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Monetary policy implementation: Which "new normal"?

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ABSTRACT

This article provides a simple model of monetary policy implementation, analyzing both the interest rate steering (IRS) and the quantitative easing (QE) policies. The model shows that the "floor system", introduced with QE policies, is preferable to the traditional "corridor system", for two reasons. First, it endows central banks with one more degree of freedom, since the interest rate and the balance sheet policies become two independent instruments. Second, it enhances the ability of central banks to keep the money market rates in line with their target level. This second prediction is confirmed by an empirical analysis of the money market in the euro area. Therefore, in the "new normal" monetary policy should be implemented by steering the level of interest rates within a floor system, instead of relying on the corridor system used in the old IRS framework.[1]

1. Introduction

The implementation of monetary policy around the world has changed dramatically over the last fifteen years. Before 2007, most central banks used to follow the "interest rate steering" (IRS) approach, where the operational target of monetary policy was the level of interest rates in the money market and this target was implemented by an active management of bank reserves, in presence of a structural liquidity shortage. By announcing a target level for the overnight (O/N) interest rate and by managing the supply of reserves, central banks were able to keep the market O/N rate in line with the level consistent with their strategic decisions. This level was typically kept within two boundaries: an upper bound provided by the rate applied to a marginal lending facility, and a lower bound provided by the rate paid on excess reserves, if any (or zero in absence of a remuneration for excess reserves). This monetary control framework goes under the name of "corridor system".

When the level of interest rates hit the zero lower bound (ZLB), many central banks adopted the "quantitative easing" (QE) approach, under which the operational target was the size of the central bank balance sheet. The QE policies implied the injection of huge amounts of liquidity into the money market, through asset purchases and long-term lending operations. The structural excess of liquidity made the market O/N rate stick to the floor provided either by the ZLB or by the rate paid on excess reserves: this is why this approach goes under the name of "floor system".[2]

The exit from QE policies and the normalization of monetary policy raise an important issue: which "new normal" should central banks follow to implement their policy? Should they come back to the old IRS approach or should they look for a new operational framework?

The answer provided by this paper is that central banks should follow a "new normal" that combines some features of the IRS

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[1] *I wish to thank the Reviewer and the Editor for their very useful comments on a previous version of this article.*

[2] For a description of the QE measures taken by the Fed (up to 2014) see Labonte (2014). For the euro area, see Rostagno et al. (2019) and Altavilla et al. (2021).

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approach with others deriving from the QE experience. Under this new approach, the level of interest rates is again the operational target of monetary policy. At the same time, the new normal relies on the floor system: the market for bank reserves features a structural excess supply and the equilibrium level of the market O/N rate coincides with the rate paid on excess reserves. I argue that this "ample reserves regime" (using the terminology of the Fed) is superior to the old IRS framework for the following reasons.

1) The ample reserves approach gives central banks one more degree of freedom, since the interest rate policy and the balance sheet policy become two independent instruments, that can be targeted to different objectives. This property, that does not hold under the traditional IRS framework, is particularly relevant in the euro area, where the interest rate policy can be used to set the stance of monetary policy while the balance sheet policy can be used to address any potential fragmentation of financial conditions across member countries.
2) The ability of the central bank to keep the market O/N rate in line with the announced target level is stronger in the floor system than in the corridor system. The traditional IRS approach relies on the ability of the central bank to forecast the daily liquidity needs of the banking system, to be matched by the active management of the supply of bank reserves. Such forecasts are necessarily subject to some errors, due to the volatility of the autonomous factors affecting the stock of available reserves. In turn, these liquidity shocks introduce an undesired volatility of money market rates. To the contrary, liquidity shocks do not have any impact on the money market rates in a floor system, where they are absorbed by the "buffer" provided by the structural excess supply of reserves. Actually, the fine tuning of the liquidity supply is even unnecessary under this approach. Notice that the ability to steer interest rates is again relevant nowadays, after a long period during which the level of interest rates was sticking to the ZLB and it was not at the center of the communication strategy of central banks, which was instead focused on QE programs.

Both the above points are supported by the model that will be exposed below, which will address the analytical features of the different operational frameworks. The second result will be tested by means of a statistical analysis focused on the euro area money market.

The paper is organized as follows. After a brief review of the related literature in the next section, the IRS/corridor system will be addressed in Section 3. The implementation of QE policies in a floor system will be addressed in Section 4. Building on the analysis of these two sections, I will focus on my central research question in Section 5: which "new normal" should central banks follow to implement their policy after exiting QE? This section also includes the above-mentioned empirical test with money market data from the euro area. Finally, Section 6 concludes and summarizes the main results of the paper.

2. Related literature

In the area of monetary policy implementation, the pioneering work done by Borio (1997, 2001) provided a conceptual framework for analyzing the different institutional contexts at the international level. At that time, the focus was on the traditional IRS approach to managing monetary policy. Borio and Disyatat (2009) derive what they call the "decoupling principle" (see below). My analysis will be able to clarify that under the IRS approach such principle holds in one direction only, while it works in both directions under the QE approach: as a consequence, interest rate and quantity of money become two independent instruments.

Guthrie and Wright (2000) (GW) made a fundamental contribution to the theory of monetary policy implementation, highlighting that a central bank can control the level of money market rates simply by announcing a target level and threating to implement open market operations, in case of deviations of the market rate from that target: this is what they call "open mouth operations", an expression that has become standard in this literature. Building on GW, Woodford (2000) provides a clear illustration of the corridor system ("channel system" in his words). Both GW and Woodford refer to an institutional setting where there is no reserve requirement. To the contrary, my paper shows how a corridor system works in an institutional setting where a reserve requirement is present, as it is in many countries like the US (until 2020) and the euro-area.

In their chapter in the *Handbook of Monetary Economics*, Friedman and Kuttner (2010) (FK) show an implementation framework which relies on the averaging facility included in the reserve requirement. However, they do not explicitly model the microeconomic optimization problem shaping the demand for bank reserves; a simple way of addressing this issue will be introduced in Section 3 below.

The opportunities implied by a floor system were anticipated by the article of Goodfriend (2002), where he proposed to introduce the remuneration of the reserve balances deposited by banks at the central bank: a policy that the Fed has introduced six years later (in October 2008). In a related paper, Goodfriend (2000) analyzes how the two tools, negative interest rates policy and reserves policy, can be used to overcome the limitations set by the ZLB to monetary policy.

My paper builds on the official and semi-official publications released by some central banks with the purpose of illustrating their own operational frameworks. A remarkable example is given by several papers written by the staff of the Fed's Board of Governors.[3] Rostagno et al. (2019) provides a detailed account of twenty years of monetary policy management in the euro area. Bank of England (2023a, 2023b, 2014, 2011) provide a description of the implementation framework adopted by the BoE and of its evolution in recent times. All these publications are very useful on descriptive grounds, but they are devoted to specific institutional settings and they lack an analytical framework.

[3] See Ihrig et al. (2015a, 2015b, 2017, 2020a, 2020b).

Finally, the book by Bindseil (2004) provides a detailed discussion of the issues, both theoretical and institutional, related to monetary policy implementation. Bindseil and Fotia (2021) provide an extensive survey of monetary policy implementation techniques, including those used in "unconventional" policies.

3. Interest rate steering and corridor system

The traditional approach to monetary policy implementation, prevailing in most countries until the 2007/2008 financial crisis, relies on the ability of the central bank to control the short end of the yield curve of interest rates, by exploiting an announcement effect and by managing the supply of bank reserves: these are the balances held by banks on their current accounts with the central bank. Under the IRS framework, the operational target of monetary policy is the level of interest rate in the interbank market, where banks can trade their reserves with each other. Most of the trades in this market are made on the O/N maturity, and central banks typically target the O/N rate.[4]

The model presented in this section provides an analytical description of the IRS approach to monetary policy implementation and it shows two main points. First, under this approach the central bank cannot have two independent targets: interest rate level and quantity of money. Once the target on the interest rate has been set, the supply of base money (and of money as a consequence) must be set accordingly, in order to reach that target. Second, the stabilization of the money market rates relies on the ability of the central bank to forecast the so-called "net liquidity position" of the banking system on a daily basis. This introduces the risk of operational mistakes, due to the volatility of the autonomous factors affecting the amount of reserves available to the banking system. This is the reason why the O/N rate shows a significant volatility around its target level, despite the frequent interventions of the central bank in the money market. This is also the reason why the averaging facility of the reserve requirement plays an important role in this framework, by introducing a self-stabilization mechanism in the money market. An additional stabilization tool is provided by the rates applied on excess reserves and on the marginal lending facility, defining the "corridor" of interest rates.

Let us denote by i the interbank O/N interest rate. The central bank can implement its target in two complementary ways. First, through communication: the stance of monetary policy is signaled to market participants by announcing the target level (i^*) for the market rate. Such announcement can be either explicit (e.g. the Federal Funds target in the USA) or implicit. In the latter case, the target is signaled by setting the level of a *policy rate*: the interest rate applied to some operations made by the central bank (e.g. the rate on the main refinancing operations of the ECB). Second, by managing the supply of bank reserves in such a way that the money (O/N) market clears at an equilibrium interest rate equal to i^*. In doing so, the central bank exploits its monopoly position as a supplier of the aggregate amount of bank reserves. This monopoly power is what makes the central bank announcements credible. The fine tuning of the supply of bank reserves, through frequent interventions in the money market, is called "active management", which is a typical feature of this operational framework. As we shall see, the ability to control the amount of bank reserves available to the banking system is far from perfect, due to the presence of a stochastic component in the so-called "autonomous factors" affecting the stock of base money. However, we can safely assume that on average the central bank is able to reach its target, and market participants are aware of this, so the expected value of the market O/N rate is equal to that target:

$$E(i) = i^* \tag{1}$$

In the following, we are going to address in turn: i) the demand for bank reserves, ii) the supply of bank reserves, iii) the equilibrium in this market, and iv) the implementation of monetary policy.

Let us define the daily demand for bank reserves (denoted by R^D) as the (end-of-day) desired balance on banks' current accounts at the central bank. The overnight interest rate in the interbank market (i) is the opportunity cost of holding reserves. The management of reserves by banks balances two objectives: i) minimize this opportunity cost, and ii) minimize the deviations of their balance on current accounts from some target level. The latter is determined by the technical features of the payment system and by the regulation. Historically, the shift from end-of-day net settlement systems to real time gross settlement (RTGS) systems has determined a significant increase of the amount of liquidity needed to settle payments.[5] More recently, regulatory liquidity requirements have contributed to further increase banks' holdings of liquid assets, including reserves with the central bank.[6] On top of this, many central banks impose a minimum reserve requirement on banks: these are required to hold an amount of reserves at least equal to some threshold level as a ratio to deposits taken. If we denote by k the reserve coefficient, the reserve requirement ($\widehat{R}$) in some period may be written as:

$$\widehat{R} = kD_{-1} \tag{2}$$

where D_{-1} is the level of bank deposits at the end of the previous period. The requirement may include an "averaging rule". In such a case, a bank is not obliged to hold a balance at least equal to $\widehat{R}$ in each business day on its current account with the central bank. To the contrary, the average of the end-of-day balances over some specified period (called "maintenance period") has to be at least equal to $\widehat{R}$.

[4] O/N is the shortest maturity in financial markets with explicit trades. An intraday (hourly) interest rate can be implicitly defined by the intraday pattern of the O/N rate: see the evidence provided by Furfine (2001) for the USA and by Baglioni and Monticini (2008) for the euro area.

[5] See Baglioni (2006).

[6] Central bank reserves are included in the range of assets of extremely high liquidity and credit quality (Level 1 assets) that can be used to comply with the Liquidity Coverage Ratio (LCR). Indeed, a large share of Level 1 assets is made up of bank reserves with the central bank: see EBA (2020) for evidence in Europe.

This implies that a bank is allowed to end some business days with a balance lower than $\widehat{R}$, provided such reserve deficits are compensated by a reserve surplus in some other days within the maintenance period. Let us denote days by $t = 1, \ldots, T$, where T is the length of the maintenance period. A bank has to meet the following constraint:

$$\frac{1}{T}\sum_{t=1}^{T} R_t \geq \widehat{R} \tag{3}$$

where R_t is the end-of-day balance on its current account.[7] If this constraint is not met, a bank incurs in a penalty: the central bank applies a penalizing (above market level) interest rate to the shortfall. A current account balance exceeding the requirement is also penalizing: while the required balance ($\widehat{R}$) is supposed to be remunerated at market rates, the interest paid on excess reserves (if any) is generally lower than that. The risk of incurring in one of these costs can be significant, due to the randomness of the payment flows and to liquidity shocks possibly hitting some banks.

The averaging rule allows banks to engage in the so-called “inter-temporal arbitrage”, in order to minimize the opportunity cost of holding reserves with the central bank, namely the O/N interbank interest rate (i). As we noted above, the interbank market is the market where banks can lend their reserves to each other. Now, suppose that in day t a bank manager expects a decline of the interbank rate in the following day: $i_t > E_t(i_{t+1})$, where $E_t(\cdot)$ is the expectation operator with the information available at time t. He can earn an expected profit by lending money in the interbank market today and borrowing tomorrow; the today reserve deficit on the settlement account ($R_t < \widehat{R}$) will be compensated by the planned tomorrow reserve surplus ($R_{t+1} > \widehat{R}$). This deal makes the demand for reserves (R_t^D) of such bank to go down in the current day. Of course, the opposite expectation ($i_t < E_t(i_{t+1})$) will lead to an arbitrage deal opposite to the previous one, thus making the current demand for reserves go up. This reasoning shows, intuitively, that there is an inverse relationship between the demand for bank reserves and the current level of the interbank interest rate, for a given level of the expected O/N rate.

As I will show below, the averaging rule plays an important stabilizing role in the money market, since the inter-temporal arbitrage operations increase the elasticity of the demand for bank reserves. This elasticity limits the impact of liquidity shocks on market rates, reducing the need for the central bank to make frequent open market operations. The higher is the banks’ willingness to engage in inter-temporal arbitrage, the larger is the elasticity of the reserve demand schedule. In the limit case, where any arbitrage opportunities were fully exploited, the O/N rate would satisfy the “martingale property”: $i_t = E_t(i_{t+1})$, so the expected change of the O/N rate would be zero. However, the empirical evidence suggests that this is not the case in general. Moreover, it shows that the elasticity of the reserve demand schedule is decreasing throughout the maintenance period, and the reason behind this result is quite intuitive. In the first days of the period, banks have a large room for compensating any reserve deficit/surplus in later days within the same period. This room gets smaller as long as the end of the period approaches. In the last day of the period, any deficit/surplus would force a bank either to borrow or to deposit money overnight at the central bank at penalizing rates: i_{ML}, i_R respectively (see below).[8]

To formally derive the daily demand for reserves of a representative bank, we can proceed as follows. Suppose to be in any day $t > 1$ of the maintenance period. First of all, we have to compute the average balance required over the time span going from day t to day T, that we denote by $\widehat{R}_t$.[9] To this aim, we can rewrite the constraint (3) as $\sum_{t=1}^{T} R_t = T \bullet \widehat{R}$, or equivalently as:

$$\sum_{j=1}^{t-1} R_j + \sum_{j=t}^{T} R_j = T \bullet \widehat{R} \tag{4}$$

from which:

$$\frac{1}{T-(t-1)}\sum_{j=t}^{T} R_j = \frac{1}{T-(t-1)}\left[T \bullet \widehat{R} - \sum_{j=1}^{t-1} R_j\right] \tag{5}$$

which defines $\widehat{R}_t$ as:

$$\widehat{R}_t \equiv \frac{1}{(T-t+1)}\left[T \bullet \widehat{R} - \sum_{j=1}^{t-1} R_j\right] \tag{6}$$

In the last day of the maintenance period ($t = T$) the above expression boils down to:

$$\widehat{R}_T = T \bullet \widehat{R} - \sum_{j=1}^{T-1} R_j \tag{7}$$

[7] Notice that what matters for the reserve requirement is the end-of-day balance on banks’ current accounts: the intraday balance can take values below $\widehat{R}$ (even negative) without any consequence. We are implicitly assuming that the amount of reserves held to meet this requirement is large enough to manage payments: this implies that the marginal demand for reserves is determined by the reserve requirement.

[8] See Bartolini et al. (2002a) for a formal treatment of this point. For empirical evidence on the interest rate elasticity of the daily demand for bank reserves, see: Hamilton (1996), Bartolini et al. (2002b), Angelini (2008), and other studies referred to in Friedman and Kuttner (2010). Hamilton (1996) also provides a model, based on the frictions in the interbank market, able to explain why the martingale property does not hold in practice.

[9] Of course, in the first day it is: $\widehat{R}_1 = \widehat{R}$.

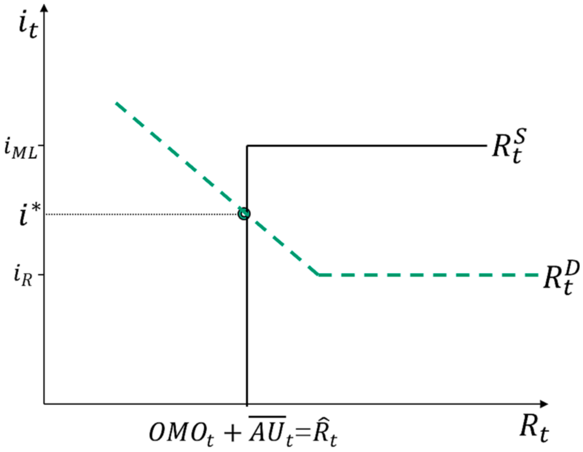

Fig. 1. Corridor system: the money market equilibrium.

The representative bank will minimize the following loss function:

$$\min_{R_t^D} L = \frac{1}{2}\left(R_t^D - \widehat{R}_t\right)^2 + \beta\left[R_t^D i_t + \sum\nolimits_{j=t+1}^{T} R_j \bullet E_t\left(i_j\right)\right] \tag{8}$$

s.to: $R_t^D + \sum_{j=t+1}^{T} R_j = T \bullet \widehat{R} - \sum_{j=1}^{t-1} R_j$

where β is a behavioral parameter capturing the weight that bank managers assign to the objective of minimizing the opportunity cost of reserves by engaging in trades in the money market.

By exploiting assumption (1), we can substitute i^* for $E_t(i_j)$ in the above problem.[10] After substituting the constraint into the objective function, the problem can be written as:

$$\min_{R_t^D} L = \frac{1}{2}\left(R_t^D - \widehat{R}_t\right)^2 + \beta\left[R_t^D i_t + i^* \bullet \left(T \bullet \widehat{R} - \sum\nolimits_{j=1}^{t-1} R_j - R_t^D\right)\right] \tag{9}$$

Finally, from the FOC we can derive the following daily demand for bank reserves:

$$R_t^D = \widehat{R}_t + \beta[i^* - i_t] \tag{10}$$

This formulation holds for $1 \leq t < T$. In the last day of the maintenance period, by definition no intertemporal arbitrage operation can be done. Then, the demand for reserves is perfectly rigid and it equals the amount due to satisfy the reserve requirement: $R_T^D = \widehat{R}_T$, where the latter is given by equation (7).

Many central banks pay an interest on excess reserves, i.e. the current account balances exceeding the reserve requirement.[11] Let us label this rate of interest by i_R, which in general can take either positive or zero or even negative values. This is the reservation rate for interbank market participants: no bank will ever lend money in the market at a rate lower than i_R, since it can always deposit money overnight at the central bank at such a rate. Equation (10) has been derived under the implicit assumption that $i > i_R$. This is quite realistic in the corridor system, where the interest paid on excess reserves (if any) is generally well below market rates, which in turn are close to the center of the corridor. For completeness, we have to consider also the case where $i = i_R$. In such a case, the net opportunity cost of holding reserves $(i - i_R)$ would vanish and the demand for reserves would become perfectly elastic: banks would be willing to hold any amount of money at the central bank. Summing up, the daily demand for bank reserves is given by equation (10) as long as $i > i_R$, and $R^D \rightarrow \infty$ if $i = i_R$: see Fig. 1.

[10] I am implicitly assuming that i^* is constant within the maintenance period. This is quite a realistic assumption. In the euro area, each maintenance period begins on the settlement day of the first Main Refinancing Operation following a Governing Council meeting, devoted to monetary policy decisions, and it ends just before the MRO, following the next GC meeting, will be settled: this way of defining the maintenance period rules out the possibility that, once a period has begun, a monetary policy decision can be taken within the same period. In the US, before the suppression of the reserve requirement, the length of the maintenance period was quite short: two weeks, implying a low probability that a policy decision, changing the Federal Funds target, could be taken within an ongoing period.

[11] Actually, in the euro area the excess reserves are not remunerated. However, the overnight deposit facility (DF) is remunerated and it is available until half an hour past the closing time of the interbank payment system (TARGET2). Banks can switch their balances from their current accounts to the DF at the end of the business day and have their liquidity available again on their current accounts at the start of business on the next day. Therefore, the interest paid on the DF is *de facto* a remuneration of the excess reserves: i_R in the model.

The supply of bank reserves, i.e. the existing aggregate amount of reserves, is under the control of the central bank. As it is well known, the "base money" (BM) is defined by the sum of the sight liabilities of the central bank. Base money can be held by financial intermediaries and the general public in two ways: bank reserves (R) and cash (C):

$$BM = R + C \tag{11}$$

The central bank issues base money through its open market operations (OMOs), which can be carried out either through repurchase agreements (repos) or through outright transactions. In addition to OMOs, central banks generally rely on a Marginal Lending (ML) facility: they stand ready to lend (overnight) any amount requested by banks at a penalty interest rate (i_{ML}), higher than the "normal" level of the market O/N rate.[12] Since no bank will be willing to borrow in the market at an interest rate above i_{ML}, this rate sets a ceiling on the money market rates. On the other side, as we noted above, the interest paid on reserves (i_R) sets a floor to the money market rates, since it is the reservation rate for market participants. Taken together, the two rates (i_R, i_{ML}) define the so called "corridor" for the money market rates: the O/N rate volatility is curbed within these two boundaries. Moreover, the ML facility has an impact on the stock of base money: when some banks apply to it, their current accounts are credited, so some base money is temporarily (overnight) issued.

In addition to the above-mentioned operations, there are other factors that can affect the stock of bank reserves. Since they do not depend on monetary policy, they are called "autonomous factors". The first one is the Public Sector. In many countries the Government holds an account (denoted by PS) with the central bank, which acts as the settlement agent for the payments of the public administration: since these payments are usually channeled through the banking system, an incoming payment to the public sector (PS goes up) implies that some base money is withdrawn from the system. The second one is the Foreign Channel (FC), which is strictly related to the balance of payments and to the interventions of the central bank in the foreign exchange market: when the central bank buys foreign currency (official reserves, denoted by FC, go up) it pays by issuing domestic base money.

Summing up, the stock of base money is determined as follows:

$$BM = OMO + ML - PS + FC \tag{12}$$

where the sign of each item derives from the above discussion.

Equations (11) and (12) together imply that the supply of bank reserves is:

$$R^S = OMO + ML - PS + FC - C \tag{13}$$

Cash in circulation must be subtracted from available reserves, since banks have to convert part of their current account balances into cash, depending on the needs of their customers. Therefore, cash can be considered as an autonomous factor affecting the stock of bank reserves. By denoting the autonomous factors as

$$AU = FC - PS - C \tag{14}$$

the supply of reserves can be written as:

$$R^S = OMO + ML + AU \tag{15}$$

which is represented in Fig. 1. The vertical segment shows the stock of base money issued through OMOs and by the autonomous factors up to some date. The horizontal line shows the potentially unlimited increase of base money triggered by the activation of the ML facility: this happens when the market O/N rate shows a tendency to go above the upper bound i_{ML}. More formally:

$R^S = OMO + AU$ if $i < i_{ML}$.

$R^S \rightarrow \infty$ if $i = i_{ML}$.

In order to implement the announced target for the O/N interest rate level (i^*), the central bank should set the supply of bank reserves at such a level to match the aggregate level of demand at rate i^*. This is a complex task for the central bank's operative desk, due to the volatility of the autonomous factors, mainly related to the daily flows of payments of the public sector: tax revenues, interest and principal payments on public debt, public employees' wages, etc. The central bank makes a daily forecast of the amount of base money created/absorbed by the autonomous factors. Such a forecasting activity, which is at the core of the active management of reserves made by the central bank, is necessarily affected by some errors. To account for this problem in our model, let us introduce a random component into the autonomous factors by writing them as follows:

$$AU_t = \overline{AU}_t + \widetilde{\varepsilon}_t \tag{16}$$

where the daily size of the autonomous factors (AU_t) is made up of two components: $\overline{AU}_t$ is the predictable component and $\widetilde{\varepsilon}_t$ is a forecast error with zero mean. The daily supply of reserves becomes:

[12] Several central banks ask banks to deposit a collateral to obtain marginal lending. In such a case, there is actually a limit to the amount that a bank can borrow, which is given by the amount of available eligible securities. In general, however, banks hold a large amount of securities, in order to avoid that the collateral constraint becomes binding. This is why the collateral constraint has not been formally introduced into our framework.

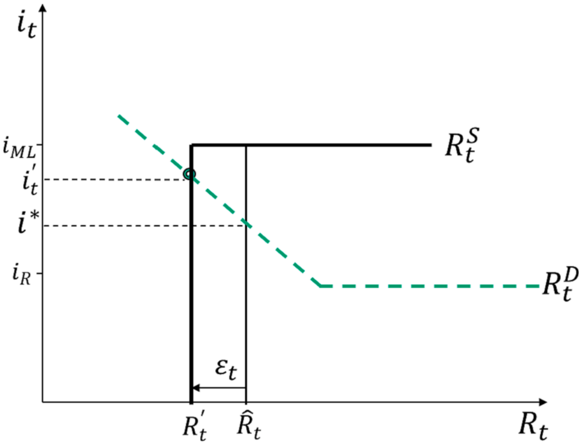

Fig. 2. Liquidity shock.

$$R_t^S = OMO_t + ML_t + \overline{AU}_t + \tilde{\varepsilon}_t \tag{17}$$

Now, let us focus on a "normal" day, where there is no particular tension in the market, so $i < i_{ML}$ and the ML facility is not activated.[13] Then, the expected value of the supply of reserves is:

$$E(R_t^S) = OMO_t + \overline{AU}_t \tag{18}$$

In the interbank market, individual banks trade their reserves with each other. However, for the money market equilibrium, what matters is the aggregate demand for reserves. The central bank manages the supply of reserves to match the aggregate level of demand at rate i^*. Formally:

$$E(R_t^S) = R^D(i^*) \tag{19}$$

The guarantee of making open market operations, if needed, to make the O/N interbank market clear at the level i^* of interest rate is crucial to affect the expectations of market participants. They know that if a significant amount of trades at a rate $i > i^*$ take place, the central bank will inject base money into the system in order to make the market rate converge to i^*. Of course, the opposite will happen starting with $i < i^*$. Therefore, market participants anticipate that the only equilibrium level of the O/N interest rate is i^*. Temporary deviations are possible, due to the volatility of the autonomous factors. But on average the interbank O/N rate will be equal to i^*. This justifies the initial assumption, made in equation (1), about the expected level of the interbank market rate.

Fig. 1 provides a picture of the equilibrium in the daily market for bank reserves. At the equilibrium point, the current market rate (i_t) equals the expected rate (i^*), so banks do not engage in any inter-temporal arbitrage trade and the demand for reserves is given by the minimum requirement: $R_t^D = \hat{R}_t$ in equation (10). This, together with equation (18), implies that the equilibrium condition (19) can be written as follows:

$$OMO_t = \hat{R}_t - \overline{AU}_t \tag{20}$$

The right-hand side of equation (20) is called "net liquidity position" of the banking system. Central banks make open market operations to match the amount of reserves needed by the banking system to satisfy the reserve requirement (due on average from day t until the end of the maintenance period) net of the base money created/subtracted from the system by the autonomous factors.

This framework relies on a shortage of bank reserves and on the active management of the stock of base money by the central bank, making frequent interventions in the money market, even on a daily basis. The target level set by the central bank for the O/N interest rate (i^*) provides an anchor to the interbank market. The two rates (i_R, i_{ML}) provide the lower and upper bounds to the corridor of interest rates: they play an active role when there is either an aggregate excess or lack of liquidity.

An important feature of this operational framework is that, since the central bank targets the interest rate level, the supply of bank reserves becomes endogenous. Bank reserves are a liability of the central bank, which can decide the amounts to be issued. However, the central bank commits to supply all the quantity of reserves needed to make sure that the money market clears at i^*. As a consequence, the money supply, which is linked to the base money through the money multiplier, is endogenous as well. In other words, *monetary policy cannot have two independent targets: interest rate level and quantity of money*. This principle will no longer apply under the quantitative easing framework, as well shall see in the next section.

[13] Some individual banks might apply for the ML facility, but the aggregate recourse to it is assumed to be negligible as long as the market O/N rate does not show a tendency to go above its upper bound i_{ML}.

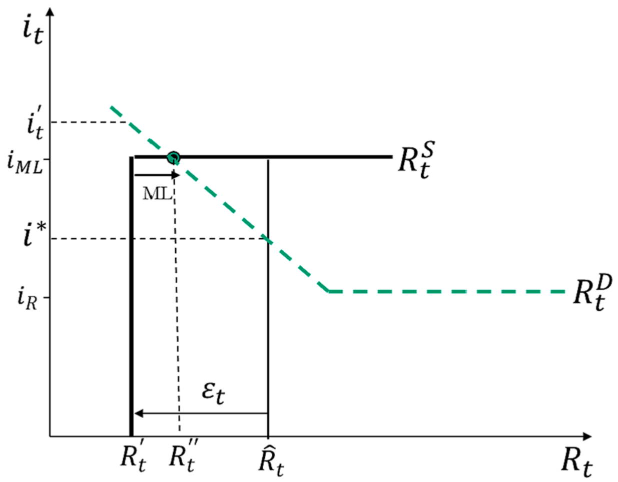

Fig. 3. Activation of the marginal lending facility.

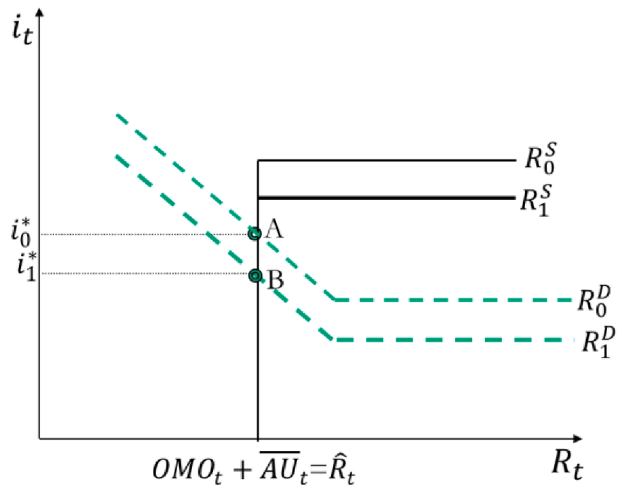

Fig. 4. Monetary policy implementation: expanding the stance.

Another feature of the IRS approach is that the ability of the central bank to stabilize the money market rates is far from perfect. This is due to the autonomous factors, affecting the stock of bank reserves, which are not under the direct control of the central bank: they introduce a volatility of the O/N rate around its target level. This feature, in turn, explains why the reserve requirement, in particular the averaging rule, used to be a useful tool for central banks under the traditional IRS approach. To see this point, remember that central banks make a daily forecast of the autonomous factors, but they can make mistakes. The unpredictable component of the autonomous factors is captured by $\widetilde{\varepsilon}_t$: the forecast error introduced above. This is equal to zero on average, but it can sometimes take sizable positive or negative values. We call these deviations from zero "liquidity shocks". Let a negative liquidity shock ($\varepsilon_t < 0$) take place: for example, an amount of tax payments larger than expected. Starting from the initial equilibrium point, where the supply of bank reserves matches the reserve requirement ($OMO_t + \overline{AU}_t = \widehat{R}_t$), this shock makes the stock of reserves shift to the left, going down to $R_t^{'} = OMO_t + \overline{AU}_t + \varepsilon_t < \widehat{R}_t$: Fig. 2 shows in bold the new supply schedule.[14] This creates an excess demand at the initial interest rate i^*. This tension in the money market will make the interest rate increase up to $i_t^{'}$. This increase is smaller, the larger the elasticity of the demand for reserves, which in turn is related to the willingness of some banks to exploit inter-temporal arbitrage opportunities[15]: they can lend money today in the interbank market, thus reducing their demand for reserves, expecting to borrow at a lower rate in the next days of the maintenance period. This behavior reduces the excess demand for reserves and consequently the impact of the liquidity shock on the O/N market rate. This self-stabilization property enables the central bank to intervene in the money market less

[14] We are implicitly assuming that the liquidity shock is temporary, as it is generally the case, so it affects the money market only in day t.

[15] The higher is the value of the parameter β, the flatter is the demand schedule R_t^D.

frequently than it should do in absence of the averaging facility.

The corridor system relies on two additional stabilizing tools: the ML facility and the interest paid on reserves. They play an active role when the level of interest rates in the money market tends to go outside the boundaries of the corridor: i_R, i_{ML}. This can happen, in particular, when the end of the maintenance period approaches: in those days, for the reasons explained above, the demand for bank reserves becomes more rigid and the self-stabilizing mechanism provided by the averaging facility is less effective (it is not available at all in the last day of the period). To show the point, let us take up again the example of a negative liquidity shock: see Fig. 3. Absent the ML facility, such shock would produce an increase of the market O/N rate up to $i_t^{'}$. This will not happen since banks can borrow money from the central bank at rate i_{ML}. The activation of the ML facility implies an endogenous injection of reserves into the system (from $R_t^{'}$ to $R_t^{''}$) able to reduce the gap between the reserve requirement and the supply of reserves: from $\widehat{R}_t - R_t^{'}$ to $\widehat{R}_t - R_t^{''}$ (where $R_t^{''} = OMO_t + ML_t + \overline{AU}_t + \varepsilon_t$). The alternative case of a positive liquidity shock (e.g. an interest/principal payment on Government debt) can be easily seen by using Fig. 1 again. Imagine to shift the vertical line rightward up to a point where it intersects the horizontal segment of the reserve demand schedule. The abundance of liquidity will exert a downward pressure on the O/N interbank rate, but this will not go below i_R, since the latter is the reservation rate for market participants.

Under the IRS framework, the stance of monetary policy is signaled to markets' participants by announcing the target level (i^*) for the market (O/N) interest rate. This announcement affects the demand for bank reserves and it is able to move the market rate in the desired way, *without the need to change the supply of base money*. Fig. 4 can help understand this point. Let us start from an equilibrium point A, where the target and market interest rates are at level i_0^*. Now, let the central bank announce a reduction of its target to i_1^*. This makes the demand schedule for reserves (equation (10) to shift downwards from R_0^D to R_1^D. The equilibrium in the interbank market (equation (19) is reached for a lower level of the market interest rate (from $i = i_0^*$ to $i = i_1^*$) and for the same level of bank reserves: $\widehat{R}_t$. The amount of base money that the central bank should supply through its open market operations remains the same (see equation (20). In the figure, this process is shown by a change of the equilibrium from point A to point B, which lie on the same vertical line corresponding to the existing stock of bank reserves. This argument shows that the central bank is able to change the equilibrium level of interest rates in the money market and keep the supply of bank reserves unchanged: this "*decoupling principle*" is an important feature of the operational framework. Fig. 4 is drawn under the assumption that the central bank, when announcing the reduction of i^*, reduces the other two policy rates, i_R and i_{ML}, accordingly: this is generally the case in practice (although the three rates are not necessarily changed by the same amount). As a consequence, the horizontal segment of the reserve supply schedule shifts downwards (from R_0^S to R_1^S). However, this is not relevant at the equilibrium point: what matters is the shift of the reserve *demand* schedule.

It is worth stressing that, under the IRS framework, the decoupling principle works in one direction only: *the central bank can implement different levels of interest rate with the same level of bank reserves, but not vice-versa*. On one hand, the central bank can set different levels for its interest rate target (i^*) while keeping the supply of bank reserves constant. On the other hand, there is only one amount of reserves able to match the quantity demanded at a level of interest rate equal to the announced target: $\widehat{R}_t$. The size of open market operations should always meet the net liquidity position of the banking system: if they fail to do so, the market rate would differ from the target rate. This conclusion is consistent with the above observation that monetary policy cannot have two independent tools: interest rate and supply of money. Once the target on the interest rate has been set, the amount of base money must be set accordingly. If, to the contrary, the central bank wanted to set a target on the quantity of money, it should give up the target on interest rates. This feature implies that the management of liquidity does not have any signaling role under the IRS approach. The monetary policy stance is signaled by setting the target level for the O/N interest rate. To the contrary, the purpose of liquidity management is to offset the volatility of the autonomous factors and to accommodate any shift of the demand for reserves, minimizing the divergence between the effective interest rate and its target level.[16]

4. Quantitative easing and floor system

The QE operational framework relies on two innovative tools: large scale asset purchases (AP) and long-term lending operations to the banking system (LTLO).[17] Under this framework, the operational target of monetary policy is the size of the central bank balance sheet: the size of the AP and LTLO programs signals the stance of monetary policy. This does not imply that the level of interest rates becomes irrelevant: however, when the level of the policy rate remains close to the ZLB for long periods, it plays a minor role. Differently from traditional OMOs, including both repos and outright purchases, APs are outright transactions only. They are unusual also for their size, and they cover a wide range of securities eligible for purchase: government bonds, corporate bonds, covered bonds, and asset-backed securities. LTLOs differ from traditional lending operations for three features: i) large scale, ii) long maturities (up to four years in the euro area), and iii) some technical features creating an incentive for banks to lend out to firms and households the money received from the central bank.[18]

There is a crucial difference between LTLOs and APs. While the latter enable the central bank to take full control of the size of its own balance sheet, the former do not. In an AP program, it is the central bank who decides the amount of securities under purchase: the

[16] This feature of the operational framework is called "separation principle" in the tradition of the ECB.

[17] Sometimes the LTLOs are labelled as "credit easing" policy.

[18] In the euro area, different rounds of Targeted – Longer Term Refinancing Operations (T-LTROs) have been implemented: their size and/or the interest rate applied depend on the amount of bank loans over an observation period.

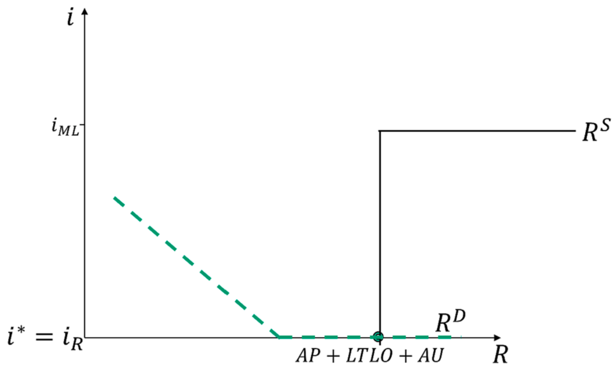

Fig. 5. Floor system: the money market equilibrium under QE.

contribution of the program to the increase of the central bank balance sheet is exogenous and it is in the hands of the central bank itself. To the contrary, the central bank can only decide the potential size of an LTLO program. The effective size depends on the ratio between the amount of loans actually taken by banks and the borrowing allowance made available by the central bank: the so-called "take-up ratio", which in turn depends on banks' behavior. In addition, LTLO programs often include a prepayment option, allowing banks to pay back the loans before maturity. Therefore, the actual size of LTLOs is endogenous, up to some limits set by the central bank.[19]

In this section, we are going to see how the analytical framework introduced in the previous section can be adapted to show the basic features of monetary policy implementation under the QE approach. The analysis of this section will highlight two main points. First, under QE the decoupling principle works in *both directions*: the central bank can set different interest rate levels for the same amount of liquidity and vice-versa. Therefore, the interest rate and the quantity of money become two independent policy instruments. Second, the volatility of the autonomous factors, affecting the stock of base money, does not have any impact on the money market equilibrium. As a consequence, the O/N rate sticks to the "floor" of the system, which coincides with the interest rate applied on excess reserves (which may also become negative): the latter becomes the crucial policy rate. This implies that the volatility of money market rates should be lower under QE than under IRS: a prediction that we are going to test in the next section. Another implication is that the stabilizing property of the reserve requirement, due to the averaging facility, is much less relevant in the floor system than it used to be in the corridor system.

QE policies have produced a remarkable change of the operational framework. As we have seen above, the IRS approach relies on the scarcity of bank reserves together with an active management of the supply of reserves. To the contrary, the QE approach relies on a large excess supply of reserves, which becomes a structural feature of the monetary control framework. The traditional OMOs, namely the frequent interventions in the money market, do not play a relevant role anymore in the provision of base money. The great part of the liquidity created by the central bank comes into the system through AP and LTLO programs. Therefore, we modify equation (15) above as follows:

$$R^S = AP + LTLO + ML + AU \tag{21}$$

which is represented in Fig. 5, where the vertical segment shows the stock of base money issued through APs and LTLOs, as well as by the autonomous factors, up to some date. The figure is drawn under the assumption that $i_R = 0$, since QE policies have generally been implemented when the policy rates have reached the ZLB. Of course, the model holds also for positive levels of the interest paid on bank reserves.

The equilibrium in the money market, shown in Fig. 5, features a structural excess supply of bank reserves, labelled "excess liquidity". The amount of reserves accumulated through time, injected into the system through AP and LTLO programs, exceeds by far the needs of the banking system to settle payments and to meet regulatory reserve and liquidity requirements. This excess supply in the market for bank reserves exerts a downward pressure on their price, pushing it to the lower bound provided by the interest rate on reserves (i_R), which is the reservation rate for interbank deals. For this reason, this operational framework is called "floor system".

In a floor system, the money market equilibrium differs considerably from that of a corridor system. Instead of being stabilized at the center of the interest rate corridor, the market rate sticks to the bottom level, which coincides with the rate paid on bank reserves. The latter becomes the crucial policy rate, sending to market participants the signal about the target level for the O/N rate: $i^* = i_R$. Market participants are aware that the equilibrium in the interbank market features an excess supply, with the O/N interest rate sticking to $i^* = i_R$. Therefore, the central bank is able to affect market expectations: equation (1) still holds. However, the rationale behind that assumption differs now from Section 3: in the traditional framework it was the central bank's guarantee of making an

[19] Egea and Hierro (2019) argue that LTLOs are less effective than APs as a tool to increase the size of central banks' balance sheet. They document that the reliance on LTLOs has limited the transmission of the unconventional measures taken by the ECB to the real economy up to 2015, when it started the APP program.

active management of reserves in order to implement its target i^*; in the new framework it is the "satiation" of the market for bank reserves, of which market participants are aware.

The transition from the corridor to the floor system can occur gradually through time, and this is indeed what happened under the impulse of the 2007/2008 financial crisis in some countries. To show the point, let us assume that, starting from the equilibrium shown in Fig. 1, the central bank begins injecting large amounts of liquidity into the money market (through asset purchases and/or lending operations) and lowering the remuneration applied to bank reserves, possibly reaching the ZLB. The excess supply of reserves will make the market interest rate move downwards and eventually get close to the lower limit of the corridor (i_R). The upper limit (i_{ML}) may be lowered as well, but not necessarily by the same amount as the lower limit (actually, the ML facility becomes less relevant as long as the market equilibrium shifts from one with scarce reserves to one with excess reserves). As a consequence, the corridor of interest rates may become wider. Graphically, this policy implies a rightward shift of the vertical line, representing the stock of available bank reserves, until it will intersect the demand for reserves schedule in the horizontal region. Through this process, the money market equilibrium will converge to the equilibrium shown in Fig. 5. Under this regard, the floor system can be seen as a limiting case of the corridor system. In the euro area, for example, the introduction of the main refinancing operations with fixed rate full allotment in 2008 and the implementation of several large-scale longer-term refinancing operations between 2009 and 2012 created an excess liquidity able to drive the short-term interest rates close to the lower limit of the corridor, namely the rate applied to the deposit facility (which was set at zero and eventually at negative levels): those years can be seen as a transition phase from the corridor to the floor system.[20]

A crucial difference between the two operational frameworks, IRS/corridor system and QE/floor system, has to do with the *decoupling principle*. This works in one direction only under the IRS framework. The central bank can set different interest rate levels for the same stock of base money, but not viceversa: once a target has been set for the interest rate level, the supply of reserves has to be managed accordingly. Under QE, instead, this principle works in *both directions*, enabling the central bank to have an additional degree of freedom in managing monetary policy. It can set different interest rate levels for the same amount of liquidity created through its own operations. But it can also change the size of such operations, affecting the stock of base money, without altering the target level of interest rates. Therefore, the central bank has *two independent instruments* to implement and signal the stance of its policy: *interest rate* and *quantity of money*. By looking at Fig. 5 again, it is easy to see that the central bank can change the target level of interest rates (i^*) by changing the policy rate i_R, thus moving up or down the equilibrium point, without changing the amount of liquidity created through AP and LTLO operations. It can also alter the size of AP and LTLO programs while keeping the interest rate target unchanged: the vertical bar in R^S can be moved to the right or to the left without altering the equilibrium level of interest rate. This property derives from the existence of a large excess of bank reserves, acting as a buffer in the money market.

The existence of a large excess of reserves has another relevant implication. The volatility of the autonomous factors, affecting the stock of base money, does not have any significant impact on the money market equilibrium, thanks to the buffer provided by the excess reserves. Therefore, liquidity shocks are not expected to add any volatility to the money market rates in the floor system, contrary to what happens in the corridor system. This is why the O/N market rate is expected to exhibit a more stable pattern and to show smaller deviations (on average) from the policy rate under the floor system than under the corridor system: a prediction that will be tested empirically for the euro area in the next section. As a consequence, the ML facility does not play anymore an active role as a stabilizing tool for market rates.

For the same reason, in the QE framework there is no need to introduce a stabilizing tool, such as the reserve requirement together with the averaging facility, which instead used to play a relevant role under the traditional IRS framework. Consider also that in a floor system the demand for reserves is perfectly elastic in the relevant range of values, so there is no point in creating an artificial demand for reserves by imposing a regulatory requirement. Indeed, in some countries like the USA and UK the reserve requirement has been abolished altogether. It is still present in the euro area, but it does not play anymore a relevant role in the determination of the money market equilibrium. The present model of the operational framework under QE is able to account for both cases: whether the reserve requirement is present or not. In both cases, the demand for reserves shows a downward-sloping segment: as long as $i > i_R$, the net opportunity cost of holding reserves at the central bank is positive and the demand for reserves is an inverse function of such cost; the presence of a reserve requirement with an averaging facility may add some elasticity to the demand schedule. However, around the equilibrium point the net opportunity cost of holding reserves is zero ($i = i_R$), so $R^D \rightarrow \infty$: the demand schedule is horizontal.

Finally, the Negative Interest Rate Policy (NIRP) was adopted in recent years by the central banks of several countries: Japan, Sweden, Denmark, Switzerland, and the euro-area. Those central banks resorted to this policy, generally as a complement to QE measures, in order to expand further the stance of their policy, after lowering the level of interest rates down to zero. The NIRP can be introduced into our QE framework by assuming that the interest rate applied to bank excess reserves becomes negative: $i_R < 0$ (Fig. 5 should be modified accordingly).[21] The aim of this measure is to drive the interest rates in the money market into a negative territory, by exploiting the property of a floor system, where the equilibrium O/N rate is equal to the lower bound: $i^* = i_R$.

[20] For a detailed description of the transition from the IRS/corridor system to the QE/floor system and eventually to the new normal, in the euro-area and in other countries (USA, UK, and Japan) as well, see Baglioni (2024).

[21] In the euro area, the NIRP has been implemented by applying a negative interest rate on the DF and on the current account balances as well, to make such policy effective. To limit the burden of this measure on the banking sector, the ECB used to apply (until September 2022) a two-tier remuneration scheme for bank excess reserves: they were applied a zero rate of return up to some threshold level, beyond which they were applied the DF rate.

5. Which new normal?

QE policies have been implemented by several central banks to overcome the limitations of the traditional IRS framework in a world of low inflation and interest rates close to the ZLB. The strong inflationary pressures, arising between 2021 and 2022, have dramatically changed this picture and induced almost all central banks to end their QE programs and to start a "normalization" of their policy. During this process, they have rapidly raised the level of their policy rates, leading the general level of (nominal) interest rates well above the ZLB. In the "new normal", the level of short-term interest rates is again the operational target of monetary policy. This process raises an important issue: should central banks come back to the old IRS approach, relying on the corridor system, or should they continue to rely on the floor system as they have been doing during the QE experience?

To answer this question, we have to compare the corridor system and the floor system, building on the analysis of the previous sections. As we have seen, the corridor system relies on the active management of liquidity, given a structural shortage of bank reserves: the central bank has to implement a daily forecast of the net liquidity position of the banking system and to match that position with its open market operations. To the contrary, the floor system relies on a structural excess supply of reserves, making the fine tuning of the liquidity supply unnecessary. My claim is that the floor system is superior to the corridor system, for the following two reasons.

First, the ample reserves regime gives central banks one more degree of freedom in managing their policy. The above analysis has shown that in the corridor system the decoupling principle works one way only: in particular, there is only one amount of reserves able to meet the liquidity demanded by the banking system at a level of interest rate equal to the target set by the central bank. As a consequence, monetary policy cannot have two independent operational targets: interest rate level and quantity of (base) money. To the contrary, in the floor system the decoupling principle works both ways, implying that the central bank is endowed with two independent tools: interest rate policy and the balance sheet policy. These two instruments can be used to pursue the same target, e.g. price stability. As an alternative, they can be targeted to different final objectives: the level of the policy rate can be used to signal the stance of monetary policy, targeting some macroeconomic variables (price stability and full employment), letting the balance sheet policy address other issues.

Let me expand on the last point. In a floor system, the balance sheet policy can play a purely technical role, namely that of providing enough liquidity to keep the market for bank reserves "satiated" at the steady state, i.e. when the excess supply of reserves has been driven down to the minimum level needed to operate a floor system. But it can also be used to signal the stance of monetary policy: in such a case, the size of the central bank's balance sheet is used as an instrument to complement the interest rate policy. This role has become evident in the transition phase, when central banks have implemented their exit strategy from QE: the quantitative tightening (QT) has been added to the interest rate tightening during the normalization process. The degree of QT (defined by the share of proceeds from maturing securities which are not re-invested in similar securities and/or by the pace of asset sales) can be designed, together with the pace of interest rate increases, to set the overall degree of monetary restriction at the desired level. For example, the Fed decided in 2022 to use both the interest rate and balance sheet policies to implement a monetary restriction, by raising its policy rates and downsizing its own balance sheet.[22] The balance sheet policy can also be used to preserve the correct transmission of monetary policy: in the euro area, for example, the Transmission Protection Instrument (TPI) responds to the objective of limiting potential fragmentations of monetary conditions across member countries. Open market operations can be used to preserve the liquidity of specific market segments (e.g. Asset Backed Securities). Finally, the composition of the (corporate) securities portfolio held by a central bank can be managed to pursue sustainability goals: this goes under the name of "greening monetary policy".

The second reason why the floor system is superior to the corridor system is that in the former the ability of the central bank to keep the money market rates in line with the announced target level is higher than in the latter. As we noted above, the corridor system relies on the ability of the central bank to forecast the daily liquidity conditions of the banking system, and such forecasts are necessarily subject to some errors, due to the volatility of the autonomous factors affecting the stock of available bank reserves. In turn, these liquidity shocks introduce an undesired volatility of money market rates.[23] In the floor system, to the contrary, the liquidity shocks do not have any significant impact on the money market rates, since they are absorbed by the "buffer" provided by the excess supply of reserves. Therefore, the theoretical analysis of the previous sections enables us to state the following prediction: in the corridor system the volatility of the O/N market rate, around the target level set by the central bank, is expected to be larger than in the floor system.

This prediction can be tested for the euro area, by analyzing the volatility of the market rate Eonia (Euro Overnight Index Average) around the target level signaled by the ECB to market participants by announcing its policy rates. I will focus this empirical test on two periods: June 6, 2003–December 5, 2005 and March 16, 2016–September 17, 2019. The first one provides a sample (with 645 daily observations) for the corridor system. The second one provides a sample (with 897 daily observations) for the floor system. The criterion for selecting these two sample periods is the following. In both of them, the policy rates have been kept constant, so the

[22] See Fed (2022b). The pace of monetary restriction to be implemented through interest rate increases and reductions of its securities holdings has been decided afterwards by the FOMC with a "meeting-by-meeting" approach.

[23] ECB (2002) provides an estimate of the forecast errors made by the ECB itself: they account for about 30 % of the volatility of the autonomous factors, which is a remarkable size. As expected, the government's deposits with the Eurosystem are the main source of liquidity shocks and of forecast errors. Bindseil et al. (2006) stress that forecasting excess reserves is a significant challenge for the implementation of monetary policy and that even small forecast errors can have a significant impact on the level and volatility of short-term interest rates; they support this view with a model of bank reserve management and with data for the euro area.

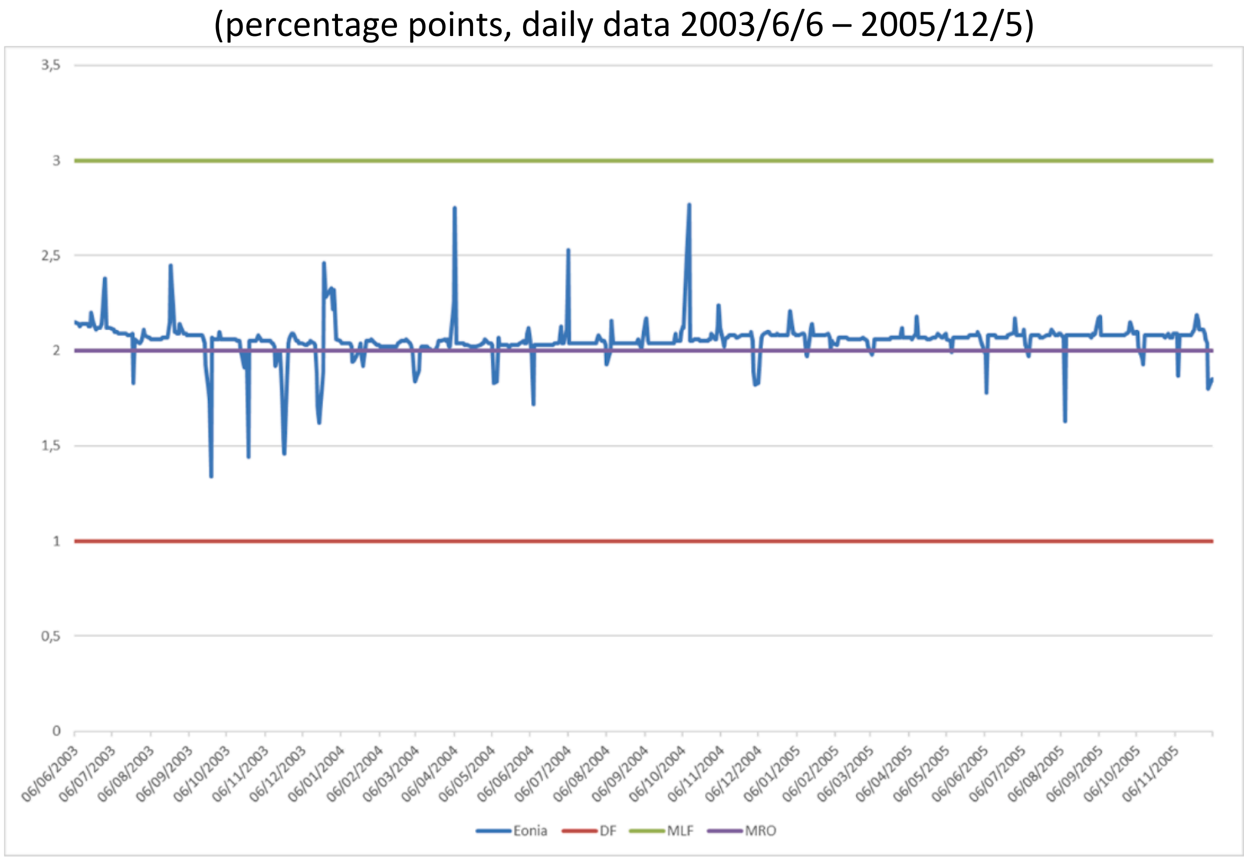

Fig. 6. Euro area: volatility of market rate in the *corridor* system (percentage points, daily data 2003/6/6–2005/12/5).

volatility of money market rates cannot be attributed to *ex ante* (anticipations) and *ex post* effects of changes in the stance of monetary policy. This criterion enables us to focus on the effectiveness of the operational framework, avoiding any interference possibly due to changes in the policy of the ECB.

As a preliminary analysis, we can look at the data reported in the following figures. Fig. 6 provides a picture of the corridor of interest rates for the first period: the Eonia rate shows a remarkable volatility around the policy rate (the MRO rate was the relevant policy rate at that time, when the ECB implemented its policy following the traditional IRS approach). Fig. 7 provides an analogous picture for the second period: except for a couple of spikes, the volatility of the Eonia rate seems to be much lower than in the previous period. Notice also that the relevant policy rate in the more recent period is the rate applied to the Deposit Facility: this is consistent with an operational framework relying on excess liquidity (floor system). Fig. 8 shows a plot of the spread (in absolute value) between the Eonia rate and the relevant policy rate for each of the two sample periods: the spread appears to be larger on average and much more volatile in the 2003–2005 interval than in 2016–2019.

The impression provided by the above pictures is confirmed by the statistical analysis reported in Table 1. In the 2003–2005 interval, the (absolute) spread between the Eonia rate and the policy rate was 8 basis points on average: it was half than that in the 2016–2019 interval. The difference in mean between the two sample periods shows a high statistical significance. There is also a huge and highly significant difference in volatility across the two periods. This evidence supports the prediction of the model that the ability of the central bank to keep the money market rates in line with the announced target level is higher in the floor system than in the corridor system.

A possible objection to the above analysis is that the volatility of the O/N market rate is heavily concentrated in the last days of the maintenance period, when the demand for bank reserves becomes more rigid since banks' treasury departments are more pressed by the need to meet the reserve requirement (as we have observed in Section 3). For this reason, the following robustness check has been done: the analysis has been replicated by dropping the observations in the last three days of each maintenance period throughout both the sample periods. The results are shown in Fig. 9 and Table 2. The volatility of the (absolute) spread between the Eonia rate and the

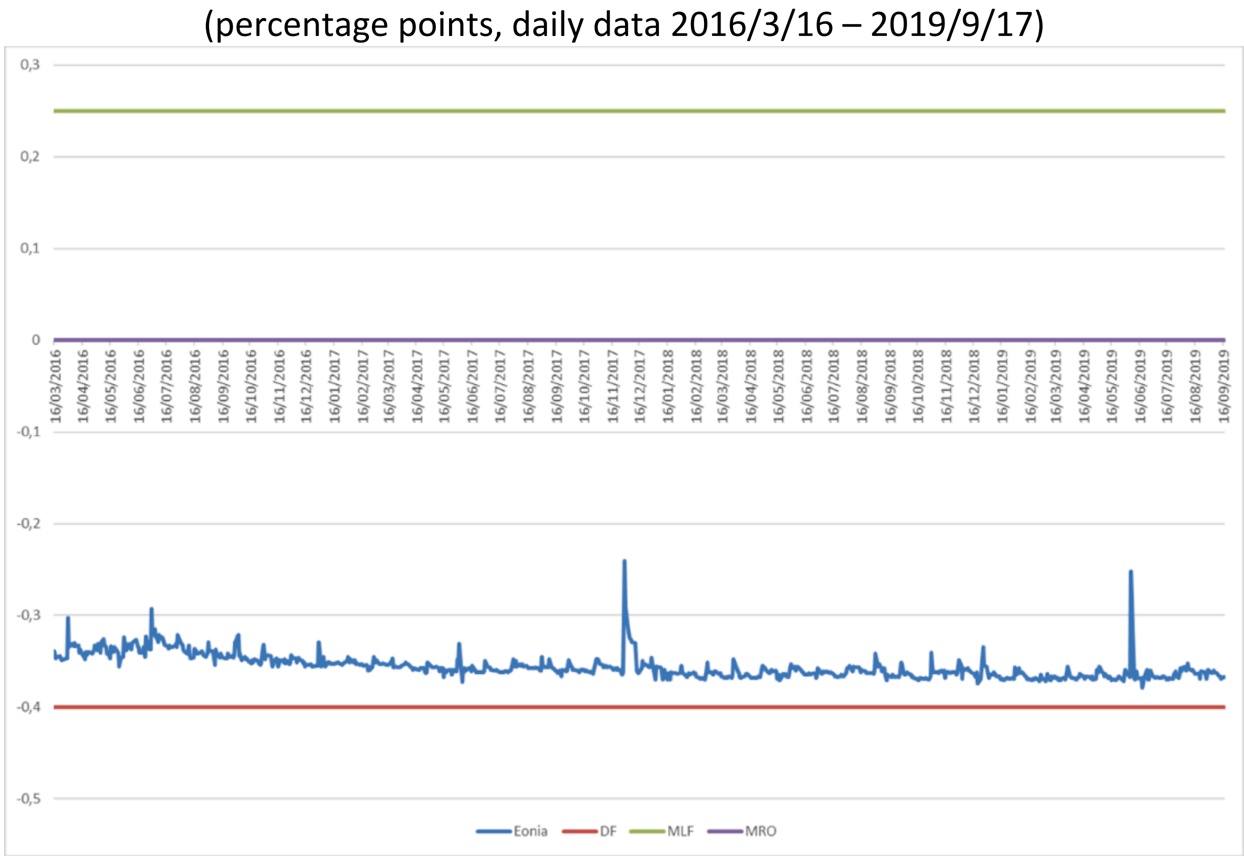

Fig. 7. Euro area: volatility of market rate in the *floor* system (percentage points, daily data 2016/3/16–2019/9/17).

policy rate shows a remarkable reduction in the 2003–2005 interval when the last three days of the maintenance period are dropped. Nevertheless, the difference in mean and volatility between the two sample periods remains large and highly significant, confirming the previous results. Notice also that dropping the last three days of the maintenance period does not have any impact in the 2016–2019 interval: this supports the view that the reserve requirement plays a much less relevant role in shaping the demand for bank reserves under the floor system than under the corridor system (see the discussion in Section 4).[24]

We are now in a position to answer the question raised at the beginning of this section: in the "new normal", following the QE era, should central banks implement their policy either in a corridor or in a floor system? The answer, based on the above arguments, is that the floor system is preferable. Therefore, monetary policy implementation should not come back to the traditional IRS approach. To the contrary, it should go towards a new normal that combines some features of that approach with others introduced during the QE era. More specifically, the new normal should exhibit the following features.

i) The level of interest rates is the primary operational target of monetary policy: the stance is identified and signaled by setting a target level for a short-term market rate, typically the O/N rate. However, the way in which this target is achieved is not the old IRS approach relying on the corridor system. The new normal should instead rely on the floor system. Therefore, the key policy rate is the interest rate paid on bank reserves (i_R in the model): by setting this rate, the central bank is able to affect the market rate.
ii) The market for bank reserves features a structural excess supply. The equilibrium of the interbank market can be represented as in Fig. 10. This is quite similar to Fig. 5, showing the money market equilibrium under QE: this is not surprising, since both the new normal and QE rely on the floor system. However, we can notice three relevant differences between them. First, in the new normal the policy rate (i_R) is generally at some positive level, following the interest rate tightening implemented during the exit process from QE policies. Second, OMOs replace APs and LTLOs: when AP and LTLO programs have been abandoned, the way to adjust the size of the central bank's securities portfolio, and of its balance sheet, is by using the standard OMOs. These can

[24] As a further robustness check, a Wilcoxon rank-sum test has been run on both samples: with and without the last three days of the maintenance period. In both cases, the null hypothesis of equal median across the two sample periods (2003–2005 and 2016–2019) is rejected with a very high statistical significance.

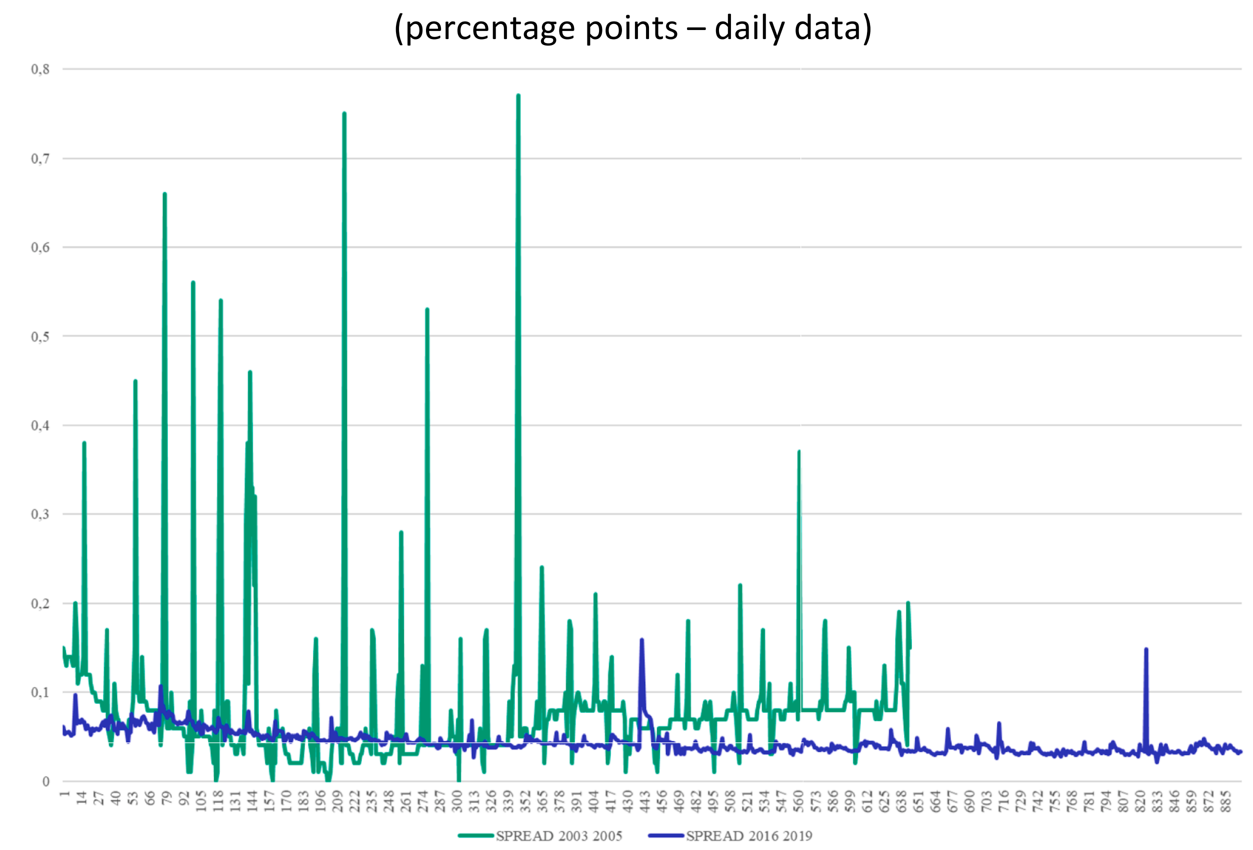

Fig. 8. Euro area: spread between market and policy rates (percentage points – daily data).

Table 1
Statistical analysis: full sample.

	Mean	Median	Stand.Dev.	Min - Max
Spread 2003–2005	0,08	0,07	0,08	0,00 – 0,77
(n. obs.: 645)	(95 % conf.int.: 0,07–0,09)			
Spread 2016–2019	0,04	0,04	0,01	0,02 – 0,16
(n. obs.: 897)	(95 % conf.int.: 0,04–0,05)			
t-test (with different variances)				
H_0: difference in mean = 0				
P-value = 0				
F-test				
H_0: difference in variance = 0				
P-value = 0				

include the (partial) reinvestment of the proceeds from maturing securities. Third, the structural excess liquidity is typically lower in the new normal than under the QE policy. The reason is that the purpose of central bank's operations is to keep the amount of liquidity at a level sufficient to maintain the market for reserves "satiated", accounting for the dynamics of the autonomous factors; they are not targeted at expanding the size of the central bank's balance sheet, as it used to be under QE.

iii) Balance sheet policies, altering the size and/or the composition of central bank's assets, remain in the toolkit of central banks. They can be used either to signal the stance of monetary policy, complementing the interest rate policy, or to pursue other targets, like the liquidity of specific market segments and the smooth transmission of monetary policy.

At this point, it may be useful to provide a schematic representation of monetary policy implementation under the three operational frameworks considered in this paper: see Table 3.

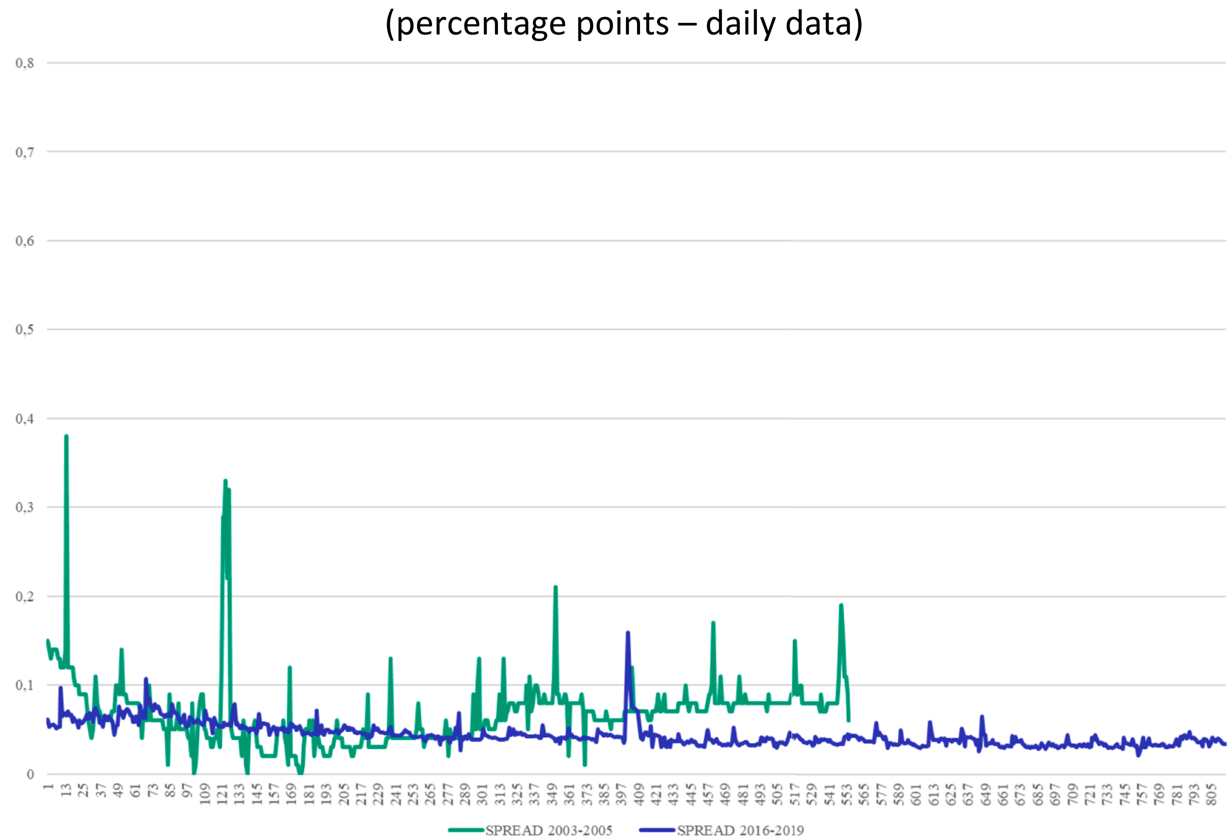

Fig. 9. Euro area spreads: dropping the last three days of the maintenance period (percentage points – daily data).

Table 2
Statistical analysis: dropping the last three days of the maintenance period.

	Mean	Median	Stand.Dev.	Min - Max
Spread 2003–2005 (n. obs.: 555)	0,07 (95 % conf.int.: 0,06–0,07)	0,07	0,04	0,00 – 0,38
Spread 2016–2019 (n. obs.: 815)	0,04 (95 % conf.int.: 0,04–0,05)	0,04	0,01	0,02 – 0,16
t-test (with different variances) H_0: difference in mean = 0 P-value = 0				
F-test H_0: difference in variance = 0 P-value = 0				

In the US, the floor system has already become the standard way of implementing monetary policy. In January 2019, the Fed made clear that this approach has replaced the old IRS framework.[25] Fig. 11 shows the basic features of the money market equilibrium in this new normal approach to monetary policy implementation. Through its open market operations (OMOs) the Desk of the New York Fed keeps the supply of reserves ample, so that the effective FF rate remains close to the floor of the system. Actually, the US system is a "two-floor system", due to the segmentation of the money market between banks and non-bank financial intermediaries, like the Government Sponsored Enterprises (GSEs) and the money market mutual funds. These non-bank intermediaries are not entitled to hold a remunerated account at the Fed. However, they can deposit money overnight at the Fed and receive an interest through reverse repos: these are operations by which the Fed sells securities to an intermediary and buys back those securities the next day. The interest rates applied by the Fed on bank reserves (i_R) and on reverse repos (i_{RR}) are the reservation rates for the two categories of participants in the money market: banks and non-bank intermediaries respectively. Since normally it is $i_{RR} < i_R$, banks can make profitable

[25] See Fed (2019).

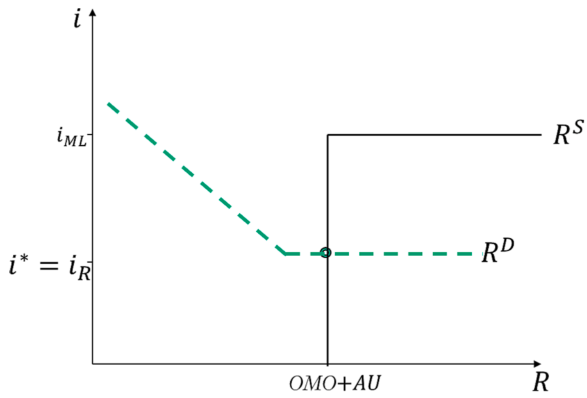

Fig. 10. The new normal.

Table 3
Operational frameworks.

	IRS	QE	New normal
Operational target	**Short-term interest rate**	Size of central bank balance sheet	**Short-term interest rate** (balance sheet policies still available)
Monetary control framework	Corridor system	**Floor system**	**Floor system**

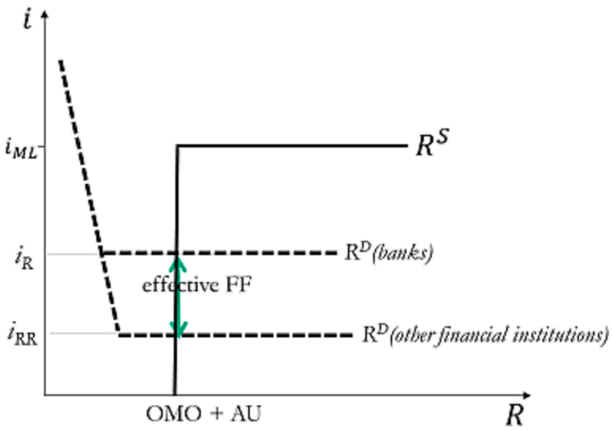

Fig. 11. USA: the *two-floor* system.

arbitrage trades by borrowing money from non-banks at rates below i_R and depositing that money on their current accounts at the Fed. These arbitrage trades keep the effective FF rate between the two "administered rates" set by the Fed (i_R and i_{RR}) delimiting the FF target range.

In the euro area, the ECB is currently implementing the normalization of its policy. Some elements of the "new normal" have been anticipated by the recent strategy review, namely: the level of short-term interest rates is its primary operational target, and asset purchases remain in its toolkit.[26] Through time, the floor system has *de facto* become the operational framework of the ECB and the rate applied to the DF has become its key policy rate, taking up the role that used to be played by the rate applied to the MROs in the past. This has been acknowledged in several documents and speeches by top ECB representatives.[27] Further details about the operational framework of the ECB in the steady state are expected to be released in 2024 as an outcome of the ongoing (as of end-2023) comprehensive review.

[26] See ECB (2021a,b).

[27] See, for example, the following statement: "In the current conditions of ample liquidity and full allotment in our main refinancing operations, the interest paid on the reserves that banks hold in the ECB's deposit facility is the Governing Council's main instrument for setting the monetary policy stance" (Letter from President C. Lagarde to some members of the European Parliament, September 22nd 2023).

6. Concluding remarks

This article is focused on the operational framework of monetary policy: it provides a simple model able to analyze the traditional IRS approach to monetary policy implementation and the more recent QE policies. In addition, and even more importantly, it addresses a crucial question: should the normalization of monetary policy, after the QE era, lead central banks to resume the old IRS approach? Or should they look for a new kind of operational framework?

The above analysis suggests that central banks should adopt a "new normal" that combines some features of the IRS approach with some innovations inherited from the QE experience. Monetary policy should be implemented by steering the level of interest rates, but under the framework known as "floor system", which has been introduced with QE policies, instead of relying on the old "corridor system". The floor system is superior to the corridor system for two reasons. First, it endows central banks with one more degree of freedom: the interest rate policy and the balance sheet policy are two independent instruments under this approach. Second, it enhances the ability of central banks to keep the money market rates in line with their target level. Both these points have been shown in the model presented in this paper, and the second one is supported by an empirical analysis of the money market in the euro area.

In some countries, like the US, UK and Canada, the outcome of the normalization process, namely a framework that relies on the floor system to steer interest rates, has been officially announced by their respective central banks.[28] In others, like the euro area and Japan, this is *de facto* the operational framework currently in place (as of 2023).

CRediT authorship contribution statement

Angelo Baglioni: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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[28] See Fed (2022a,b), Bank of England (2022), and Bank of Canada (2022).

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