Chapter 3

Conventional Monetary Policy

This chapter introduces conventional monetary policy, i.e. monetary policy during periods of economic and financial stability and when short-term interest rates are not constrained by the zero lower bound. We introduce the concept of an operational target of monetary policy and explain why central banks normally give this role to the short-term interbank rate. We briefly touch macroeconomics by outlining how central banks should set interest rates across time to achieve their ultimate target, e.g. price stability, and we acknowledge the complications in doing so. We then zoom further into monetary policy operations and central bank balance sheets by developing the concepts of autonomous factor, monetary policy instruments, and liquidity-absorbing and liquidity providing balance sheet items. Subsequently we explain how these quantities relate to short-term interest rates, and how the central bank can rely on this relation to steer its operational target, and thereby the starting point of monetary policy transmission. Finally, we explain the importance of the collateral framework and related risk control measures (e.g. haircuts) for the liquidity of banks and for the conduct of central bank credit operations.

3.1 Short-Term Interest Rates as the Operational Target of Monetary Policy

3.1.1 *The Targets of Monetary Policy*

The **operational target** of monetary policy is an economic variable, which the central bank wants, and indeed can control on a day-by-day basis using its monetary policy instruments. It is the variable for which (i) the policy decision making committee sets the target level in each of its meetings; which (ii) gives guidance to the staff of the

central bank what really to do on a day-by-day basis, and (iii) serves to communicate the stance of monetary policy to the public.

There are essentially three main types of operational targets: (i) a **short-term interest rate**, which is today and was until 1914 the dominant approach; (ii) a **foreign exchange rate**, for central banks which peg their own currency strictly to a foreign one, usually a small or developing economy; and (iii) a **quantitative, reserve related concept**, which was in different variants the official operational target of the Federal Reserve of the United States in the period 1920–1983. However, how it was meant to be applied is not completely clear (for a deeper discussion of this topic, see Bindseil [2004]).

The **ultimate target** of monetary policy is the objective that the central bank wants to achieve in the medium or in the long run. It is the precise quantitative specification of the objectives established by the mandate of the bank. Currently there are two predominant ultimate targets:

- **Inflation rate:** usually defined as an annual increase of the consumer price index. It is the most common target for advanced economies and is used also in some emerging economies. In some cases, it is the ultimate target together with other objectives. For example, in the case of the Fed, the objectives spelled out in Section 2A of the Federal Reserve Act are “maximum employment, stable prices, and moderate long-term interest rates”;
- **Foreign exchange rate:** in case of a currency peg, the ultimate target is the exchange rate, and all other variables, and the operational and ultimate target collapse into one.

Other ultimate targets, which have been applied in the past, or which are currently being discussed, include:

- **Monetary aggregates:** Friedman (1982) proposed to make a narrow monetary quantity the ultimate target of the central bank. A somewhat less radical variant was defined by the Deutsche Bundesbank with monetary growth as an intermediate target to pursue price stability (Deutsche Bundesbank 1995).
- **Nominal GDP targeting.** At least since Clark (1994), nominal GDP targets have been considered as an alternative monetary policy strategy to inflation targeting. Recently, Williams (2016) has advocated nominal GDP targets as they would have a number of advantages in a world with lower growth and lower natural interest rates.
- **Price-level targeting** has similarities to inflation targeting, but would compensate past deviations of actual inflation from the target with subsequent opposite deviations. Such an approach would reduce long-run uncertainty regarding the price level. For a survey, see Ambler (2009). Arguably the Fed adopted elements of price-level targeting in its recent decision of pursuing an *average* inflation rate of 2% by allowing an inflation rate moderately above 2% after periods in which inflation has been below 2% (Fed 2020d).

A central bank may have a **single or dual mandate**: for example, the ECB has the primary objective of price stability and other economic objectives are subordinate to that imperative (EU 2007), while the US Fed has, according to the Federal Reserve Act as amended in 1977, the statutory objectives for monetary policy of maximum employment, stable prices, and moderate long-term interest rates (although these seem to be three objectives, reference is made to a “dual” mandate).

The ultimate target must be precisely defined: for example, the ECB decided that “Price stability is defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%.” and operationalised the target by aiming at an increase of the HICP of “close to but below 2%” with a medium-term orientation. Some, like Ball (2014), have suggested that it would be better to set the inflation target to 4%, at least in the possible new world of secular stagnation in which the zero-lower bound can easily constrain monetary policy (as further explained in the next section).

3.1.2 *The Basic Natural Rate Logic of Monetary Policy*

Thornton (1802b, 254) may have been the first to view central bank policy as a “bank rate” (Bank of England discount facility rate) policy, and analyses how bank rate policy should be conducted. Accordingly, short term nominal interest rates would need to follow the real rate of return of capital to control the expansion of money and hence achieve price stability.

Thornton also insists that the bank rate is always a sufficient tool to prevent over-issuance of money and hence inflation (except when usury laws constrain the central bank in this respect). Thornton’s concept of a “rate of mercantile profit” is similar to the **“natural rate” of interest described in 1898 by Wicksell** (1898, 1936, 102) as follows:

There is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them. This is necessarily the same as the rate of interest which would be determined by supply and demand if no use were made of money and all lending were effected in the form of real capital goods. It comes to much the same thing to describe it as the current value of the natural rate of interest on capital.

Figure 3.1 provides an arbitrage diagram (Richter, 1989) with two goods (wheat and money) at two points in time (today and tomorrow) to illustrate the natural rate idea.

By moving within the diagram from one good to another via different paths, arbitrage logic establishes some relationships between prices which are the starting point of the natural rate theory. Buying a unit of wheat for an amount p_1 today, and selling its real returns tomorrow, yields a revenue of $(1 + r)p_2$, while keeping the p_1 in money until tomorrow yields $(1 + i)p_1$. These two returns must be equal:

$$p_1(1 + i) = (1 + r)p_2$$

Fig. 3.1 Arbitrage diagram with real and nominal rates

Dividing both sides by p_1 , and writing $p_2/p_1 = (1 + \pi)$, with π being the inflation rate, one obtains the Fisher equation:

$$(1 + i) = (1 + r) \cdot (1 + \pi)$$

The equation states that return on money must be equal to the return on real assets multiplied by the growth factor of asset prices. The latter equation is for small values of r and π approximately equivalent to $i = r + \pi$, i.e. in equilibrium the nominal interest rate should be the sum of the real rate and the inflation rate.

Above, **the real rate of interest is simply a relative price between “wheat tomorrow” and “wheat today”**. Its equilibrium value should depend on the preference of consumers and on the intertemporal production function. People normally prefer consumption today to consumption tomorrow, and the intertemporal production function normally produces positive returns, implying together that real interest rates are normally positive. However, in recent years, as well as in some other periods in history, negative real rates seem to have been observed (see the next sub-section).

Moreover, the simple arbitrage logic assumed that the inflation and the real rate of return were perfectly known, which is not the case. Starting from an initial state in which actual and expected inflation corresponds to the central bank’s target and stable inflation expectations, $E(\pi_{t+1}) = \pi_t = \pi^*$, the central bank could preserve this state if it manages to keep the money (nominal) interest rate, i_t , always equal to the expected real rate of return on capital $E(r_t)$ plus the inflation target π^* . Wicksell’s above quoted statement on the natural rate of interest assumes as starting point zero inflation expectations, so that the **natural interest rate** equals the expected real rate of return on capital goods, $E(r_t)$. If however inflation expectations are positive, then the relevant concept is the **“non-accelerating interest rate”**, which is the rate that is neutral not to the price level, but to the rate of change of the price level, and this rate is equal to $E(r_t) + E(\pi_t)$:

$$i_t = E(r_t) + E(\pi_t)$$

The expected real rate of return on capital goods, $E(r_t)$, will vary over time, as its underlying factors varies. Therefore, the central bank also has to adjust the nominal interest rate across time to achieve stability of the inflation rate at its target level over time.

The nominal interest rate i_t is contractually fixed at the point in time t and is the nominal interest rate on money covering the period $[t, t + 1]$. The real rate r_t covering $[t, t + 1]$ is not yet fixed at t , nor is $\pi_t = (p_{t+1} - p_t)/p_t$. The general idea of the dynamics triggered by a perceived arbitrage opportunity is as follows (with i_t^* we mark the neutral rate):

- $i_t > i_t^* = E(r_t) + E(\pi_t) \rightarrow$ it is profitable to sell real goods and hold more money investments $\Rightarrow$ excess supply of real goods today $\rightarrow$ disinflationary impulse $\rightarrow$ actual inflation will fall below expected inflation: $\pi_t < E(\pi_t)$
- $i_t < i_t^* = E(r_t) + E(\pi_t) \rightarrow$ it is profitable to buy more real goods for real investment projects, hold less money investments (or be short in money, i.e. borrow money), $\rightarrow$ excess demand for goods today $\rightarrow$ inflationary impulse $\rightarrow$ actual inflation will turn out to be above expected inflation: $\pi_t > E(\pi_t)$.

It is not obvious how this dynamic process can be fully specified in a two-point-in-time arbitrage diagram.¹ Modern macroeconomic monetary theory aims at capturing such dynamics.

The **central bank can choose its inflation rate target**. For example, central banks often concluded that $\pi^* = 2\%$ is the optimal inflation rate (on models of the optimal rate of steady state inflation, see e.g. Schmidt-Grohe and Uribe [2010], who support low inflation targets, such as 2%).

3.1.2.1 Zero Lower Bound

An important limitation to the above-stated logic is **the zero lower bound to nominal interest rates implied by the existence of banknotes with zero remuneration**. If the interest rates on deposits were to be negative, economic agents could convert their deposit in banknotes, to avoid the loss caused by the negative interest rates. Due to the cost connected to the storage of banknotes, slightly negative interest rates can actually be applied by central banks. For this reason, some refer to an “effective lower bound”, whereby central bank practice so far suggests that this effective lower bound could be of the order of -1% .

Assuming that the zero-lower bound would be strictly at 0% , the choice of the inflation target π^* must respect the constraint that $r_t + \pi^* > 0$. Since the real rate of return on capital r_t can be negative, for instance if the economy shrinks and the population is aging, a positive target inflation rate can be necessary to “lift” the non-accelerating rate of interest into positive territory.

¹It is interesting to note that a similar issue arises in foreign exchange interest rate parity arbitrage. The main difference is that the exchange rate is a price that reacts immediately (as it is set in the most liquid financial market), while the price level in an economy reacts sluggishly to news.

The key problem associated with the zero lower bound to nominal interest rates is that it could make the central bank incapable of preventing a so-called “**deflationary trap**”. Indeed, if the non-accelerating interest rate i_t^* were negative ($i_t^* = E(r_t) + E(\pi_t) < 0$), but the central bank cannot set the nominal interest rate (i_t) sufficiently below zero, then monetary policy will be dis-inflationary. That means that—at least according to the simple arbitrage logic—inflation and inflation expectations will fall further, making zero interest rate policies even more dis-inflationary, etc. This is why some authors (e.g. Ball 2014) have concluded that in a world of low growth dynamics and low real rates of return, it is preferable to choose a higher inflation target (e.g. 4%) as a buffer against negative shocks that could push the economy into the deflationary trap.

3.1.3 *Complicating the Basic Natural Rate Logic*

The equilibrium relationship above reflects a number of simplifications. In the real world, at least the following five issues complicate the basic natural rate logic.

3.1.3.1 Different Concepts of the Real Rate

The price system will most of the time be **outside steady state equilibrium**. Prices and real rates of return on capital are constantly hit by exogenous shocks. This implies that one needs to differentiate between the expected (ex-ante) and the actual (ex-post) real rate of return on capital, $E(r_t)$ and r_t . For instance, the actual rate of return on wheat is affected by the unpredictable weather conditions over the next 12 months. Moreover, when non-anticipated price pressures (relative to expected prices) occur, adjustment of prices are typically sticky and react only gradually. Amongst other things, this implies that the **real rate of return on capital** will be distinct from the ex post **real rate of return on money investments**. Indeed, the fact that ex-ante $i_t = E(r_t) + E(\pi_t)$ does not imply that ex-post $i_t = r_t + \pi_t$. The real rate of return on money investments is equal to (ex-post) $i_t - \pi_t$. The real rate of return on capital is (ex-post) r_t . There is a third concept that needs to be distinguished, which is the **ex-ante real rate of return on money investments**, which is $i_t - E(\pi_t)$. This is the most frequently used concept when the term “real interest rates” is used in the media and academic papers. In an ex-ante arbitrage steady state equilibrium, this should be equal to $E(r_t)$. However, in reality, ex-ante adjustments to reach an arbitrage equilibrium may be imperfect and slow (e.g. the “time to build” argument), so that it is necessary to distinguish between the expected real rate of return on capital ($E(r_t)$) and the expected real rate of return on money investments ($i_t - E(\pi_t)$). **Table 3.1** summarises the four concepts of real rates that eventually need to be distinguished, as they will, for the reasons mentioned above, not be identical. Note the assumption that the nominal interest rate on money is identical ex-post and ex-ante. This holds as long as debtors do not default.

Table 3.1 Four concepts of the real rate of interest

	<i>Ex-ante</i>	<i>Ex-post</i>
<i>Real capital investment</i>	$E(r_t)$	r_t
<i>Money investment</i>	$i_t - E(\pi_t)$	$i_t - \pi_t$

3.1.3.2 More Than One Real Good

In reality there is not only one real good (“wheat”) which is at the same time a consumption and an investment good, but there is a **wide range of goods** with very different properties. Investment goods are supposed to determine the real rate of return on capital, while consumer goods determine inflation. Consumer and investment good prices are eventually linked, but such links are imperfect and lagged.

3.1.3.3 Funding Costs of the Economy Versus Short-Term Risk-Free Rates

Nominal funding costs of the real economy are not identical to the short-term nominal interest rate that the central bank sets. **Nominal funding costs of the real economy** can be estimated by producing a weighted average of funding rates, the weights reflecting the share of that type of funding in the total funding of the real economy. For example, for the euro area, **Table 2.4** of the statistical annex of each ECB Economic Bulletin contains a detailed split up of lending rates for new and outstanding loans to various obligor classes (household consumer credit, household mortgage loans, loans to non-financial corporates, etc.) with volumes known from the Monetary Financial Institutions (MFI) statistics. Corporate and sovereign bond yields can be collected from information systems such as Reuters and Bloomberg. The weighted average nominal lending rate of the economy can be thought to reflect three main factors: (i) the quasi-risk-free short-term interbank interest rate which is normally controlled precisely by the central bank; (ii) The term spread in the risk-free benchmark yield curve; (iii) The various instrument-specific credit risk and liquidity premia. Credit risk premia result from investors requiring an additional return on credit risky assets, to be compensated against possible losses in case of debtor default. Liquidity premia result from investors requiring an additional return on assets which cannot be easily liquidated, compared to those assets which are highly liquid. Indeed, many investors may have to unexpectedly liquidate their assets under some scenarios, and in that case holding an illiquid asset will lead to losses, in particular if large amounts need to be sold quickly. In the presence of such premia, the challenge for the central bank is then no longer limited to the estimation of the expected real rate of return on capital goods only (such as to shift the nominal short-term interest rate across time in parallel to this), but in addition to adjust across time for the varying spread between the weighted average funding costs of the real economy and risk free short-term rates. Moreover, if the real rate of return on capital is low (as is likely the case in a

crisis), and in addition credit and liquidity spreads are high, then it is likely that the central bank will reach the zero lower bound before being able to make monetary policy expansionary. To express this generalisation formally, define:

- τ as the **term spread** summarising the slope of the risk-free yield curve, i.e. the difference between the risk-free rate at the average duration of real economic projects (say five years) and the short end of the risk-free yield curve.
- λ as the spread between the weighted funding costs of the real economy and the risk-free yield with the same duration, i.e. capturing **credit and liquidity premia**.

What does τ and λ imply for the setting of short-term nominal interest rates by the central bank? Does the central bank have to set $i_t^* = E(r_t) + E(\pi_t) - \tau_t - \lambda_t$? If in a liquidity crisis, λ shoots up significantly, this would indeed have to be compensated by a corresponding lowering of the short-term interest rate i_t to ensure that monetary conditions remain unchanged. In economic and financial crises, the increase of liquidity and credit spreads may also add to the potential ZLB problem. However, central banks can also influence spreads through non-conventional measures, namely forthcoming LOLR policies (to moderate credit/liquidity spreads) and long-term bond purchases (to moderate the term spread).

3.1.3.4 Quantity Constraints in Credit Markets

It has to be kept in mind that the actual availability of credit to the real economy cannot necessarily be measured by contemplating interest rates alone (e.g. Stiglitz and Weiss 1981). Funding markets for some indebted companies can break down completely due to an increase of uncertainty and information asymmetries (see also Chapters 6 and 7). The role of quantitative funding constraints has been recognised as a relevant element of monetary conditions by central banks, and therefore central banks have started to systematically collect survey data to be able to monitor this element of the transmission mechanism. For example, the ECB collects on a quarterly basis qualitative and quantitative bank lending data (see the “Euro area bank lending survey”, ECB 2020a) and data on the access of SMEs to funding (“Survey on the access to finance of small and medium-sized enterprises in the euro area” [ECB 2020d]).

3.1.3.5 Empirical Estimation Issues

The expectations theory of the term structure of interest rates (longer term rates as a geometric mean of expected short term rates) does not explain comprehensively movements of long-term yields. Term premia vary over time, and decomposing long-term rate changes into expectations on short-term rates and varying term premia is challenging (see e.g. Abrahams et al. 2016). The variability of term premia for nominal interest rates can be of a similar order of magnitude as variations in expected future nominal short-term interest rates. The same holds for the inflation component

of nominal rates (i.e. its split up into expected inflation and inflation term premia, or inflation risk premia) and for its real rate component (split up into expected real rates and real rate term premia). Term premia may be regarded as a residual item also capturing, beyond the term risk premium, other effects not captured by the measurement of expected short term rates.

Laubach and Williams (2016) review different approaches for estimating real interest rates:

- The simplest way would be to calculate past average values of ex-post real rates (average nominal short term interest rates minus average inflation rates).
- More sophisticated statistical approaches use time-series filtering techniques that try to separate longer-term trends from short-term variations.
- Yields on inflation linked bonds can be used to extract future expected real rates. However, forward rates include a term premium that contaminates the measurement of the market perception of the natural short-term interest rate.
- The Laubach–Williams (2003) model uses a multivariate model that explicitly takes into account movements in inflation, output, and interest rates. The natural rate of interest is implicitly defined by the absence of inflationary or deflationary pressures.

Recent estimates of the natural rate using the Laubach–Williams (2003) model suggest that the natural rate fell from a 1980-level of around 3.5% in the US and 2.8% in the euro area to levels below 1% and to below 0%, in 2015, respectively.

3.1.3.6 Conclusion

The five issues above are the reason why the theory of optimal short-term central bank interest rate setting is complex, diverse and inconclusive, and also why central banks have large departments devoted to monetary policy analysis. Modern New Keynesian economics relies, as a starting point, on Wicksellian ideas, and tries to capture short term dynamics (e.g. Woodford 2003; Galí 2015). The New Keynesian approach has received important qualifications and has also been challenged from various perspectives (e.g. Cochrane 2011).

3.1.3.7 Two Extreme Examples from German History in Which Arbitrage Logic was Ignored

In retrospect, one can identify episodes in which the central bank was obviously way off a reasonable interest rate policy, and thereby triggered fatal dynamics of the purchasing power of money. German monetary history of the twentieth century provides two outstanding illustrations.

Inflationary central bank interest rate policies are best illustrated by the application of the 5% discount rate by the Reichsbank from 1914 to 1922. Applying the arbitrage logic above, this discount rate was far too low as of 1915. Indeed, as shown

Table 3.2 Reichsbank discount rate and inflation in Germany, 1914–1923

	Reichsbank discount rates (%)	Consumer price Inflation (%)
1915	5	35
1916	5	33
1917	5	25
1918	5	38
1919	5	58
1920	5	113
1921	5	28
1922	5–10	1025
1923	10	>10 ⁹

Source Bundesbank 1976, 6

in **Table 3.2** inflation reached 35% already in 1915 (essentially due to the extreme public demand shock associated with war mobilisation) and remained at similar or higher levels until it exploded in 1922 and 1923. The approach “(i) borrow money; (ii) buy and hold real assets; (iii) sell real assets in the future” was therefore a consistent profit-making opportunity without interruption for eight years. Actual inflation rates were certainly limited by the price controls for basic goods during the war years and would otherwise have exploded even earlier.

Deflationary central bank interest rate policies are exemplified by the maintenance of high nominal interest rates in the deflationary context of Germany in 1930–1932, as shown in **Table 3.3**. There were various reasons why the Reichsbank kept discount rates so high despite deflation: defending the gold standard and convertibility of the Reichsmark as prescribed according to International Treaties like the Dawes Plan and the Young plan, despite capital flight and a debt overhang due to reparation debt. However, having explanations for these interest rate policies does not change the conclusion that they were highly deflationary, illustrating the Wicksellian cumulative process in the opposite direction than during the period 1914–1923.

Table 3.3 Reichsbank discount rate and inflation in Germany, 1929–1932

	Reichsbank discount rates (%)	Consumer price Inflation (%)
1929	6.5–7.5	0.0
1930	4–5	–5.5
1931	7–15	–9.3
1932	4–6	–10.4

Source Bundesbank 1976, 6

3.1.4 *Transmission Channels of Monetary Policy*

We do not aim to cover monetary macroeconomics in any depth here, but only touch upon it very briefly to provide the link to monetary policy implementation. The monetary macroeconomics literature distinguishes a number of so-called transmission channels of monetary policy, i.e. how changes of the operational target impact the financial system and the economy so as to eventually reach the ultimate target of monetary policy—say price stability.

The most basic transmission channel that central bankers tend to have in mind today is **the interest rate channel** based on the Wicksellian arbitrage logic explained above: If $i_t > E(r_t) + E(\pi_t) \Rightarrow \pi_t \downarrow$; If $i_t < E(r_t) + E(\pi_t) \Rightarrow \pi_t \uparrow$. The following further transmission channels are often mentioned in the literature, whereby the first three channels are closely linked to Wicksell's arbitrage logic.

- **Exchange rate channel:** $i_t \downarrow \Rightarrow$ capital outflows $\Rightarrow$ value of the currency $\downarrow \Rightarrow$ Exports $\uparrow$, Imports $\downarrow$, $\Rightarrow$ Aggregate demand $\uparrow \Rightarrow \pi_t \uparrow$
- **Equity/housing price channel (Tobin's Q):** $i_t \downarrow \Rightarrow$ Value of discounted cash flows from asset $\uparrow$, Asset prices $\uparrow$ and therefore above replacement costs $\Rightarrow$ Investment $\uparrow \Rightarrow$ Aggregate demand $\uparrow \Rightarrow \pi_t \uparrow$
- **Wealth channel:** $i_t \downarrow \Rightarrow$ Value of discounted cash flows from asset $\uparrow$, Asset prices $\uparrow \Rightarrow$ Wealth $\uparrow \Rightarrow$ Consumption $\uparrow \Rightarrow$ Aggregate demand $\uparrow \Rightarrow \pi_t \uparrow$
- **Balance sheet channel:** $i_t \downarrow \Rightarrow$ Asset prices $\uparrow \Rightarrow$ Equity of banks, firms and households $\uparrow \Rightarrow$ balance sheet constraints to expand activity $\downarrow \Rightarrow$ balance sheet expansion $\Rightarrow$ Asset prices $\uparrow$ and aggregate demand $\uparrow \Rightarrow \pi_t \uparrow$.

A more detailed overview of the transmission channels, with extensive literature, can be found e.g. in Boivin et al. (2010). The theory and empirical assessment of transmission channels is the key issue of monetary macroeconomics. Deciding on interest rate changes relies on predictions of transmission, so as to achieve to the best possible extent the ultimate target across time. Non-conventional monetary policies will partially rely on the same transmission channels, but partially also on additional ones.

3.2 **Composition of the Central Bank Balance Sheet**

The central bank balance sheets shown so far have been simplifications with regards to two important aspects that now need to be differentiated further.

Table 3.4 Several autonomous liquidity factors in the accounts of the bank and central bank

Bank			
Lending to corporates	$D + B - INV$	Deposits	$D - D_{St} + FR$
		Credit CB	$B + D_{St} - INV - FR$
Central Bank			
Investment portfolio	INV	Banknotes	B
Foreign reserves	FR	Deposits Govt	D_{St}
Credit to banks	$B + D_{St} - INV - FR$		

3.2.1 Autonomous Factors

Autonomous factors are those factors affecting the central bank balance sheet and the amount of deposits of banks with the central bank which are **not monetary policy operations**. They are not under direct control of the monetary policy implementation function, although they have a potential impact on liquidity conditions, and on short-term market interest rates. In the central bank balance sheets presented so far, banknotes were the only autonomous factor, but in fact there are other autonomous factors, which can all be integrated into the financial account model: (i) Governments often deposit their cash with the central bank, implying that on tax collection days, government deposits with the central bank may increase steeply, while they decline on days the government pays out wages of its employees. (ii) The central bank may intervene in foreign exchange markets, or act as foreign exchange agent of the government, and thereby increases or decreases its foreign reserves holdings. (iii) The central bank may buy or sell financial assets for investment purposes. (iv) the IMF may have credit lines with the central bank and may occasionally draw on those.

As illustrated in the financial accounts in **Table 3.2**, the starting level and fluctuations of any of these four autonomous factors affect the necessary recourse of banks to central bank credit, which can matter both from a monetary policy perspective and from a bank funding/financial stability perspective (**Table 3.4**).

3.2.2 Monetary Policy Instruments

Monetary policy instruments are the tools used by the central bank to reach its operational target. Central banks mainly use three such tools: standing facilities, open market operations, and reserve requirements.

Standing facilities are **central bank financial transactions at the initiative of banks**, on the basis of a commitment of the central bank to enter such operations at certain conditions. Three variants have to be distinguished: An **overnight lending**

Table 3.5 Overnight lending facility's and deposit facility's name in selected central banks

	Overnight lending facility	Deposit facility
Bank of England	operational standing lending facility	operational standing deposit facility
Bank of Japan	complementary lending facility	complementary deposit facility
European Central Bank	marginal lending facility	deposit facility
Federal Reserve	Primary credit facility Secondary credit facility ^a	Term deposit facility

^aThe Fed's primary and secondary credit have been introduced in 2003 in an attempt to overcome stigmatisation of the discount window (the overnight lending facility of the Fed). Primary credit is restricted to a limited number of well-capitalised credit institutions (Armantier et al. 2015)

facility allows banks to borrow at any time against eligible collateral at the rate specified by the central bank, with overnight maturity. It sets the upper limit of the interbank rate, as no bank would borrow at a higher rate than the rate offered by the central bank. A **deposit facility allows banks to deposit** funds at any time with the central bank on a specific account where it gets remunerated at a specific rate. It sets the lower limit for the interbank rate, as no bank would lend at a lower rate than the one it can obtain by safely depositing its reserves at the central bank. In the past central banks offered a **discount facility**: banks could **sell** certain short-term securities to the central bank at any time, whereby the discount rate specified by the central bank was applied to calculate the price on the basis of the securities' cash-flows. It was the main tool of central bank liquidity provision in the nineteenth century, but is no longer in use today.

Table 3.5 provides the relevant names of these facilities across some major central banks.²

Open market operations are central bank financial transactions with banks at the central bank's initiative, whereby two subtypes can be distinguished: (i) Outright purchases or sales of assets (normally debt securities) from banks; (ii) Lending (or "credit", "reverse" or "temporary") operations with banks. Loans are provided through well-defined procedures: in a "fixed-rate tender", the central bank announces the interest rate and maturity at which it will provide credit, banks then express the intended quantity they wish to obtain, and finally the bank announced a full or partial allotment. In a "variable-rate tender", banks are allowed to submit bids at different interest rates and the central bank decides on a cut-off interest rate.

Reserve requirements oblige banks to hold in a certain period (per day, or on average over a two weeks or one-month period, for example) a certain minimum level of sight deposits on their account with the central bank. Fulfilment is measured only on the basis of end of day snapshots (i.e. intra-day levels of reserves are not relevant). The size of the reserve requirement of a specific bank is normally set as a percentage of specific liability items of its balance sheet which need to be reported on a monthly basis. In the case of the European Central Bank, the requirement for each bank amounts to 1% of its liabilities to non-banks with a maturity below two

²BoE 2020a; BoJ 2020b,2020a; ECB 2020c; Fed 2020c,2020a.

years. Even if reserve requirements are zero, there is still a sort of reserve requirement in the sense that banks need to hold at day end at least a zero balance on their deposit account with the central bank.

3.2.3 *Liquidity Providing and Liquidity Absorbing Items*

Both monetary policy operation and autonomous factors can each be further subdivided into liquidity providing and liquidity absorbing. If an asset item increases (be it a monetary policy item or an autonomous factor), then, everything else unchanged, the deposits of banks with the central bank (i.e. their “liquidity”) will increase, such as for example if the central bank purchases securities for monetary policy purposes, or if the central bank intervenes in foreign exchange markets to purchase a foreign currency. If a liability item increases, and all the other monetary policy items and autonomous factors are unchanged, then the deposits of banks with the central bank will decrease. This happens if for example the central bank collects fixed term deposits from banks, or if the circulation of banknotes goes up. Vice versa, if asset and liability items decline, the opposite effects on the level of bank deposits with the central bank will occur. In practical terms, the effect on deposits of banks with the central bank materialise because the banks are the counterparties of the central bank when the related financial operations are undertaken, and their accounts with the central bank are debited or credit as a consequence of the operations. Below, we will assume that the central bank offers an overnight lending facility and a deposit facility, but that it does not impose reserve requirements. When the control of short-term interest rates will be modelled, the differentiation between (i) outright open market operations; (ii) credit open market operations; and (iii) standing facilities will be necessary. The **Table 3.6** reflects this slightly more differentiated representation of the central bank balance sheet, ordered according to the three main types of balance sheet items.

Table 3.6 The central bank balance sheet ordered according to the monetary policy implementation perspective

Central Bank	
Liquidity providing items	Liquidity absorbing items
Autonomous factors <ul style="list-style-type: none"> • Net Foreign assets • Investment portfolios 	Autonomous factors <ul style="list-style-type: none"> • Banknotes • Government deposits
Monetary policy operations <ul style="list-style-type: none"> • Open market operations—outright purchases • Open market operations—credit to banks • Borrowing facility 	Monetary policy operations <ul style="list-style-type: none"> • Fixed term deposits or repo • Issuance of debt certificates • Deposit facility
	Deposits of banks

What was labelled B (for “banknotes”) in the previous financial accounts is now defined as “autonomous actors”, being the following net sum:

$$\begin{aligned} \textit{Autonomous factors} &= \textit{Banknotes} + \textit{Government deposits} \\ &\quad - \textit{Foreign reserves} - \textit{Investment portfolios} \end{aligned}$$

We netted autonomous factors as a central bank *liability* item. Defining “monetary policy operations” as the sum of all monetary policy operations netted as a central bank balance sheet *asset* item allows us to restate the balance sheet identity of the central bank as follows:

$$\textit{Deposits of banks} = \textit{Monetary policy operations} - \textit{Autonomous factors}$$

If the central bank imposes reserve requirements on banks, then deposits of banks with the central bank have to be at least equal to reserve requirements. Central banks therefore have to set the volume of monetary policy operations as follows:

$$\begin{aligned} \textit{Monetary policy operations} &= \textit{Reserve requirements} \\ &\quad + \textit{Autonomous factors} \end{aligned}$$

The left-hand side of this equation is the “supply”, and the right-hand side the “demand” for central bank deposits. The deposit supply by the central bank has to suffice both for reserve requirements and net liquidity absorption due to autonomous factors. Define as “liquidity absorbing” all central bank balance sheet *liability* items (except bank deposits), and as “liquidity providing” all central bank balance sheet *asset* items. Bank deposits can be interpreted as a “residual” central bank liability item: any increase of another central bank liability item leads to a decrease of commercial bank deposits, while any increase of a central bank asset item leads to an increase in central bank deposits.

3.3 Monetary Policy Implementation Techniques

We now illustrate three basic techniques of short-term interest rate control through monetary policy operations: the ceiling, floor, and symmetric corridor approaches.

3.3.1 The Ceiling Approach

In the ceiling approach, the interbank interest rate will be close to the liquidity providing standing facility offered by the central bank. The central bank needs to ensure (through the choice of the two variables it controls), with a sufficient margin,

that

$$\text{Open market operations} < \text{Autonomous factors} + \text{reserve requirements}$$

In this inequality we use “open market operation” to designate the net stock of securities and liquidity providing credit operations of the bank (“net” of liquidity absorbing open market operations). “Autonomous factors” have been netted as a central bank balance sheet liability item. Given the implied scarcity of reserves in the system, **banks are forced to borrow from the central bank facility, implying that the rate in the interbank market will be anchored around the central bank borrowing rate.** In case of changes of the interest rate target, the central bank simply changes the interest rate of the liquidity providing standing facility. The approach relies on sufficiency of central bank eligible collateral, as otherwise the ceiling is not necessarily effective in constraining market rates. The set of financial accounts shown in Table 3.7 illustrates this technique.

This approach was standard during the nineteenth century, when banks had to take structural recourse to the central banks’ overnight lending facility and the overnight lending facility rate determined market rates.

Table 3.7 The ceiling approach to monetary policy implementation

Households			
Real assets	$E - D - B$	Equity	E
Banknotes	$B + d$		
Deposits bank	$D - d$		
Corporates			
Real assets	$D + B$	Corporate Equity	E_{Co}
		Debt	D_{Co}
State			
Real assets	$E_{St} + D_{St}$	State Equity	E_{St}
		Debt	D_{St}
Bank			
Loans to corporate	$D + B$	Deposits of HH	$D - d$
Reserves of banks (incl. RR)	RR	CB borrowing facility	$RR + B + d$
Central Bank			
Borrowing facility	$RR + B + d$	Banknotes	$B + d$
		Reserves of banks (incl. RR)	RR

3.3.2 The Floor Approach

The **floor approach** has been used by all major central banks after 2009, and is now considered a new normal. In the floor approach, the interbank interest rate will be close to the liquidity absorbing standing facility (the deposit facility; or the rate of remuneration of excess reserves) offered by the central bank. The central bank needs to ensure (through the choice of the two variables it controls), with a sufficient margin, that

$$\text{Open market operations} > \text{Autonomous factors} + \text{reserve requirements}$$

Moreover, the central bank needs to set the rate of the deposit facility (or the remuneration of excess reserves) to the level of the intended policy target interest rate. **Given the abundance of reserves, commercial banks will be willing to lend them in the interbank market at any rate marginally higher than the remuneration of the deposit facility.** The financial accounts shown in Table 3.8 illustrate this approach. The central bank chooses the size of its outright portfolio OMO (“open market operations”) such that $D + B > \text{OMO} > B + \text{RR}$.

Sometimes central banks have implemented **one-sided facility approaches with two facilities offered in the same direction** (i.e. either two liquidity absorbing facilities under the floor approach, or two liquidity-providing facilities under the ceiling approach). For example, during the gold standard, central banks often steered interest rates between two liquidity providing facilities, with *Lombard rate* $> i > \text{discount rate}$ (the Lombard facility was the name of a collateralised overnight lending facility at that time; note that this was a ceiling system). Since 2005 the Fed has applied a floor system with *Interest rate on excess reserves (IOER)* $> i > \text{Reverse repo rate}$. These systems require that the more attractive of the two facilities is somehow

Table 3.8 The floor approach to monetary policy implementation

Corporate/State			
Real assets	D + B	Debt	D + B
Bank			
Loans and securities	D + B – OMO	Deposits of HH	D – d
Deposits CB	RR		
CB deposit facility	–B – RR + OMO – d		
Central Bank			
Securities	OMO	Banknotes	B + d
		Deposits banks	RR
		Deposit facility	OMO – RR – B – d

constrained in terms of access (discount facility possibly through scarcity of available eligible paper, IOER through limiting access to banks, excluding non-banks).

3.3.3 The Symmetric Corridor Approach

Under the symmetric corridor approach, which was standard in the years before 2008, the central bank offers both a liquidity providing and a liquidity absorbing facility, and keeps liquidity broadly “neutral” in the sense that ex-ante,

$$\text{Open market operations} = \text{Autonomous factors} + \text{reserve requirements}$$

This means that the probabilities that at day end (or at the end of the reserve maintenance period) the banking system will need one or the other facility are ex-ante symmetric, and therefore the interbank interest rate will trade in the middle of the corridor set by the interest rates of the liquidity providing and liquidity absorbing standing facilities. The central bank sets the rate of the two facilities symmetrically around the target interest rate. To capture the technique more precisely, assume the following daily timeline of events, as also summarised in the (Table 3.9).

- Every morning, the central bank determines its securities holdings S_{CB} such that $S_{CB} = B + RR$. B is the expected autonomous factors level, and RR the required reserves, and therefore, the expected level of bank reserves R is equal to RR .
- Second, interbank trading for overnight reserves with the central bank occurs, and the interbank rate is set as a weighted average of the two standing facility rates. The weights are the perceived probabilities of the banking system having to take recourse to one or the other standing facility at day end. As these probabilities are equal, the interbank rate should be in the middle of the standing facilities corridor.
- Third, the actual level for autonomous factors ($B + d$) materialises. The random variable d may be assumed to have a symmetric distribution and expected value of zero.
- Finally, at day end, the banks need to take recourse to one or the other facility.

Table 3.9 The symmetric corridor approach to monetary policy implementation

Bank			
Loans to corporate	$D - RR$	Deposits of HH	$D - d$
Reserves with CB (incl. RR)	RR	CB borrowing facility	$\max(0, d)$
CB deposit facility	$\max(0, -d)$		
Central Bank			
Securities (S_{CB})	$RR + B$	Autonomous factors	$B + d$
CB borrowing facility	$\max(0, d)$	Reserves of banks (incl. RR)	RR
		CB deposit facility	$\max(0, -d)$

The overnight interbank rate will be equal to the expected end of day marginal value of reserves, i.e. a weighted average of the two standing facility rates:

$$\begin{aligned} i &= P(\text{short})i_B + P(\text{long})i_D \\ &= P(OMO \leq RR + B + d)i_B + P(OMO > RR + B + d)i_D \\ &= i_D + P(OMO \leq RR + B + d)(i_B - i_D) \end{aligned}$$

Substituting $OMO = B + RR$ implies: $i = i_D + P(0 \leq d)(i_B - i_D)$. We can further simplify by taking assumptions on the random variable d : If for example d is symmetrically distributed around zero, then: $i = i_D + 0.5(i_B - i_D) = \frac{i_B + i_D}{2}$. The recourse to the borrowing facility will be $\max(d, 0)$ and the recourse to the deposit facility $\max(-d, 0)$. If we moreover assume that $d \approx N(0, \sigma_d)$, then ($\Phi(\cdot)$ is the cumulative standard normal distribution):

$$i = i_D + \Phi\left(-\frac{OMO - RR - B}{\sigma_d}\right)(i_B - i_D)$$

This equation will also allow us to calculate the effect of deviations of OMO from $RR + B$ on the interbank overnight rate (assuming OMO, B and RR are observed by the banks before the interbank market session), which a central bank could rely on if it aims at an **asymmetric corridor approach**, with i^* in $[i_D, i_B]$, but $i^* \neq (i_D + i_B)/2$. However, any asymmetric approach requires the central bank to take into account, when choosing OMO, second-order moments of autonomous factors (i.e. not only the expected value of autonomous factors, but also the variance), which increases complexity. Neither the floor, nor the ceiling, nor the symmetric corridor approaches required this. Therefore, central banks only very rarely implement changes of their operational target level through a “liquidity effect” (i.e. change OMO volumes relative to autonomous factors) but through changes of interest rates of standing facilities. Academic authors have sometimes imagined that changes of the interest rate target would be implemented through liquidity effects, see for example Hamilton (1996).

In practice, a symmetric corridor approach also needs specification regarding the width of the corridor. Before 2008, corridor widths of 50 to 200 basis points were often observed. The choice of the corridor width is discussed e.g. by Bindseil and Jablecki (2011). Before 2008, the Fed’s operational framework was the only one amongst major central banks that did not rely on a corridor approach.

3.4 The Central Bank Collateral Framework

3.4.1 Why Collateral?

Central banks conduct open market operations both in the form of purchases and sales of securities, and in the form of credit operations with banks. For the latter,

central banks require collateral, i.e. the pledging of certain eligible securities, called collateral, to protect its credit exposures to banks. The central bank will sell the collateral in the market if the borrowing bank does not repay the credit.

The value of collateral required by the central bank will exceed the credit provided by the central bank because **central banks apply “haircuts”**. For each security pledged as collateral, the haircut will be deducted to determine the maximum amount of central bank credit that can be obtained against it from the central bank. The haircut will depend on the price volatility of the security, its liquidity, and possibly on its credit risk. The collateral protects the central bank from a default of the commercial bank. Once the bank reimburses the credit from the central bank, the collateral is returned in its full value. There are several reasons why a central bank should not offer uncollateralised credit. (i) the central bank must ensure transparency and equal treatment, and uses uniform policy rates, but the credit worthiness is not the same for all institutes. (ii) the central bank is not specialised in assessing credit risk. (iii) the central bank must deal with a high number of banks, and also banks with a low rating must have access to liquidity. Collateral solves all these problems to a very large extent.

The **collateral framework potentially influences the relative price of financial assets and thereby potentially the allocation of credit**, as Nyborg (2017) has recently emphasised. Bindseil et al. (2017) also review the economics and practice of a collateral framework. The long history of collateral issues in central banking is also discussed in Chapter 4 of Bindseil (2019).

3.4.1.1 What Makes an Asset Suitable as Collateral?

Financial assets should fulfil certain qualities to be suitable as central bank collateral, in particular: legal certainty of the validity of the pledge; minimum liquidity to ensure the ability of the central bank to easily sell the collateral in case of counterparty default; simplicity; ease of pricing (through market prices or reliable theoretical prices), etc.

3.4.1.2 Principles of a Collateral Framework

First of all, the collateral framework should ensure a high degree of protection of the central bank from credit risk. Second, it should ensure **sufficiency of collateral** to implement monetary policy through credit operations, i.e. collateral scarcity should not lead to a distortion of interest rates or constrain the access of the banking system as a whole to the necessary amount of central bank credit. Third, the collateral framework should ensure **sufficient access** of all parts of the banking system considered important for the transmission of monetary policy. Third, the collateral framework should avoid that the **collateral eligibility premium** is so high that collateral scarcity and the relative treatment of assets by the collateral framework could influence relative asset prices in a way that unduly affects resource allocation in the economy. A

larger collateral set supports a lower collateral eligibility premium and hence reduces the risks of distortions. Fourth, the collateral framework should avoid pro-cyclicality: haircuts and eligibility criteria should be specified in good times in a conservative way so that they do not need to be tightened in crisis times.

3.4.1.3 The Risk Control Framework

The **risk control framework** for central bank collateral essentially consists in the haircut schedule and possible limits on the use of certain types of collateral. Gonzalez and Molitor (2009) and ECB (2015) present methodologies for deriving a central bank risk control framework for credit operations, such as haircuts, daily valuations, and margin calls. For example, the haircut scheme is a mapping of three features of each security into a haircut, namely (see ECB Press Release of 18 July 2013): **Rating**: BBB rated assets have higher haircuts than A-AAA rated assets (assets with ratings below BBB are normally not eligible at all); **Residual maturity**: the longer the residual maturity of bonds, the higher the price volatility and hence the higher the haircut; **Institutional liquidity category** of assets: The ECB has established six such categories, which are supposed to group assets into homogenous institutional groups in terms of liquidity. To keep the risk control framework simple, central banks rarely impose concentration limits on collateral portfolios, i.e. limiting the share of individual issuers, or the share of a certain asset type (concentration limits would have the advantage that in case of liquidation of a collateral portfolio, the price impact on the individual assets would likely be lower).

3.4.1.4 Methodology for Haircut Determination

The haircut setting of central banks tends to follow the principle of risk equivalence, i.e. after haircut, it should not matter from the central bank risk taking perspective which type of asset a bank brings as collateral. In case of counterparty default, the collateral submitted by that counterparty needs to be sold. This takes time and, for less liquid assets, a fire sale (i.e. a very quick sale) would have a negative impact on prices. The ECB classifies each security in one liquidity category, which is associated with a certain liquidation period, i.e. the period for which it can be assumed that the sale has no impact on prices. The haircut should depend on the price volatility of the relevant asset and on the prospective liquidation time, and possibly also on uncertainty regarding the initial value of the asset. High haircuts protect the central bank, but increase collateral needs for banks. This trade-off needs to be addressed by setting an adequate confidence level against losses. ECB (2004) set haircuts to cover 99% of price changes within the assumed orderly liquidation time of the respective asset class. Later, the ECB adjusted this method to cover with 99% the Expected Loss, which is the expected loss conditional on exceeding the 99% confidence level (i.e. haircuts were increased).

Assume an asset with a four week orderly liquidation period, and that the four week price change due to general volatility of the risk free yield curve is $N(0, \sigma_M)$; the uncertainty on the true asset value at the pre-default valuation is $N(0, \sigma_V)$; the liquidation price uncertainty stemming from spread changes (if it is a BBB asset, then the volatility of the BBB-AAA spread) and credit migration risks (the risk that the asset gets downgraded from BBB to e.g. BB with the associated price decline) is $N(0, \sigma_S)$. Assuming independent factors, the total uncertainty on liquidation value is $N\left(0, \sqrt{\sigma_M^2 + \sigma_V^2 + \sigma_S^2}\right)$. Call σ_T^2 the variance of the total liquidation value uncertainty of the asset. If the risk tolerance of the central bank has been defined as “preventing with 99% probability that the asset value at liquidation falls short of the last valuation minus the haircut”, then haircuts need to be set at $\sigma_T \Phi^{-1}(0.01)$, where $\Phi(\cdot)$ is the cumulative standard normal distribution. If for example $\sigma_M^2 = 4\%$; $\sigma_V^2 = 2\%$; and $\sigma_S^2 = 2\%$, then the adequate haircut achieving a 99% confidence level is 58% since $\Phi^{-1}(0.01) = 2.33$ and $\sigma_T = \sqrt{4\% + 2\% + 2\%} = 2.83\%$.

3.4.1.5 Collateral Constraints

The quantity and quality of central bank eligible collateral limits the borrowing potential of banks from the central bank. Limits arise from (i) restricted eligibility (e.g. excluding particularly non-liquid and non-transparent bank asset classes and setting a minimum credit quality for the collateral obligor), (ii) conservative collateral valuation, (iii) haircuts, or (iv) quantitative collateral limits to address concentration and correlation risks (e.g. the share of a certain asset type in a collateral portfolio must not exceed a certain percentage). Assume the bank balance sheet in **Table 3.10**, with two liabilities, household deposits and central bank credit, and two assets, loans and securities. Assume also that the central bank imposes a haircut of h_1 on loans to corporates and of h_2 on securities, with $1 > h_1 > h_2 > 0$. Collateral value after haircuts (or central bank credit potential) is for loans $(1 - h_1)L$ and for securities $(1 - h_2)S$.

The maximum borrowing of this bank from the central bank is the value of loans after haircut and the value of securities after haircut, i.e.: $(1 - h_1)L + (1 - h_2)S$. The actual borrowing from the central bank, CB, must not exceed this, i.e.:

$$L + S - D + d \leq (1-h_1)L + (1-h_2)S$$

This implies that the bank will hit the collateral constraint when deposit outflows exceed $d^* = (1 - h_1)L + (1 - h_2)S - (L + S - D) = D - h_1L - h_2S$, and could

Table 3.10 Bank balance sheet to illustrate collateral constraints

Bank			
Loans to corporates	L	Household deposits	D - d
Securities holdings	S	Credit from central bank	L + S - D + d

default unless it finds alternative funding or is able to fire-sell assets. For example, in the case of the euro area, out of approximately EUR 30 trillion of aggregated bank assets, the value of central bank eligible collateral after haircuts that could be

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