. This rate could be taken to be the interest rate of a loan, which is itself a reference interest rate.

Definition 1.2. The interest rate i of an economy is supposed to represent the average interest rate charge for a typical loan of currency.

2. Meaning of the interest rate

Interpretation 2.1. Reward for saving. For a moneylender, the interest rate i means that he or she receives at maturity $1 + i$ for every unit lent: for a moneylender, i measures the profit of lending one unit of currency.

From the moneylender’s perspective, thanks to the interest rate, 1 monetary unit in t becomes $1 + i$ monetary units in $t + 1$. For the moneylender, i is the reward for saving: by giving up 1 today, he or she obtains $1 + i$ in the future. Hence, i represents the benefit of sending money to the future. This interpretation suggests a redefinition of the concept of interest rate.

Definition 2.2. The (nominal) interest rate (between periods t and $t + 1$) expresses the value in period of $t + 1$ of one monetary unit of period t.

Interpretation 2.3. Cost of a loan. For a borrower, the interest rate i means that he or she must pay $1 + i$ for each unit borrowed: for a borrower, i measures the cost of receiving a loan of one unit.

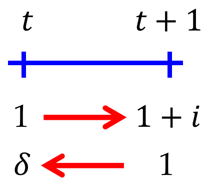
From the borrower’s perspective, thanks to the interest rate, $1 + i$ monetary units in $t + 1$ can be transformed into 1 monetary unit in t. For the borrower, i is the cost of a loan: if he or she is going to receive $1 + i$ in the future, 1 unit could be obtained today. Thus, i also represents the cost of bringing money from the future.

Interpretation 2.4. Measure of patience. The higher i, the more a borrower is willing to pay for having one unit of currency today instead of tomorrow and, accordingly, the less patient the borrower is. A positive i expresses a preference for the present: it is better to have money today than tomorrow.

3. The discount factor

Definition 3.1. The discount factor (between periods t and $t + 1$) expresses the value in period of t of one monetary unit of period $t + 1$.

Whereas the interest rate transforms today's money into tomorrow's money (1 today is $1 + i$ tomorrow), the discount factor does the opposite by transforming tomorrow's money into today's money. Fig. 1 shows how the discount factor δ determines present values out of future values.



The discount factor makes 1 become δ. This δ is the value in period t that, when the interest rate between t and $t + 1$ is i, becomes 1 in period $t + 1$. By the rule of three, $\delta = 1{\cdot}1/(1 + i) = 1/(1 + i)$ is the discount factor, which depends on the interest rate i. This leads to a more precise definition of δ.

Definition 3.2. The discount factor δ between periods t and $t + 1$, when i is the interest rate between t and $t + 1$, is

$$\boxed{\delta = \frac{1}{1 + i}}.$$

4. Interest rate and asset prices

Proposition 4.1. *The price of a financial asset and the nominal interest rate move in opposite directions*.

Since the interest can be interpreted as the price of money (the cost of a loan), Proposition 4.1 asserts that the price of financial assets and the price of money move in opposite directions.

Example 4.2. Proposition 4.1 will be illustrated for the case in which the financial asset is a T-bill. The T-bill is issued in period t and matures in $t + 1$. The price of the T-bill in t, when issued, is P. The face value of the T-bill is V, which means that, in $t + 1$, the T-bill pays V to the owner of the T-bill. Let i be the interest rate between t and $t + 1$, so i represents the profit of making a loan with the same maturity as the T-bill. An investor having P monetary units may consider two options.

- Option 1: lend P. When the loan matures, in $t + 1$, the investor gets $(1 + i) \cdot P$.
- Option 2: buy the T-bill. When the T-bill matures, in $t + 1$, the investor gets V.

For both options to be equally attractive, the outcomes must coincide $(1 + i) \cdot P = V$. That is,

$$\boxed{P = \frac{V}{1 + i}}. \qquad (1)$$

Since V is a fixed given value, (1) means that the larger i, the smaller P.

5. Financial arbitrage

Definition 5.1. Arbitrage consists of making purchases and sales that ensure a sure profit.

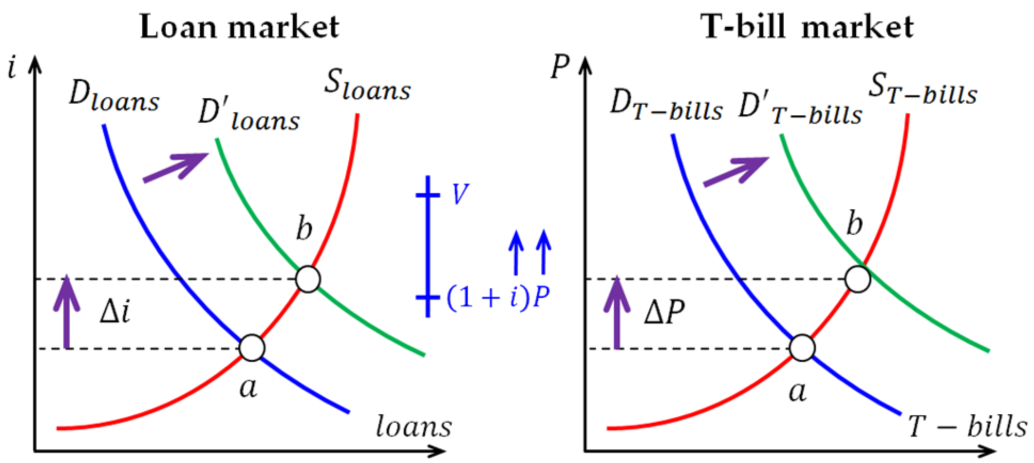
Under financial arbitrage, an arbitrageur buys and sells financial assets to obtain a sure profit. It will be next argued that financial arbitrage justifies the inverse relationship between the price of a T-bill and the interest rate established by (1). To this end, suppose (1) is false; that is, $V > (1+i) \cdot P$ or $V < (1+i) \cdot P$. Only the former possibility is handled, the latter being left as an exercise. The economic logic of the proof relies on the idea that arbitrage opportunities (the possibility of making sure profits) cannot last. Thus, outcomes that create arbitrage opportunities cannot be stable nor be taken as good economic predictions. Specifically, the proof will show that:

(i) $V > (1+i) \cdot P$ creates arbitrage opportunities; and that

(ii) the act of profiting from arbitrage opportunities make such opportunities disappear.

So let $V > (1+i) \cdot P$. An arbitrageur can obtain sure profits as follows, even having no money.

- Step 1: the arbitrageur borrows P monetary units in t and, consequently, has to repay $(1+i) \cdot P$ monetary units in $t+1$.
- Step 2: the arbitrageur purchases in t a T-bill with the P monetary units.
- Step 3: reached period $t+1$, the T-bill pays V monetary units and, owing to $V > (1+i) \cdot P$, the arbitrageur repays the loan and pockets a profit of $V - (1+i) \cdot P > 0$ monetary units.



It is very likely that many arbitrageurs will be attracted by the prospect of sure benefits. Hence, significant amounts of money will be borrowed in step 1. Assuming the market for loans and the market for T-bills to be competitive (a reasonable assumption for financial markets), the borrowing of money by arbitrageurs will shift the demand for loans to the right. As depicted in the figure above (left-hand side), an expanding demand for loans causes a rise in the interest rate i. On the other hand, the purchases of T-bills executed in step 2, shifts to the right that demand for T-bills (see the right-hand side of the figure). This shift leads to an increase in the price P of T-bills. With both i and P going up, $(1+i) \cdot P$ also goes up. The result is that $V - (1+i) \cdot P$ diminishes. Arbitrageurs will borrow money and buy T-bills until the gap between values V and $(1+i) \cdot P$ is decreases until $V = (1+i) \cdot P$, in which case arbitrage opportunities vanish. This reasoning proves $V > (1+i) \cdot P$ to be inconsistent with financial arbitrage. A similar reasoning shows the incompatibility of $V < (1+i)$ with financial arbitrage.

6. Prices of assets as present values

The concept of present value also justifies (1). In fact, the value in $t + 1$ (the future value) of the T-bill is V. With interest rate i between t and $t + 1$, the value of V in t (its present discounted value) is

$$V \cdot \frac{1}{1+i}$$

where $\frac{1}{1+i}$ is the discount factor between t and $t + 1$. In view of this, equation (1) states that the price of a T-bill coincides with the present discounted value of its face (future) value.

7. Equalization of rates of return

A third justification of (1) comes from the presumption of the equalization of the interest rates of all financial assets. A justification for this presumption is that, if the equalization does not occur, financial assets with a smaller rate of return would have no demand and, consequently, they would not exist. Given that many financial assets exist, their rates of return should be the same. The interest rate $i_{T\text{-}bill}$ implicit in (associated with or corresponding to) a T-bill is

$$i_{T\text{-}bill} = \frac{V-P}{P}.$$

Letting i represent the interest rate of a loan, the equalization condition $i = i_{T\text{-}bill}$ leads to

$$i = i_{T\text{-}bill} = \frac{V-P}{P} = \frac{V}{P} - 1$$

or, equivalently,

$$1 + i = \frac{V}{P}.$$

Solving for P yields equation (1).

8. The central bank (CB)

Definition 8.1. The central bank is the monetary authority in an economy. It is the public institution that, typically,

- provides and regulates the money supply (M1, M2, M3);
- issues the currency (see the letters "ECB" in euro banknotes);
- controls (or pretends to control) the interest rates and/or the inflation rate;
- oversees the banking and the payment systems (the CB is the systems' supervisor);
- acts as a lender of last resort to the banking system (the CB is a banker to banks);
- establishes mininum reserve requirements and conducts the monetary policy;
- is independent of the government (though the CB may a banker to the government).

For the purposes here, the CB is the institution that determines and executes the monetary policy.

9. Monetary policy instruments

There are three standard tools by means of which a central bank can influence the money stock.

- The quantity tool: changes in the supply of reserves to the banking system through open market operations or direct lending through standing facilities.
- The price tool: changes in the interest rate at which the CB lends (the CB's policy interest rate).
- The formal regulatory tool: changes in the reserve requirement.
- The direct control of the quantity of bank credit is an unofficial, extra-legal, informal regulatory tool: the CB informs the banks by how much they are allowed to increase lending in a certain period. Violation of the limit is punished.

10. Open market operations (OMOs)

Definition 10.1. Open market operations by the central bank are sales or purchases of financial assets (normally, government securities, like T-bills, and central bank bills) to, typically, certain counterparties (typically, the main banks of the economy).

In the textbook view, the immediate aim of OMOs is to control the money stock: an OMOs modifies **M0** and, through the money multiplier, the change in **M0** alters **M1** in the desired direction.

Definition 10.2. An expansionary OMO expands the monetary base (and, supposedly, the money stock) by buying financial assets: the CB gets financial assets in exchange for currency, so there are more funds in the economy (alternatively, the CB may pay the financial assets by enlarging the amount of reserves that the banks that sold the assets hold in the CB); see Fig. 1.

Definition 10.3. A contractionary OMO contracts the monetary base (and, supposedly, the money stock) by selling financial assets: the CB injects financial assets in the economy and drains currency out of it (or reduces reserves that the banks that bought the assets have in the CB); see Fig. 2.

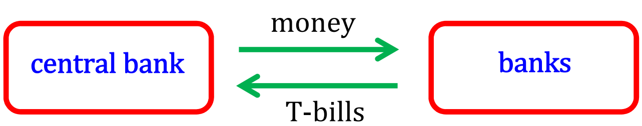


Fig. 1. Expansionary OMO

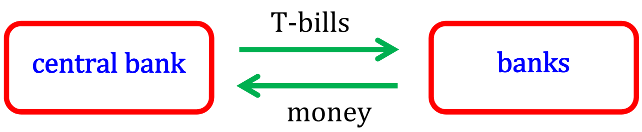


Fig. 2. Contractionary OMO

According to the nature of the transaction, OMOs can be divided in two types: repo (and reverse-repo) transactions and outright transactions.

Definition 10.4. An outright transaction is an OMO in which the rights embodied in the financial asset that is bought or sold are permanently transferred to the buyer (the asset is then said to be bought or sold outright).

Definition 10.5. A repurchase agreement (or repo, for short) is an OMO in which the rights embodied in the financial asset that is bought or sold are temporarily transferred to the buyer: in a repo, the seller of the financial asset must buy it back in a future date and at a preestablished price.

Definition 10.6. A reverse repurchase agreement (or reverse-repo, for short) is an OMO in which the buyer of the financial asset must sell it back in a future date and at a preestablished price.

In a repo transaction liquidity is drained (absorbed) by the central bank temporarily: the CB sells financial assets with the compromise of repurchasing them in the future. By means of a reverse-repo transaction liquidity is injected by the central bank temporarily: the CB buys financial assets with an agreement of selling them back in the future; see Fig. 3.

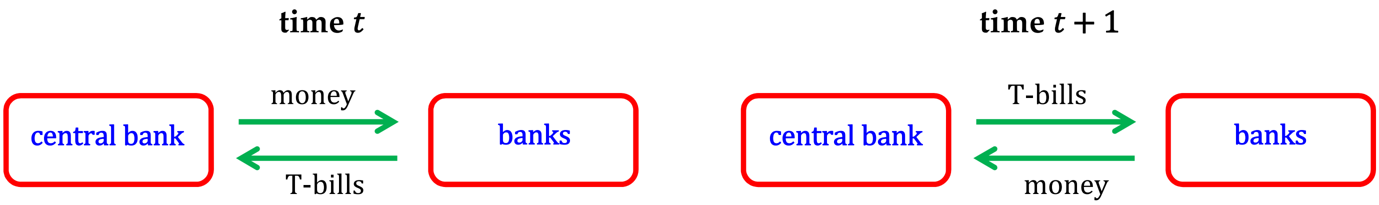


Fig. 3. A reverse repurchasement agreement by the central bank (reverse-repo transaction)

11. Standing facilities

Definition 11.1. A standing facility is a procedure by means of which banks can borrow or lend funds directly with the central bank.

With OMOs the CB intervenes directly in financial markets. With standing facilities, the CB deals directly with some counterparties (the main banks) and afterwards lets financial markets determine how founds are allocated among financial institutions. Such facilities are passive tools to neutralize or smooth out the excessive volatility to which financial markets are prone, so that the market interest rates are in line with (or not pushed too far away from) the interest rate target of the CB (as signalled by the CB's interest rate policy).

Definition 11.2. A deposit facility is a standing facility that allows selected banks having an excess of liquidity (that is, excess funds) that cannot be used in the markets to deposit that excess in the central bank and in return be paid an interest rate normally below the market rate.

Definition 11.3. A lending facility is a standing facility that allows selected banks unable to obtain short-term liquidity in the markets to borrow directly from the CB, normally at an interest rate higher than the market rate.

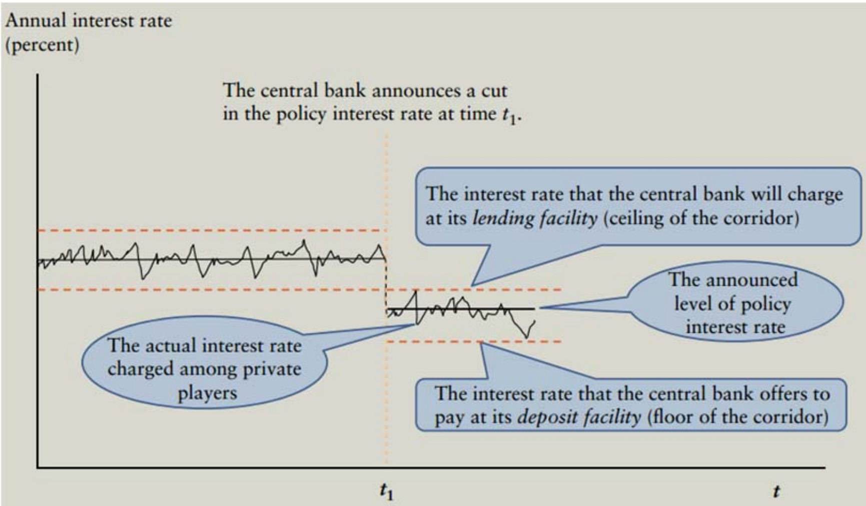
12. The policy interest rate and the interest rate corridor

Definition 12.1. "The policy interest rate refers to a short term interest rate that the central bank uses to indicate its monetary policy stance." (Thammarak Moenjak (2014), *Central banking*, p. 128)

By making public the policy interest rate, the CB tries to induce market rates to be close to the policy interest rate. Whereas the policy rate signals the central bank's monetary policy stance, OMOs and standing facilities constitute tools to induce market rates to be near the policy interest rate.

In normal circumstances, competition among banks tends to ensure that borrowing and lending rates do not differ much. Temporal liquidity shortages or surpluses may induce market rates to differ significantly from the policy interest rate. In this case, appropriate expansionary or contractionary open market operations could be used to move market rates toward the goal. Knowing that the CB is willing to intervene in order to put market rates in line with the policy interest rate, banks would normally accept borrowing and lending at the CB's desired rate.

If the CB finds more convenient to regulate market conditions without stepping in (because direct intervention would be too frequent or involve too much funds), then banks can deal with temporal liquidity shortages or surpluses by resorting to the standing facilities.



Definition 12.2. The expression *interest rate corridor* makes reference to the combined use of standing facilities and the policy interest rate with the aim of keeping market rates within a specified corridor (fluctuation band) around the policy interest rate; see the figure on the left, taken from Moenjak (2014, p. 128).

The interest rate the CB charges for using the lending capacity is higher than the policy interest rate to induce banks to look first in markets a solution to their liquidity problem (shortage in this case). This makes the interest rate of the lending facility a ceiling for short-term market rates. A symmetric role is played by the interest rate of the deposit facility: it is a floor for market rates to encourage banks with liquidity surpluses to find borrowers in the markets, so that such banks turning to the central bank's deposit facility only as a last resort (when there is no better option).

13. Reserve requirements

Definition 13.1. Reserve requirements constitute the minimum amount of reserves that banks must deposit in the central bank.

Reserve requirements are usually computed as a fraction (the reserve ratio) of (sight) deposits. Reserves contribute to control the money stock by altering the portion of any deposit that has to be retained: under a zero reserve requirement, banks would have no constraint to create deposits. By increasing the reserve ratio, the CB detracts lending funds from banks: according to the textbook model of **M1** creation, less loans, less expendi-ture, less revenue, less deposits, smaller **M1**. This reduces the money multiplier: $\uparrow r \Rightarrow \downarrow mm$. <u>A reduction of the reserve ratio has an expansive effect on **M1**</u>: more fuel can be added to the flames of the money creation process.

The banks' reserves held on account at the CB are simply numbers, like deposits. An aditional purpose of the reserves system is to <u>settle interbank payments</u>. That is why banks must retain each day enough reserves to facilitate the interbank clearing process plus enough cash reserves to meet the withdrawal requests from depositors; see Fig 4.

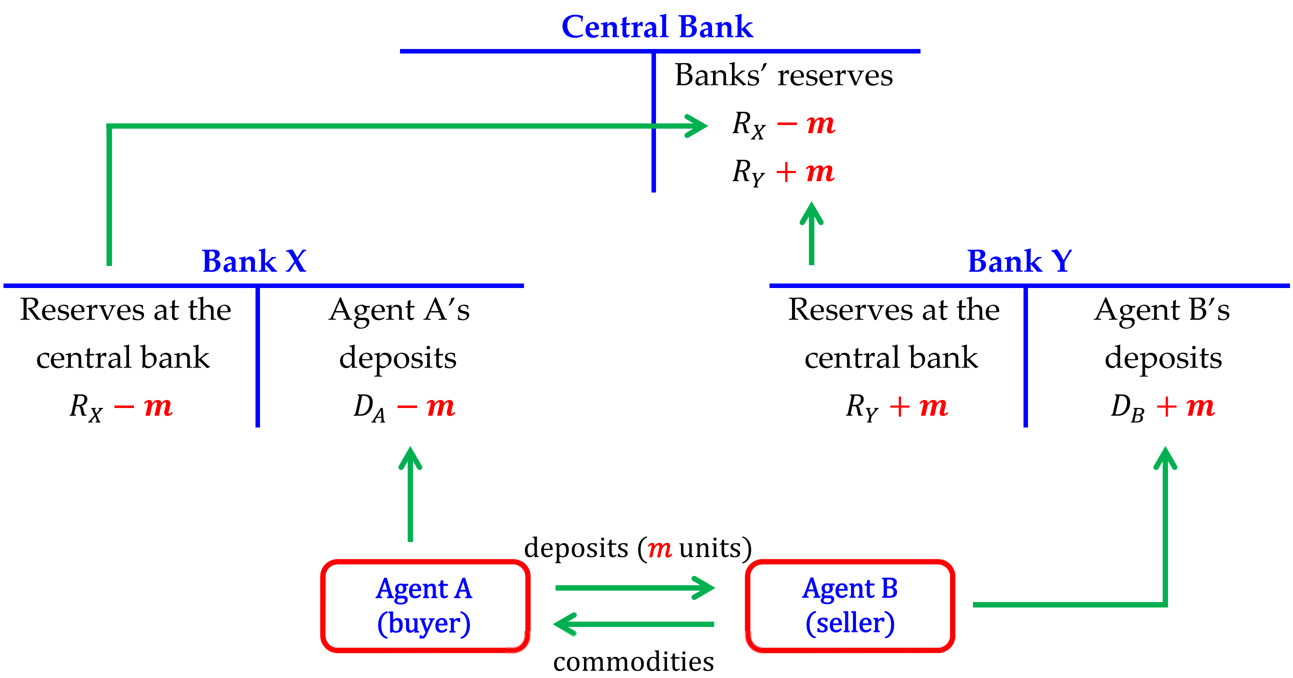
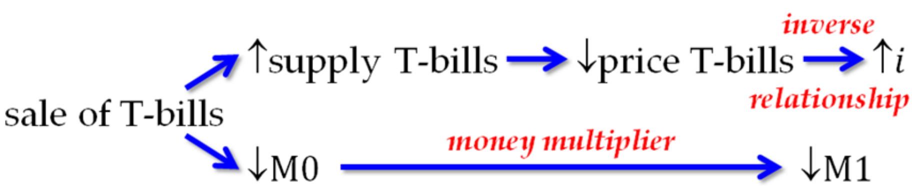


Fig. 4. The central bank and the economy's payment system
(for more on the payment system, see Sergio Rossi (2007): *Money and payments in theory and practice*)

14. The CB dilemma: *i* and M1 cannot be simultaneously controlled

Suppose the CB wants to reduce the money supply by selling T-bills. To encourage banks to buy T-bills, the CB must lower appropriately the current price of T-bills: otherwise, banks may not be willing to buy T-bills. But a reduction in the price of the T-bill raises its rate of return, so the average interest rate of the economy rises. In sum, <u>↓ **M1** implies ↑*i*</u>. Conversely, if the CB wants to increase the money supply by buying T-bills, the demand for T-bills shifts to the right, causing a price rise. This leads to a fall in the rate of return of T-bills: <u>↑**M1** implies ↓*i*</u>.



The figure on the left illustrates the impossibility of using a policy tool (a contractionary OMO) to achieve two goals (reduce both *i* and **M1**). The attempt to control **M1** entails a loss of control over *i*. If the sale of T-bills aims at increasing *i*, the loss of control is over **M1** (in the sense that it cannot be reduced).