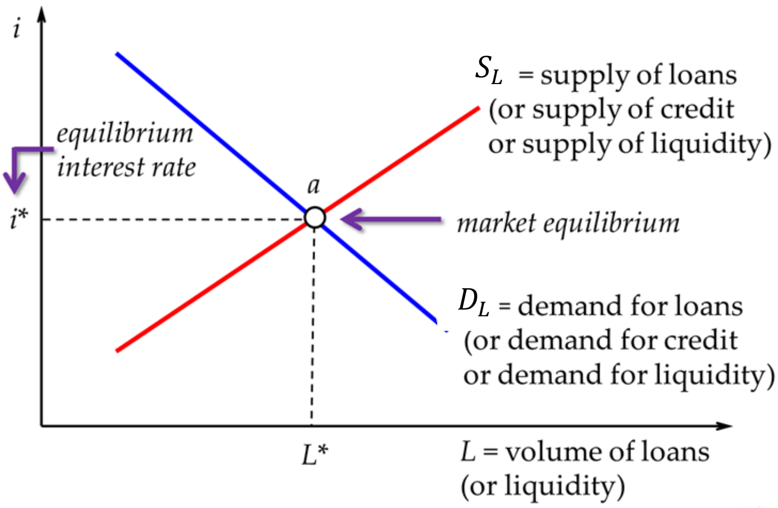
10. Models of interest rate determination

1. The orthodox liquidity market model

Definition 1.1. The orthodox liquidity (or loan or loanable funds) market model is as a competitive market model, represented in Fig. 1, that determines the nominal interest rate.



The orthodox liquidity market is supposed to be a competitive market whose equilibrium yields the nominal interest rate. A decreasing market demand function represents the demand for liquidity (for loans, for credit) in the economy. An increasing market supply function represents the supply of liquidity (loans, credit) in the economy.

Fig. 1. The orthodox liquidity market model

2. The supply of liquidity

Definition 2.1. The direct supply of liquidity is provided by banks (who supply consumers, firms, and other banks) and the central bank (who supplies banks).

Definition 2.2. The indirect supply of liquidity corresponds to purchases of (interest-bearing) financial assets.

Purchasing a financial asset supplies liquidity since the buyer of an asset gives money in exchange. Consequently, the seller of a financial asset is in practice obtaining a loan of money. The difference is that a bank's loan is not generally marketable, whereas interest-bearing assets can be resold (a lender can easily become a borrower).

Definition 2.3. The market supply of liquidity function relates the total volume of liquidity supplied to the nominal interest rate at which this volume is supplied; see function S_L in Fig. 1.

The supply of liquidity function represents the decisions by lenders (savers). The agents creating the supply of liquidity are banks, financial intermediaries, buyers of interest-bearing financial assets, and the central bank.

3. The demand for liquidity

Definition 3.1. The direct demand for liquidity corresponds to loan applications typically addressed to banks; for instance, the demand for loans for house purchase.

Definition 3.2. The indirect demand for liquidity is given by the sale or issuing of interest-bearing financial assets, like T-bills, government bonds, corporate bonds…

There is no substantial difference between the two components of liquidity demand: when a bank accepts a loan application, it is as if the applicant sold a financial asset to the bank (the loan).

Definition 3.3. The market demand for liquidity function establishes, for each value of the nominal interest rate, the total volume of liquidity demanded at that rate; see function D_L in Fig. 1.

The demand for liquidity function represents the decisions by borrowers (investors). The agents generating (net) demand for liquidity are consumers (consumer credits, loans for house purchase), firms (trade credit, issuance of corporate bonds), and the government (T-bills, bonds).

4. Liquidity market equilibrium

Definition 4.1. A liquidity market equilibrium is a pair (i^*, L^*) such that:

- when the interest rate is i^*, the total volume of liquidity demanded is L^*; and
- the interest rate at which suppliers are willing to supply exactly the amount L^* is i^*.

Every market equilibrium is graphically represented by a point (i, L) where the supply and demand functions intersect; see point a in Fig. 1.

5. Shifting the liquidity demand function

Remark 5.1. Rule of thumb for shifting the demand function. Any event that, for any given interest rate, stimulates the demand for liquidity (for loans, for credit) shifts the market demand for liquidity function to the right; any event that discourages demand, shifts its function to the left.

Fig. 2 shows the effect on the market of equilibrium of an expansion of the demand for liquidity: a demand shift to the right causes a rise in both the equilibrium interest rate and the volume of liquidity (as market equilibrium goes from a to b).

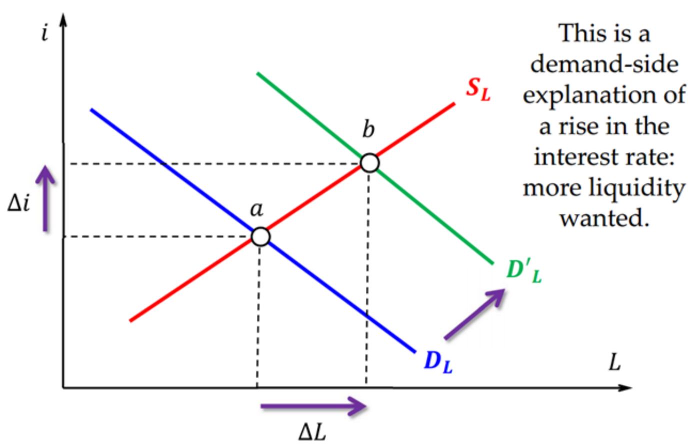


Fig. 2. Effects of a demand shift to the right

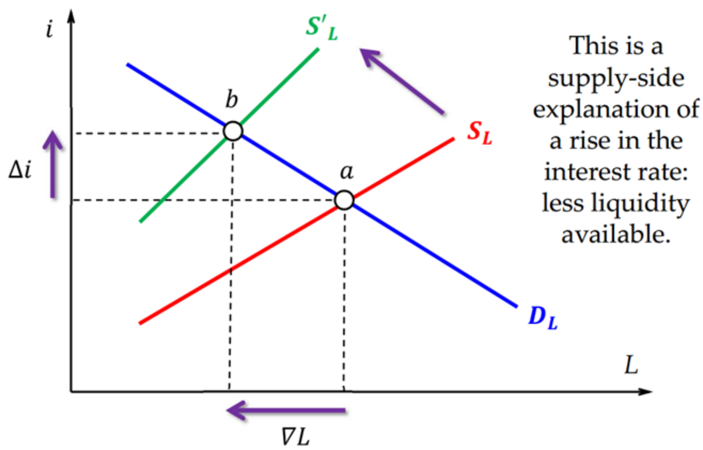


Fig. 3. Effects of a supply shift to the left

Events that pressumably shifts the demand function to the right: having more consumers, more firms, a higher budget deficit, the expectation of a higher inflation rate, an improvement in indices of business or consumer confidence, an increase in wealth or profits (may be), an increase in the foreign demand for domestic loans… The opposite changes will tend to shift the demand function to the left.

6. Shifting the liquidity supply function

Remark 6.1. Rule of thumb for shifting the supply function. Any event that, for any given interest rate, stimulates the supply of liquidity shifts the market supply function of liquidity to the right; any event that discourges supply, shifts its function to the left.

Fig. 3 shows the effect on the market of equilibrium of a contraction of the supply of liquidity: a supply shift to the left causes a rise in the equilibrium interest rate and a decline in the volume of liquidity (as market equilibrium goes from a to b).

Events that pressumably shift the supply function to the right: having more banks, the expectation of a higher inflation rate, an increase in the consumers' or the firms' saving rate, expansionary open market operations by the central bank, lifting credit controls imposed on banks, fiscal advantages granted for purchasing financial assets… The opposite changes will tend to shift the supply function to the left.

7. Simultaneous shifts of supply and demand functions

Fig. 4 analyzes the effect on market equilibrium of a simultaneous shift of both functions to the left. To establish the result of such changes it is convenient to investigate each shift separately and next combine the effects.

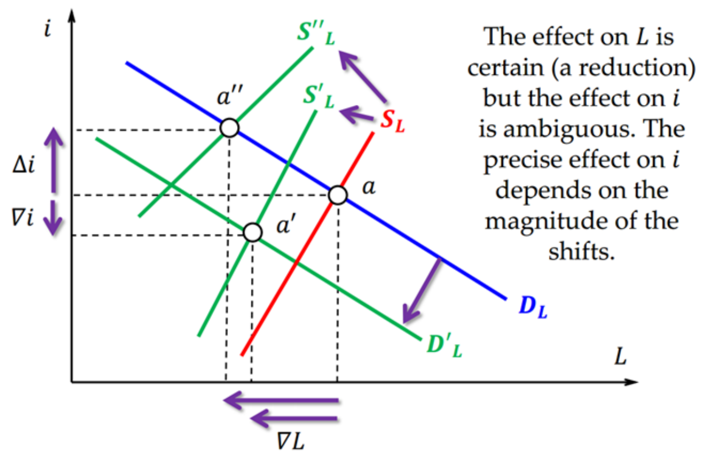


Fig. 4. Effects of a demand and supply shifts to the left

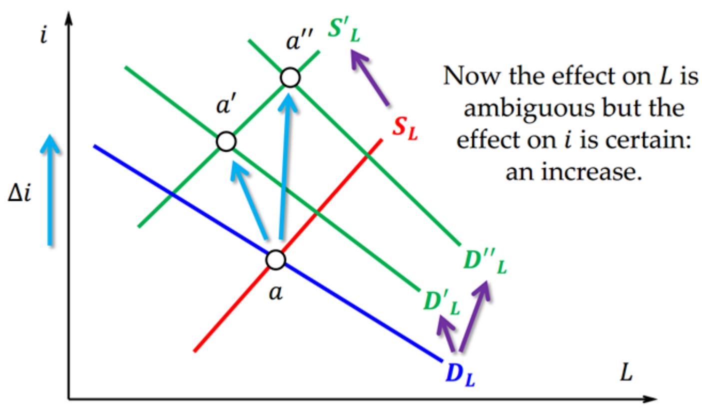


Fig. 5. Supply to the left, demand to the right

If, on Fig. 4, only the change in demand took place, in equilibrium, both liquidity and interest rate would fall. If only the supply change occurred, then, in equilibrium, liquidity would fall but the interest rate would shoot up. Therefore, when both changes happen, it follows that liquidity decreases but the effect on the interest rate cannot be determined: the demand shift pressures down, whereas the supply shift pressures up. Without knowing which effect dominates, the net impact on the interest rate remains uncertain. Fig. 4 shows two possibilities: if the supply function shifts from S_L to $S_L{}'$, the demand impact dominates and the interest rate falls (equilibrium going from a to a'); if the supply function shifts from S_L to $S_L{}''$, the supply impact dominates and the interest rate goes up (equilibrium going from a to a'').

Fig. 5 considers the case of a demand surge and a supply contraction. Each event separately causes a rise in the equilibrium interest rate; thus, when combined, they produce an interest rate increase. On the other hand, the demand surge increases equilibrium liquidity, whereas the supply crunch causes a liquidity contraction. The net effect is uncertain: equilibrium liquidity could go up (when market equilibrium moves from a to a'') or down (from a to a').

8. The real interest rate

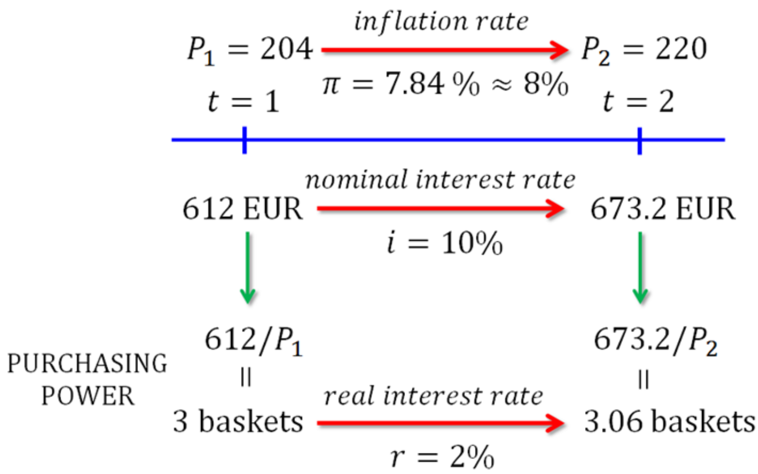
Definition 8.1 (informal). The <u>real interest rate</u> r of an economy represents the purchasing power of the economy's nominal interest rate i: it is the nominal rate i expressed in terms of goods.

That the nominal interest rate between period t and period $t+1$ is i means that, by lending 1 currency unit in t, one gets $1+i$ currency units in $t+1$.

That the real interest rate between period t and period $t+1$ is r means that, by lending 1 unit of goods int t, one gets $1+r$ units of goods in $t+1$. Therefore, r expresses purchasing power: the amount of goods obtained from each unit of good lent.

Example 8.2. Let "goods" be represented by the CPI basket. There are two periods, $t=1$ and $t=2$. The nominal interest rate between $t=1$ and $t=2$ is $i=10\%$. The cost of the CPI basket in $t=1$ is $P_1=204$ EUR. The cost of the CPI basket in $t=2$ is $P_2=220$ EUR; see the sketch on the right. With this information, the CPI inflation rate is

$$\pi = \frac{P_2 - P_1}{P_1} = \frac{220-204}{204} = 7.84\%.$$



Now suppose 612 EUR are lent in $t=1$. Then $612 \cdot (1+i) = 612 \cdot (1+0.10) = 673.2$ EUR are obtained in $t=2$. In $t=1$, the purchasing power of 612 EUR is $612/P_1 = 612/204 = 3$ baskets. In $t = 2$, the purchasing power of 673.2 EUR is $673.2/P_2 = 673.2/220 = 3.06$ baskets. <u>The real interest rate r measures the change in purchasing power of the money lent</u>. Specifically, r transforms 3 baskets into 3.06 baskets. Thus, r satisfies $3 \cdot (1+r) = 3.06$, so $r = 0.02$ (2%).

9. The Fisher equation

Definition 9.1. The Fisher equation (1), which is an approximation of the relationship between i and r, holds that the real interest rate is the nominal interest rate minus the inflation rate.

$$r = i - \pi \tag{1}$$

Definition 9.2. The real interest rate r of an economy is defined by equation (1).

Example 9.3. In Example 8.2, $i = 10\%$ and $\pi = 7.84\%$ (as P jumps from 204 to 220). According to the Fisher equation, $r = i - \pi \approx 10 - 7.84 = 2.16\%$, which is close to the correct value of 2%.

Irving Fisher argued in 1907 that the nominal interest rate eventually, in the long run, captures the inflation rate. In this view, $i = r + \pi$: a lender expecting to earn a real interest rate r and expecting an inflation rate π will at least charge a nominal interest rate $i = r + \pi$. In some circumstances, the lender may also add a risk premium ρ to compensate the lender for taking an excessive default risk by lending a not fully creditworthy borrower. This suggests that nominal interest rates could be decomposed into at least three components, as shown in (2).

$$i = r + \pi + \rho \tag{2}$$

10. Negative real interest rates and negative nominal interest rates

Negative real interest rates may arise in practice: it suffices to have $\pi > i$. In Example 8.2, if the price level went up to, say, 269.28 instead of 220, then 673.2 EUR could only buy 2.5 baskets. Hence, after the loan is repaid one can purchase fewer baskets than the initial 3 baskets. In this case, $r = i - \pi = 10\% - 32\% = -22\%$ (from 3 to 2.5 baskets the actual loss is 16.6%). Although negative nominal interest rate might at first appear impossible, investors may be willing to accept a negative i to shelter their money. In March 2017, Spanish 12 month T-bills had negative rates of return: −0,302%. A negative nominal interest rate might also be observed if deflation is expected.

Example 10.1. Let the nominal interest rate be 1% and the inflation rate 0.25%. The real interest rate (computed using the Fisher equation) is 0.75%. Imagine that the inflation rate is expected to be −1%. In this case, a negative nominal interest rate equal to −0.25% is still capable of ensuring a real interest rate of 0.75%. The lesson of this example is that the relevant variable for lenders is the real not the nominal interest rate: the nominal interest rate is instrumental, not an end it itself.

11. The Fisher effect

Definition 11.1. The Fisher hypothesis states that the real interest rate is approximately constant.

Definition 11.2. The Fisher effect (an implication of the Fisher hypothesis) asserts that there is a one-to-one relationship between i and π: every additional point of the inflation rate becomes an additional point of the nominal interest rate.

The Fisher effect appears to be consistent with the empirical evidence: economies with high inflation rates tend to be economies with high nominal interest rates; see Fig. 6.

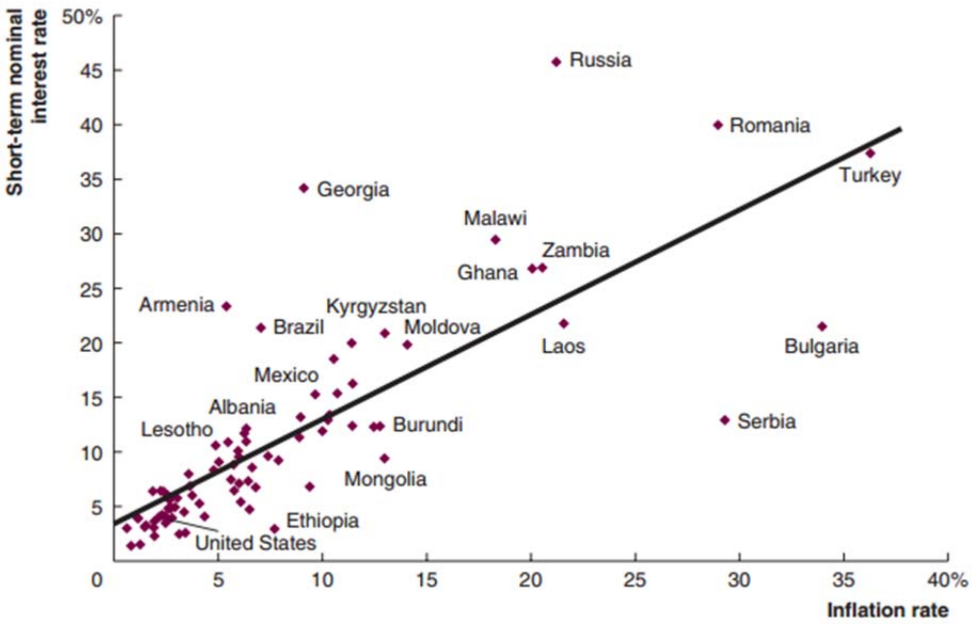


Fig. 6. Evidence for the Fisher effect, RG Hubbard, AP O'Brien, M Rafferty (2012): *Macroeconomics*, p. 204

According to (2), it is natural to expect that, when the inflation rate rises, lenders will demand a higher nominal interest rate to get back the purchasing power lost due to the price increase. Example 11.3 illustrates numerically this presumption.

Example 11.3. Let $P_0 = 100$, $P_1 = 110$, and $P_2 = 132$, so $\pi_1 = 10\%$ and $\pi_2 = 20\%$. Suppose $r_1 = 5\%$: from period $t = 0$ to $t = 1$ lenders get a 5% increase in purchasing power. This means that for each equivalent to 1 basket lent in $t = 0$, the equivalent of 1.05 baskets are received in $t = 1$. That is, if 100 EUR are lent in $t = 0$, 115.5 EUR will be received in $t = 1$. Using the Fisher equation, the i_1 ensuring that $r_1 = 5\%$ when $\pi_1 = 10\%$ is $i_1 = r_1 + \pi_1 = 15\%$.

Assume the Fisher hypothesis, so $r_2 = r_1 = 5\%$. If i_2 remained at 15%, by lending €110 (the basket value in $t = 1$), the amount received in $t = 2$ would be $110 \cdot (1 + i_2) = 110 \cdot 1 + 0.15 = 126.5$. As $P_2 = 132$, the purchasing power of €126.5 is 0.958 baskets: there is a loss of purchasing power. By the Fisher equation, the i_2 needed to preserve the purchasing power of a money loan is $i_2 = r_2 + \pi_2 = 5\% + 20\% = 25\%$: from $t = 1$ to $t = 2$, π goes up 10 points and i also goes up 10 points.

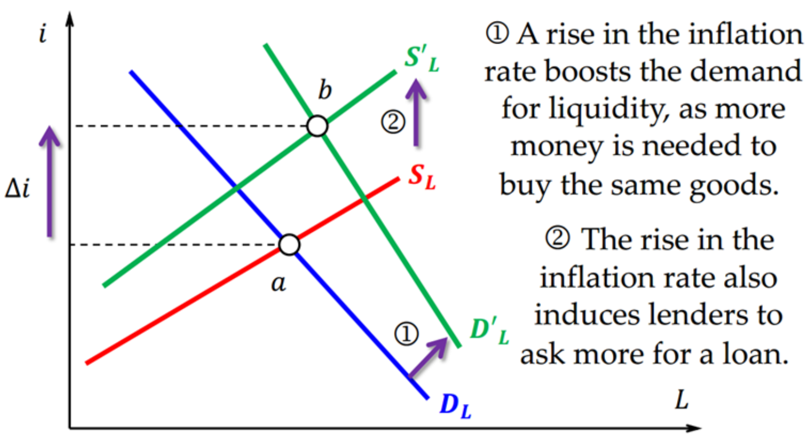


Fig. 7. The Fisher effect in the liquidity market model

Fig. 7 shows how to obtain the Fisher effect in the liquidity market model. On the one hand, to be able to afford their consumption plans, borrowers will likely demand more liquidity (this reaction is uncertain). On the other hand, a rise in the inflation rate encourages lenders to charge a higher nominal interest rate for supplying liquidity.