3

MONETARY POLICY DESIGN IN THE MEDIUM AND LONG TERM

Summary

The response to the global financial crisis of the main advanced economies' central banks has significantly impacted both their interest rates and their balance sheets. At the onset of the crisis central banks reduced their interest rates to historically low levels. These were even negative in some cases, such as in the euro area. Interest rates in the advanced economies currently remain at or near their record lows, a situation which could persist in the future. Also, as the leeway for further cuts in interest rates narrowed, the main central banks initiated a policy of balance sheet expansion, reaching historically high levels. This chapter analyses the possibilities, challenges and dilemmas posed by these two aspects (low interest rates and a large balance sheet) for a monetary policy design in the medium and long term.

Interest rates may fluctuate in the future around levels that are lower than before the crisis and, therefore, closer to the effective lower bound (ELB). And in this respect, central banks will have less room to cut rates in response to future crises. This chapter shows that the current low interest rate environment in the advanced economies is linked to structural factors, such as the progressive ageing of the population and moderate productivity growth. Indeed, the situation could continue – or even be compounded – in the future if current demographic projections are confirmed. This has led some central banks to discuss possible alternatives to the current monetary policy strategy (consisting of inflation targets with a 2% reference level), responding to the ELB constraint by, for instance, raising the numerical inflation target or setting a goal in terms of price levels. The analysis conducted in this chapter shows that these strategies may prove useful in alleviating the ELB constraint on monetary policy, while noting their costs and limitations.

In the medium and long term, central banks face the strategic decision of maintaining the size of their balance sheets at levels similar to those at present or of bringing them back to the pre-crisis trend, and of choosing the appropriate composition of the assets and liabilities in their balance sheets. This chapter analyses the pros and cons of maintaining a large balance sheet and of preserving the current "floor" system with money market yields very close to the remuneration of reserves. In particular, the advantages of a floor system, in terms of better control of market interest rates, are noted. However, in the case of the Eurosystem, in principle it would be possible to maintain such a system with a lower volume of reserves than at present. The possibility of changing the term structure of the balance sheet (especially important in the case of a large balance sheet) by reducing (lengthening) average asset (liability) terms is also analysed.

1 Introduction

In response to the global crisis, the main central banks reduced their interest rates to historically low and even negative levels. The global financial crisis and the ensuing economic recession in the main advanced economies had notable implications for economic policy. As to monetary policy, the severity of the crisis led central banks to drastically cut their benchmark rates as from 2008, reaching levels close to zero (see Chart 3.1.1). In recent years, monetary authorities such as the European Central Bank (ECB) and the Bank of Japan have lowered their benchmark rates to levels which are even negative.

Also, as the leeway for further cuts in interest rates narrowed, the main central banks initiated a policy of balance sheet expansion, reaching historically high levels. As interest rates came closer to their ELB,[1] central banks began to use a series of unconventional tools, such as forward guidance and quantitative easing to achieve a higher degree of monetary expansion.[2] Forward guidance polices aim to guide economic agents' expectations about future changes in short-term interest rates in order to maintain medium- and long-term interest rates at moderate levels. Quantitative easing measures, such as large-scale asset purchases and liquidity- and financing-providing operations for banks, have given rise to an unprecedented expansion of the liquidity provided to credit institutions and of the size of the main central banks' balance sheets (see Chart 3.1.2).

The current low interest rate environment, which could persist in the future, poses a significant challenge for monetary policy. Central banks face a new scenario where their interest rates will probably fluctuate at lower levels than in the past and, therefore, closer to their lower bound. Should this scenario be confirmed, the scope for reducing interest rates in response to future crises would be restricted. The unconventional measures adopted as a result of the crisis have shown some effectiveness in responding to situations in which conventional monetary policy is restricted by the ELB.[3] However, insofar as the scenario of recent years persists, with inflation systematically lower than the medium-term price stability references, considering alternative monetary policy strategies might be advisable.

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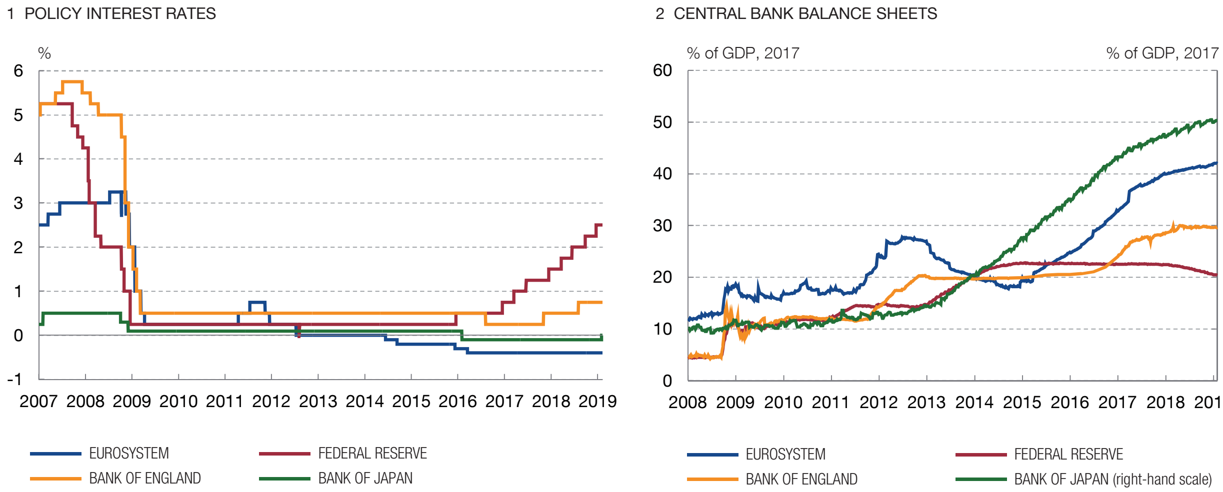
1 The effective lower bound on interest rates is a consequence of the fact that if the remuneration of deposits is sufficiently negative, economic agents may prefer to withdraw them in cash (with zero remuneration). The ELB is below zero owing to intrinsic costs and risks associated with banknote storage (security, risk of loss or theft, etc.).

2 For a detailed analysis of the monetary policy response to the crisis in the euro area, see Banco de España (2016).

3 In the case of the ECB, the end of net purchases under the asset purchase programme (APP) at end-2018 led to a phase of reinvestment of the principal payments from maturing securities for the purpose of maintaining the programme portfolio constant and prolonging the programme's monetary stimulus. These reinvestments, together with the forward guidance on the future path of interest rates, have become one of the ECB's main stimulus tools. For a detailed analysis of the role of these two tools in providing monetary accommodation in the current setting, see Arce, Nuño and Thomas (2019).

Chart 3.1
THE CRISIS FORCED CENTRAL BANKS TO NAVIGATE "UNCHARTED WATERS"

The main central banks reduced their interest rates to close to zero or even negative levels; at the same time, they increased the size of their balance sheets through asset purchase programmes.



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SOURCES: Datastream, ECB and Banco de España.

Central banks also face the dilemma of maintaining the size of their balance sheets at levels similar to current ones or of reducing them to pre-crisis levels. In the short term, the main central banks' decisions about their balance sheets (particularly those relating to their current asset purchase programmes or to bank refinancing) will be determined by the changes in their inflation and growth forecasts. In the medium and long term, however, central banks face the strategic decision of maintaining the size of their balance sheets at current levels (or at least at substantially higher levels than before the global crisis) or of bringing them back to sizes consistent with the pre-crisis trend. In parallel, there is debate about the appropriate composition of the balance sheet's assets and liabilities.

The foregoing challenges are currently the subject of an incipient debate about the design of monetary policy in the medium and long term in what has been called the "new normal" in monetary policy after the crisis. This chapter aims to show the guiding principles of that debate, including the main theoretical and empirical arguments.

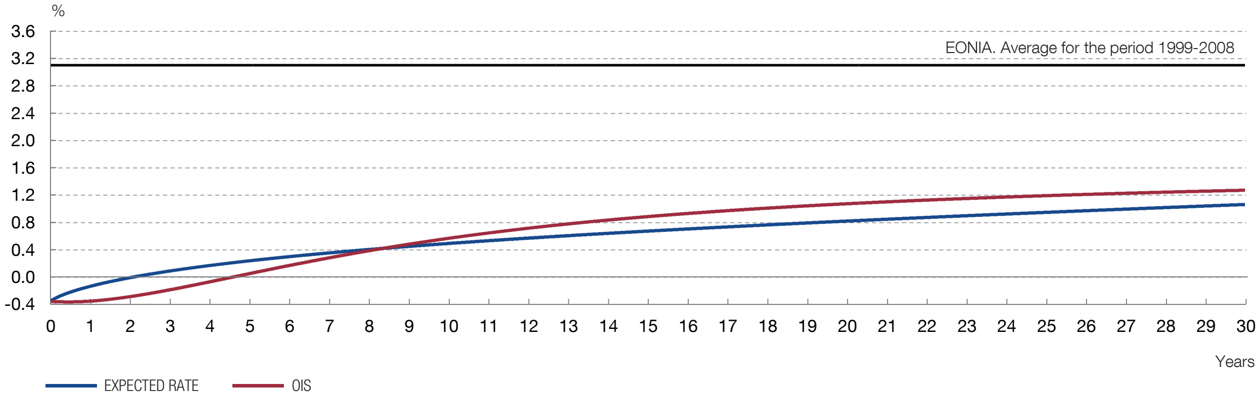
The next section reviews in depth the issues relating to the scenario of persistently low interest and inflation rates and how the monetary authorities can tackle them in the future. The third section addresses the issue of size and the composition of central banks' balance sheets, analysing different arguments for and against maintaining size at levels similar to current ones and about the most desirable

Chart 3.2

MARKETS EXPECT LONG-TERM INTEREST RATES FAR BELOW THE HISTORICAL AVERAGE

In the context of fixed-income securites, such as government bonds, the yield curve is the relationship between the term to maturity of the securities (for example, one month, one year, two years, etc.) and the return (annualised) offered for this maturity. The yield curve generally has two components: the "expectations" component (that is, the average expected short-term interest rate over a given horizon) and the "term premium" component, which reflects the compensation demanded by investors for "term risk", that is, the risk of holding medium/long-term fixed-income securities in light of the fluctuations in their market price over their life. The chart suggest that, in the case of the euro area, the markets expect the EONIA indicator (considered to be the ECB's implicit operational target) to remain at below 1% in the coming decades, clearly below the average for this indicator up to 2008 Q3 (3.1%).

1 OIS YIELD CURVE (AT 29.2.2019) AND EXPECTATIONS COMPONENT (a)



SOURCE: Banco de España.

a The instantaneous forward yield curve of the OIS is calculated on the basis of the prices negotiated in the OIS contracts, which represent the EONIA rate that should be applicable at any future time for these contracts not to imply payment between the parties concerned. The interest rate expectations were obtained from a term structure model in which the parameters follow an ARFIMA-type structure.

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composition of the asset- and liability-sides of the balance sheet. The last section draws conclusions and describes some possible monetary policy lessons for the future.

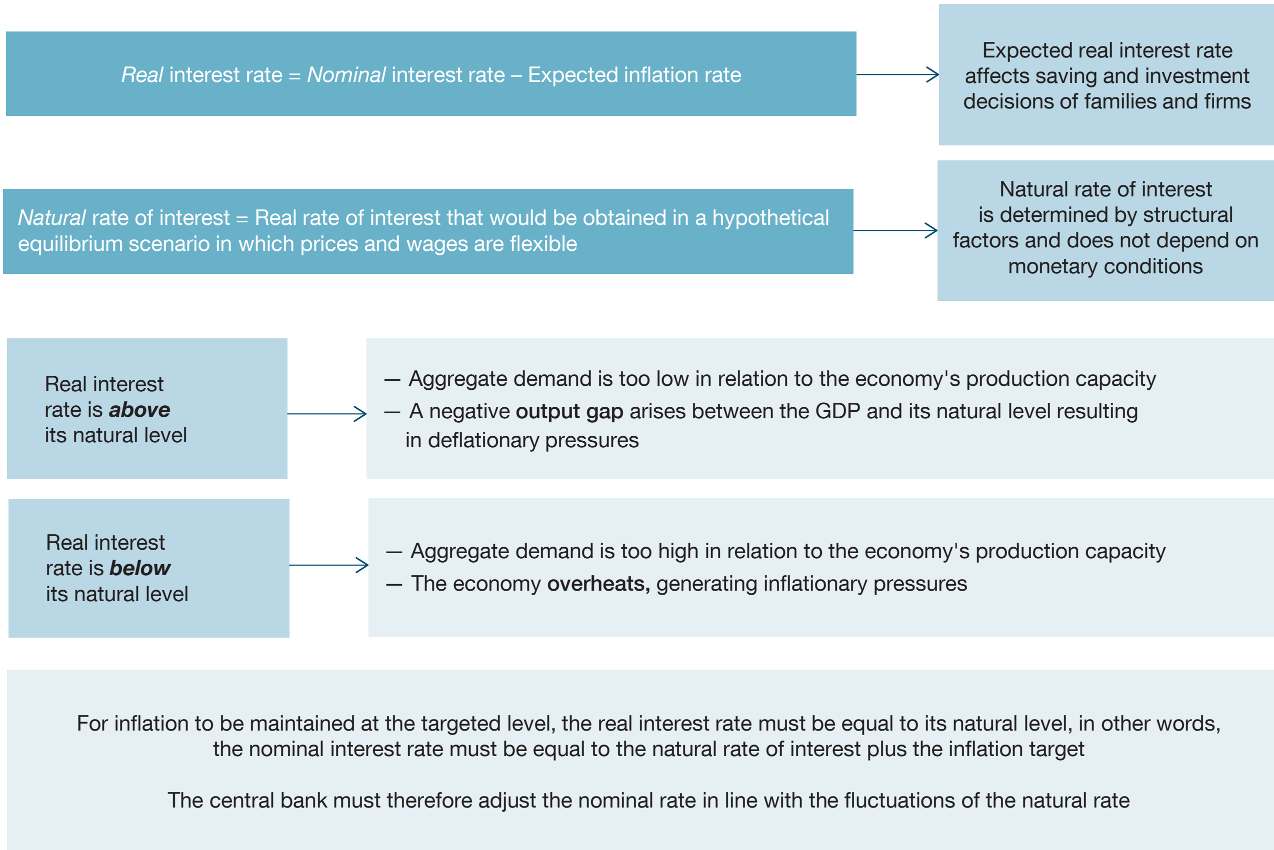
2 Monetary policy strategies in a low interest rate environment

Central bank interest rates in the main advanced economies are currently very low, a situation that could persist for some time. In some economies, such as the euro area and Japan, interest rates remain at historically low levels. In others, such as the United Kingdom and, particularly, the United States, interest rates have normalised somewhat, but remain at relatively moderate levels. Looking ahead, the information contained in the term structure of interest rates (or “yield curve”) of different currencies suggests that, according to market expectations, short-term interest rates will, in the coming years, continue to be substantially lower than the average values before the economic crisis (see Chart 3.2 for the euro area). Should these projections be confirmed, central bank rates will, in the coming years, fluctuate around levels that are closer to their respective lower bound, entailing less leeway

Figure 3.1
MONETARY POLICY AND THE NATURAL RATE OF INTEREST

With inflation targeting, monetary policy aims to maintain inflation at a certain level, for which purpose the central bank manages the nominal interest rates.

RELATIONSHIP BETWEEN NOMINAL, REAL AND NATURAL INTEREST RATES



SOURCE: Banco de España.

for central banks to cut interest rates in response to future economic crises. This section analyses the possible determinants behind low interest rates, and the monetary policy strategies that could be adopted to alleviate the ELB constraint.

In order to understand why nominal interest rates are so low, it is useful to look at the concept of the *natural rate of interest* (see Figure 3.1). The interest rate that is important for the savings and investment decisions of households and firms is the expected real rate of interest, which is the difference between the nominal interest rate and expected inflation. In the framework of the macroeconomic models used by most central banks, and which are based on the neo-Keynesian paradigm, *the natural rate of interest* is the real rate of interest that would be observed in a hypothetical equilibrium scenario in which prices and wages are flexible (also referred to as the “natural equilibrium”). The importance of this concept stems from the fact that when the real interest rate rises above its natural level, aggregate demand is too low in relation to the economy’s production capacity; in other words, a negative “output gap“ arises between the GDP and its “natural” level, resulting in deflationary pressures. Conversely, when the real interest rate falls below the natural rate, the economy “overheats”, generating inflationary pressures. Thus, to ensure that inflation is equal to its target at all times, the real interest rate must always reproduce the behaviour of the natural interest rate. That is to say, the nominal interest rate must be equal to the natural interest rate plus the inflation target, so that the central bank adjusts the nominal rate in line with the fluctuations of the natural rate.[4]

In general, the estimated natural rate of interest is an important reference for monetary policy strategies based on an inflation target. In practice, the relationship between the interest rate, aggregate demand and inflation is far more complex than in the standard neo-Keynesian model. However, the natural rate of interest is an important reference when determining central banks’ interest rate policy. Consequently, the central banks that have managed to stabilise inflation around the target have, to a certain extent, adjusted their nominal interest rates in line with the estimated behaviour of the natural rate in their respective economies.[5] In this respect, the natural rate is a major determinant of changes in the benchmark nominal interest rates.

Most estimates of the natural rate of interest show a significant decline in the recent period. By definition, the natural rate of interest is not observable, but is defined in terms of a hypothetical equilibrium where prices and wages are flexible which, in practice, cannot be observed either. But it is possible to proxy the behaviour of the rate using econometric models (albeit with a notable degree of uncertainty in most cases). In general, these models find that the natural rate of interest has declined significantly in recent decades, to historically low, even negative, levels.[6]

By way of example, Chart 3.3 shows the changes in the natural rate in the main advanced economies, estimated using one of these models (see Box 3.1 for a description of the model and its estimates of the natural rate of interest in several advanced economies). In the euro area, the current natural rate is probably negative and even below -1%. If this situation persists, given the ECB’s medium-term inflation target (below, but close to, 2%), the nominal policy rate would converge in the future towards average levels of less than 1% and would leave relatively little room to cut interest rates to respond to future crises. In the euro area, although the ECB’s interest

4 For a detailed analysis of the natural rate of interest and its implications for monetary policy, and a description of the relationship between the natural rate of interest and inflation in the context of the basic neo-Keynesian model, see Galesi, Nuño and Thomas (2017).

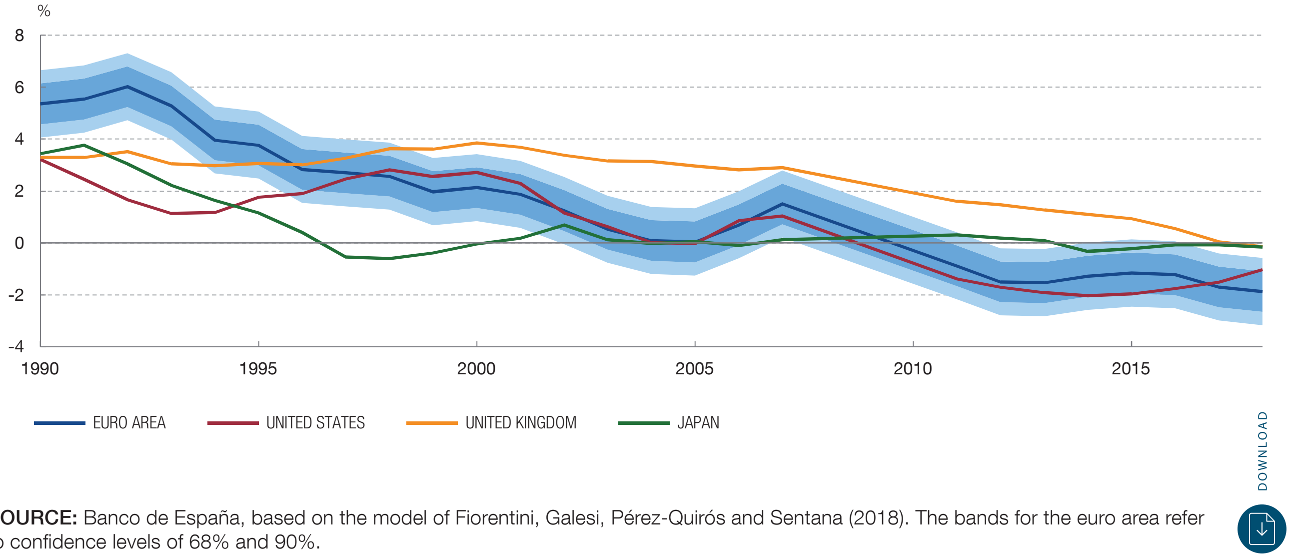
5 See, for example, Cúrdia, Ferrero, Ng and Tambalotti (2017).

6 Holston, Laubach and Williams (2017), for example, estimate that the natural rate in 2016 was positive but very close to zero in the United States, and *negative* in the euro area. Brand, Bielecki and Peñalver (2018) present various estimates with similar results.

Chart 3.3

CHANGES IN THE NATURAL RATE OF INTEREST IN THE MAIN ADVANCED ECONOMIES

This chart shows the changes in the natural rate in the economies of Japan, United States, United Kingdom and the euro area, including the confidence bands of the euro area estimate.



SOURCE: Banco de España, based on the model of Fiorentini, Galesi, Pérez-Quirós and Sentana (2018). The bands for the euro area refer to confidence levels of 68% and 90%.

rate policy has shown that the lower bound is not zero, but a negative value,[7] it is reasonable to assume that this bound is not distant from the current level of the interest rate on the ECB's deposit facility [-40 basis points (bp)]. This means that if the lower bound is below 1%, the leeway for cutting interest rates would most likely be less than 150 bp.

The economic literature mentions several reasons for the sustained decline of the natural rate in recent decades (see Figure 3.2).[8] Various papers agree on the essential role played by ageing in advanced economies, as analysed in Chapter 4. Specifically, factors such as the gradual increase in life expectancy and the falling birth rate are thought to have pushed down the real rate of interest. The increased life expectancy prompts current employees to save for their retirement, while the lower birth rate increases the capital intensity per employee and, consequently, reduces the return on capital. Both these factors would lead to a reduction in the real return on savings.[9] Other authors attribute the drop in the natural rate to a secular

7 In particular, the ELB is below zero owing to the costs and the risks associated with banknote storage (security, risk of loss or theft, etc.).

8 See Summers (2014) for a seminal discussion of the possible determinants of the fall in the natural interest rate and the implications for monetary policy in relation to the lower bound of interest rates. For two extensive analyses of the natural interest rate and the factors determining its historical trends, see Rachel and Smith (2015) and Brand, Bielecki and Peñalver (2018).

9 For modelling of the demographic effects on the natural rate, see Eggertsson and Mehrotra (2014), Eggertsson, Mehrotra and Robbins (2019) and Carvalho, Ferrero and Nechio (2016).

Figure 3.2
RECENT DEVELOPMENTS IN THE NATURAL RATE OF INTEREST

The natural rate of interest is unobservable and is therefore estimated using econometric models. Chart 3.3 shows changes in the natural rate of interest in the main advanced economies, estimated using one of these models (see Box 3.1 for a description of the model). In recent years, the natural rate of interest has gradually declined and is currently estimated to be negative in the euro area.

FACTORS UNDERLYING THE DECLINE IN THE NATURAL RATE OF INTEREST

DEMOGRAPHIC FACTORS

— The gradual increase in life expectancy encourages current employees to save for their retirement

— Falling birth rates increase the capital intensity per employee and, consequently, reduces the return on capital

ECONOMIC FACTORS

— A secular decline in the productivity growth rate

— Excess demand for financial assets in emerging economies

— Widespread shortage of assets that are perceived to be safe, against a background of strong aversion to risk

SOURCE: Banco de España.

decline in the productivity growth rate, to excess demand for financial assets in emerging economies or to a widespread shortage of assets that are perceived to be safe, against a background of strong aversion to risk, partly due to the latest global financial crisis.[10]

Some of the determinants of current low interest rates may be of a temporary nature. In part, the (recent) drop in the natural rate may be a temporary phenomenon (which will foreseeably persist), linked to the private-sector deleveraging process triggered by the financial crisis and the consequent scant demand for credit. As this process subsides and gives way to a new phase of credit and investment growth, the natural rate may return to values that are higher than the present ones.[11]

Looking ahead, the factors mentioned above will play a key role in the future path of the natural rate of interest. There is considerable uncertainty about future behaviour of factors such as productivity growth or the shortage of safe assets.

10 Regarding the secular decline in productivity, see Gordon (2015). The excess demand for assets in emerging economies is discussed, for example, in Bernanke (2005) and Caballero, Farhi and Gourinchas (2008). The shortage of safe assets is analysed in Caballero and Farhi (2017). Although it is difficult to quantify the relative significance of each of these factors, it is important to note that demographic developments do not sufficiently explain the behaviour of natural interest rates, since in countries with lower birth rates and older populations, such as Japan, natural rates tend to be similar to those of other economies with more favourable population dynamics, such as the United States.

11 See Rogoff (2015).

However, demographic developments are more predictable. In this regard, the outlook among the advanced economies is, on the whole, unfavourable and points to further falls in the natural rate in coming decades.[12] In Box 3.2, a macroeconomic model is used to simulate the future path of the natural rate of interest in the euro area, conditional on demographic patterns in the model which are consistent with those observed in recent years, and with several official projections.[13] This analysis which, by its very nature, is subject to a high degree of uncertainty, suggests that the worsening demographic prospects may have reduced the natural rate by close to 2 percentage points (pp) since 2007, and may drive it down further, by almost 1 pp, by 2030.

While natural rates remain at low levels, monetary policy will have less room than in the past to cut rates in response to adverse shocks in the future. The foregoing analysis suggests that if the fall in the natural rate is not reversed or becomes more pronounced in the future, central bank interest rates will tend to fluctuate around levels that are lower and, therefore, closer to their ELB. The central bank cannot reduce interest rates to levels below the ELB, since this would intrinsically entail the widespread withdrawal of cash deposits by economic agents (with the consequent negative impact on the financial system). This could represent a major obstacle for the stabilising capacity of conventional monetary policy instruments. When, in a low inflation scenario (following an economic recession, for example), a central bank cannot further reduce its interest rate because it already stands at its lower bound, the real rate of interest tends to rise above its natural level, generating deflationary pressures which further increase the real rate. In turn, this tends to depress aggregate demand and, by further reducing inflation, makes it even more difficult to return to the target set by the monetary authority.[14]

In recent years there has been an intense debate as to how the basic monetary policy strategy might be modified so as to reduce the impact of the ELB for the interest rate (see Figure 3.3). In most of the advanced economies, the monetary policy strategy is based on the existence of a numerical inflation target (a strategy known as inflation targeting).[15] Some authors consider that the new instruments adopted during the recent crisis by central banks, such as large-scale asset purchase programmes and forward guidance, mean that the effective lower bound

12 For an analysis of the future behaviour of the theoretical determinants of the natural rate of interest, such as demographics and productivity growth, see Jimeno (2015).

13 Specifically, it uses the model proposed by Basso and Rachedi (2018).

14 In addition to the drop in the natural rate and the constraint of the ELB, there are other structural factors that would be exerting downward pressure on inflation in the euro area and other advanced economies. For a detailed analysis of these structural factors, see Chapter 2 of this Report.

15 In some cases, such as that of the US Federal Reserve, there is a dual mandate, which requires the achievement of full employment, in addition to the stabilisation of inflation.

Figure 3.3
MONETARY POLICY STRATEGIES IN A LOW INTEREST RATE ENVIRONMENT

LIMITS OF CONVENTIONAL MONETARY POLICY WHEN NATURAL INTEREST RATES ARE LOW

Households and businesses can save in cash if the interest rates on deposits are too low

The central bank cannot lower nominal interest rates below the effective lower bound (ELB)

In a low natural interest rate environment conventional monetary policy will have less room to respond to adverse shocks

MONETARY POLICY STRATEGIES TO REDUCE THE IMPACT OF THE ELB

INFLATION TARGETING WITH QUANTITATIVE EASING (QE) AND FORWARD GUIDANCE (FG)

This is the current strategy of the main central banks

QE = Using the central bank's balance sheet to influence medium and long-term interest rates

FG = Communicating the details of future monetary policy to influence inflation expectations

RAISING THE INFLATION TARGET

Raising the inflation target from the current level of 2% to 3% or 4%

— Equivalent to raising the nominal interest rate in the long term and, thus, its distance from the ELB

PRICE-LEVEL TARGET (PLT)

Settting the monetary policy target in terms of a path for the price level (instead of its rate of change, i.e. inflation)

— This means that below-target inflation rates must be offset for a time by above-target inflation rates

— Temporarily higher inflation expectations reduce the real interest rate and boost aggregate demand

TEMPORARY PLT

Operating a PLT only during episodes in which the ELB is binding and inflation falls below target

— Inflation targeting continues to be applied in normal times

SOURCE: Banco de España.

for interest rates is not such a pressing problem and that the current monetary policy framework can be kept broadly unchanged.[16] Indeed, as explained below, the discussion has generally focused on proposed modifications to key aspects of the current strategy.

16 See, for example, Swanson (2018).

One possibility is to raise the numerical inflation target. Raising the inflation target from its current level in the main advanced economies of 2% to, for example, 3% or 4%, would have the advantage of increasing the nominal interest rate in the long term and, thus, its distance from the ELB.[17] The current 2% reference rate was, in many cases, set at a time when interest rates had been fluctuating at levels substantially higher – and therefore more distant from their lower bound – than the present ones. Thus, a priori, the selected target entailed sufficient scope for any necessary interest rate cuts.[18] This latter consideration has been widely called into question as a result of the experience of recent years and the evidence mentioned above of a secular decline in the natural rate of interest.

However, the inflation target cannot be raised without costs and distortions, which means that the optimal level of inflation is the subject of intense debate. In a standard neo-Keynesian model, in the absence of the ELB constraint, the optimal inflation target is zero. This is because non-zero inflation generates distortions owing to the inefficient dispersion in the relative prices of consumer goods.[19] When the possibility that monetary policy may be constrained by the ELB is taken into account positive inflation targets can be justified. In the past, studies of this type have prescribed relatively low inflation rates, typically of less than 2%.[20] However, more recent studies have questioned this conclusion, using various arguments. First, according to the evidence provided by microeconomic data, the models employed tend to overestimate the impact of inflation on relative price dispersion.[21] Second, the optimal inflation rate depends on the level of the natural rate of interest. Specifically, the lower the natural rate of interest the higher the optimal inflation rate, since more room for manoeuvre is needed above the ELB. Recent studies that take into account the empirical evidence on price dispersion and the recent decline in the natural rate tend to prescribe higher inflation targets than those currently in force.[22]

Apart from those deriving from price dispersion, there are other costs associated with raising the inflation target. These costs include the increase in the opportunity cost of holding cash (i.e. the nominal interest rate) and distortions arising from taxes

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17 See, for example, Blanchard, Dell'Ariccia and Mauro (2010) and Ball (2014).

18 In the case of the ECB, the 2003 decision to set a target of «below, but close to, 2%» was based on an analysis that weighed the benefits of higher inflation - in terms of alleviation of the ELB constraint - against the associated costs (ECB, 2003). This analysis was based on the assumption of a natural interest rate of between 2% and 3%, well above the current estimates of the natural rate in the euro area (see, once again, Chart 3.3).

19 See Woodford (2003).

20 See, for example, Coibion, Gorodnichenko and Wieland (2012).

21 See, for example, Nakamura, Steinsson, Sun and Villar (2018) for an empirical analysis of the costs of inflation.

22 For example, Blanco (2018) finds that the optimal inflation rate would be around 3%. Andrade *et al.* (2018) study the optimal inflation target as a function of the long-term natural rate of interest.

and subsidies that are not inflation-indexed.[23] Also, a rise in the average level of inflation may lead to higher inflation volatility and, ultimately, to a deanchoring of inflation expectations.[24] In any event, raising the inflation target means that the costs of higher inflation must be borne at all times, even when interest rates are far from the ELB, a less efficient outcome than under other strategies that only entail relatively high inflation around episodes of a binding ELB, which are discussed below.

Another option currently being analysed by academics and central bankers is to use the price level as the target variable rather than the inflation rate (so-called price-level targeting (PLT)).[25] To understand how this strategy works, consider a situation in which the price level falls below the trend set as target for this variable or, what amounts to the same, in which the inflation rate falls temporarily below the rate consistent with that trend.

This will typically occur in a scenario like that of recent years, in which, as a result of a sufficiently severe recession, interest rates are temporarily constrained by the ELB and the central bank has difficulty preventing inflation from falling below its "target" (understood here as the rate of increase of the target path around which the price level is to be stabilised). As the PLT regime requires that the price level return to its announced path, the negative deviation of inflation from target must subsequently be offset by above-target inflation rates for a time (see Chart 3.4). By contrast, once inflation has returned to target there is no need for such offsetting under inflation targeting. While interest rates are constrained by the ELB, a PLT strategy automatically generates expectations of the high future inflation required to return the path of prices to the target trend. Such expectations reduce real interest rates, which stimulates aggregate demand and, consequently, reduces the duration of the ELB episode.[26]

Given that it operates through agents' expectations, the effectiveness of a PLT strategy depends crucially on its credibility. Under PLT, periods of above-target inflation will subsequently be offset by periods of below-target inflation. In so far as the latter require, in certain circumstances, a contractionary monetary

23 See, for example, Feldstein (1997).

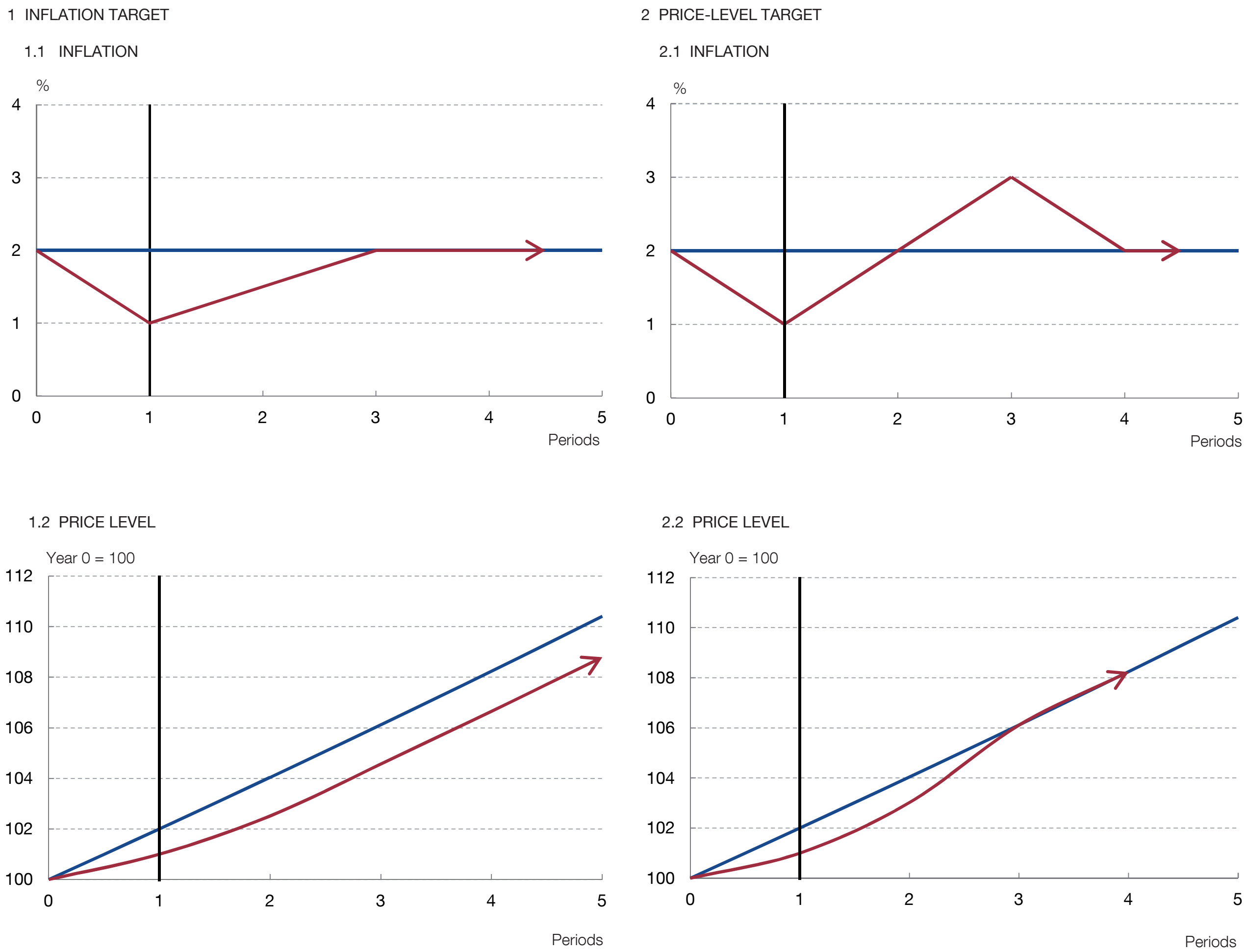
24 See e.g. Ascari, Florio and Gobbi (2017). A further challenge involved in raising the inflation target relates to its credibility in the current low inflation environment. In an environment characterised by inflation rates persistently below the 2% reference rate in the euro area and other advanced economies, economic agents may doubt the ability of central banks to achieve higher inflation targets, which might hamper the achievement of the new target.

25 For a discussion of the PLT strategy, see, for example, Williams (2017).

26 The stabilising advantages of PLT are endorsed by the fact that, in the standard neo-Keynesian model, a flexible PLT strategy (which permits temporary deviations from the target path and also takes into account output gap stabilisation) is very similar to the optimal monetary policy, and in particular to the optimum in the context of a binding ELB. See Eggertsson and Woodford (2003).

Chart 3.4
PRICE OR INFLATION TARGET?

Description of the differences between a strategy of inflation targeting and a strategy of price-level targeting. The chart shows how inflation and prices should react to an unexpected fall in inflation in year 1.



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SOURCE: Banco de España.

policy with negative consequences for output and employment, the credibility of this commitment may be questioned. Heeding this criticism, some authors have proposed a “temporary” or asymmetric PLT regime, which would only be applied in episodes in which inflation falls below target owing to a binding ELB episode. Thus, the central bank would commit to maintaining an above-target inflation rate in future, until the price level converges with the path prior to this episode.[27] In

27 See Bernanke (2017b).

"normal" times, this regime operates in the same way as conventional inflation targeting.[28]

Box 3.3 uses a macroeconomic model to simulate the effects of the strategies described above, in a context in which, as a result of recurrent negative shocks, monetary policy is frequently constrained by the ELB.[29] The analysis shows that raising the inflation target may indeed reduce both the frequency and duration of binding ELB episodes and the losses of economic activity associated with such episodes. However, as already mentioned, this strategy is not cost-free. By contrast, a PLT regime has similar benefits to those of raising the inflation target, without incurring the costs associated with this latter strategy. The temporary PLT strategy operates in a very similar way to permanent PLT around periods with a binding ELB, but outside such periods it behaves similarly to the current inflation targeting regime, giving rise on average to a certain inflationary bias. Finally, it is shown that policies involving balance sheet expansion by means of asset purchases, of comparable size to that of the programmes implemented in the Eurosystem, may also reduce the frequency and severity of binding ELB episodes.

In conclusion, the current monetary policy strategy, with inflation targets of 2% in most advanced economies, is facing a growing challenge from the interest rate lower bound constraint. The non-standard monetary policy measures applied since 2008 (balance sheet expansion, forward guidance, etc.) may help to alleviate the effects of this constraint in future crises. However, if the apparent process of decline in the natural interest rate continues (as a consequence of adverse demographic developments and other structural factors referred to above) and, therefore, the ELB becomes an increasingly frequent obstacle for monetary policy, it may be necessary to consider possible changes in the basic strategy of central banks. In the case of the euro area, the evidence on the natural rate of interest and the projections of this rate suggest that a debate on possible changes to the ECB's monetary policy strategy may need to be held soon.

Irrespective of the possibility of changing the monetary policy strategy, one way of addressing the ELB problem involves the issue of digital currency by central banks, along with the gradual elimination of cash. The issue of central bank digital currency (CBDC) would involve extending the possibility – available at present to credit institutions and the public sector – of holding deposits at the central

28 It is important to highlight that implementation of the temporary PLT regime may involve significant challenges, especially as regards its communication if two different strategies (IT and PLT) are alternated according to whether or not interest rates are at the ELB.

29 The model is based on the work of Almeida, Hurtado and Rachedi (2019), who build a general equilibrium model of a monetary union with two regions (Spain and the rest of the euro area). The model is estimated econometrically with data for both regions, which makes it especially appropriate for conducting a quantitative analysis of the effects of different economic policies.

bank to other economic agents: non-bank financial institutions, non-financial corporations and households. In a cashless economy, the CBDC interest rate would set the floor for interest rates.[30] In this hypothetical situation, the central bank would not be constrained by the ELB, so that, in principle, it would be able to reduce interest rates below zero if necessary. However, the introduction of CBDC could give rise to problems of a different kind, including some potentially large ones relating to financial stability. In this scenario, commercial banks would suffer, to a greater or lesser extent, outflows of deposits to the central bank. As a result they would need to resort to more costly and possibly more volatile sources of financing, reducing their profitability and potentially increasing the probability and severity of financial crises.

In any event, raising the natural rate of interest is mainly the task of structural policies. To conclude this section, it is important to stress the role that other policies can play in relation to the natural rate. As mentioned above, this rate is largely determined by demographic changes and productivity growth. Since it is difficult to influence the first factor in the short term, the possibility of raising the natural rate largely depends on achieving higher productivity growth. As a result, structural reforms and supply-side policies to achieve this objective are particularly desirable in the current context, since they would provide greater scope for monetary policy action.[31]

Fiscal policy can also alleviate the effects of the binding ELB. Here, there are two issues to consider: the effects of fiscal policy when the economy is in a liquidity trap and its ability to increase the natural rate of interest. In relation to the first question, the literature has emphasised that the efficacy of fiscal policy is greater when monetary policy is constrained by the ELB. The reason is that the inflationary effects of an expansionary fiscal policy are not counteracted by rising interest rates because, during the binding ELB episode, the monetary authority would wish to reduce the interest rate even further. Moreover, in the context of a monetary union, fiscal expansions in part of the union may have significant positive spillover effects on the rest of the union.[32] On the other hand, to the extent that the low interest rates reflect a shortage of safe assets, fiscal expansions financed by an increase in public debt may increase the natural rate of interest, provided that such debt continues to

30 There are other CBDC proposals, in which it is not remunerated. For a discussion of the impact of CBDC on the conduct of monetary policy, see Nuño (2018).

31 Andrés, Arce and Thomas (2017) analyse the role of structural reforms when providing a macroeconomic stimulus in a context in which monetary policy is unable to do so.

32 This is particularly true of fiscal stimuli based on increases in public spending, as they are more inflationary than comparable tax reductions. See Christiano, Eichenbaum and Rebelo (2011), Woodford (2011) and Eggertsson (2011) for an analysis of the effectiveness of fiscal expansions when interest rates are at the ELB; and Blanchard, Erceg and Lindé (2016) and Arce, Hurtado and Thomas (2016) for an analysis of such effectiveness and the associated spillovers in the context of a monetary union.

be perceived as safe (a requirement that may, in practice, limit the possibility of raising the natural rate by this means).[33]

3 The size and composition of the central bank's balance sheet

Quantitative easing has led to an unprecedented increase in the size of central bank balance sheets. In the case of the euro area, the Eurosystem balance sheet expanded from 13% of GDP in 2006 to 41% as at end-2018. On the asset side, the expansion reflected an increase in the holdings of monetary policy assets, at first mainly in the form of long-term refinancing operations (LTROs) for banks and subsequently, from early 2015, primarily in the form of large scale purchases of financial securities through the APP programme. On the liabilities side, these transactions have led to an expansion of excess bank reserves, i.e. the liquidity deposited by euro area commercial banks at the ECB and at the Eurosystem banks (see Chart 3.5.2). This latter phenomenon has been widely experienced by the other central banks of the main advanced economies.[34]

Before the crisis, the ECB conducted its monetary policy by means of a "corridor system". Since commencing operations, the ECB has guided the economy's interest rates by influencing the short-term interbank market interest rate. Specifically, the EONIA (Euro Overnight Index Average) index of interest rates on overnight loans is usually considered to be the ECB's implicit target. As seen in Chart 3.5.1, before 2008 the EONIA fluctuated within the corridor made up of the ECB's lending and deposit facility interest rates, i.e. the interest rates at which the ECB allows euro area commercial banks to borrow overnight or to deposit their reserves, respectively. In fact, these two rates are the ceiling and floor, respectively of the corridor in which the EONIA moves, since the banks have no incentive to borrow at a higher rate (or to lend at a lower rate) than they can obtain from the ECB for the same maturity.[35] In a context of very limited excess reserves (beyond the regulatory requirement), the EONIA fluctuated close to the middle of the corridor, so that this regime was known as the "corridor system".

33 See, for example, Caballero, Farhi and Gourinchas (2017). According to Jimeno (2015), an over-expansionary fiscal policy, against a background of high public debt and doubts regarding the future transfers to be received from the pension system, may lead households to increase their saving, which would exert downward pressure on the equilibrium interest rate.

34 See, for example, Reis (2016).

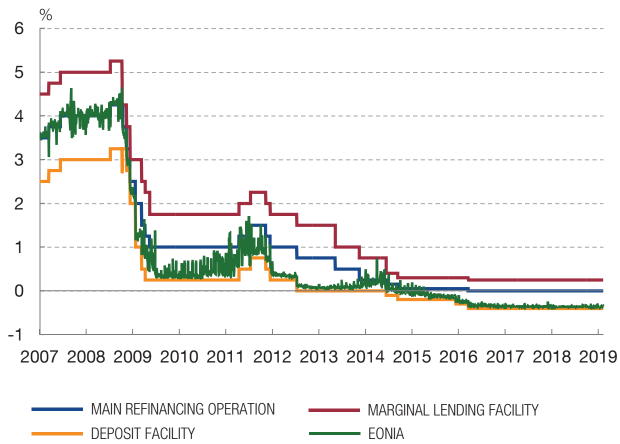
35 Another ECB instrument is the interest rate on main refinancing operations (MROs), which is typically equal to the mid-point between the lending and deposit facility rates. MROs are one-week loans tendered on a weekly basis, unlike the overnight loans of the marginal lending facility, which are always available on business days.

Chart 3.5

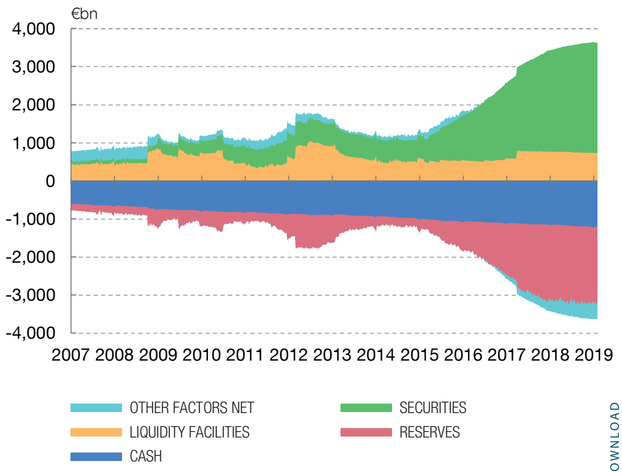
THE ECB HAS SWITCHED FROM A CORRIDOR SYSTEM TO A FLOOR SYSTEM

The increase in the Eurosystem balance sheet has led the ECB to switch from a corridor system, with EONIA in the centre of the band formed by the interest rate on lending facilities and the deposit rate, to a floor system, with EONIA close to the deposit rate.

1 ECB POLICY INTEREST RATES AND EONIA



2 EUROSYSTEM BALANCE SHEET



DOWNLOAD

SOURCES: Datastream and ECB.

The expansion of the volume of reserves has meant that the ECB now uses a floor system, like most major central banks today. The increase in the volume of reserves and the consequent increase in excess liquidity in the interbank market have meant that the EONIA and other similar indicators of very-short-term interbank yields have moved very close to the ECB's deposit facility interest rate (DFR), the minimum remuneration lending banks are willing to accept (see Chart 3.5.1). The ECB has thus, de facto, switched to operating a floor system, so called because the EONIA now normally stands very close to the floor for overnight interbank yields, i.e. the DFR. This transition to a floor system has also occurred at many of the other central banks of the largest advanced economies, such as the United States, Japan and the United Kingdom.[36]

Looking ahead, as they take steps to normalise their monetary policies, the ECB and other central banks face the dilemma of whether to maintain the current floor system or to revert to the pre-crisis corridor system. In terms of balance sheet size, the first option involves maintaining a relatively large balance sheet, while the second involves reducing it to levels directly related to households' and firms' demand for cash and banks' demand for reserves and, thus, returning to the pre-crisis corridor system. The main arguments explored in the economic literature for and against these two systems are analysed below (see Figure 3.4).

36 See Arce, Nuño, Thaler and Thomas (2018).

Figure 3.4
ADVANTAGES AND RISKS OF A LARGE BALANCE SHEET

QUANTITATIVE EASING HAS SIGNIFICANTLY INCREASED THE SIZE OF CENTRAL BANK BALANCE SHEETS

The ECB uses its lending and deposit facilities to provide and absorb liquidity:

— Commercial banks that need liquidity can borrow from the ECB at the interest rate on the lending facility

— Commercial banks that have excess liquidity can deposit it at the ECB and earn the interest rate on the deposit facility

Before the financial crisis, banks did not on aggregate have excess liquidity → The interbank interest rate fluctuated in the middle of the corridor formed by the interest rates of the ECB's two facilities (lending and deposit)

During the crisis, central banks:

— Refinanced commercial banks at relatively long maturities

— Purchased financial assets on a large scale

→ The amount of commercial bank reserves has been multiplied, which has generated a sharp increase in aggregate excess liquidity

— The ECB has switched to a floor system: the interbank interest rate has fallen from the middle of the corrridor to its lower limit (the interest rate on the deposit facility)

THE DEBATE ON THE SIZE OF THE CENTRAL BANK BALANCE SHEET: SHOULD IT REMAIN LARGE OR BE REDUCED TO PRE-CRISIS LEVELS?

IN FAVOUR OF A LARGE BALANCE SHEET

— Low volatility of short-term interest rates

— Provision of safe and liquid short-term assets to the private sector, which may improve financial stability

— More room, relative to the ELB, to respond to future adverse developments

AGAINST A LARGE BALANCE SHEET

— Unjustified distortion of the yield curve

— Deterioration in central bank solvency

SOURCE: Banco de España.

A large balance sheet may lead to an excessively flat yield curve. An initial argument in favour of returning the size of the balance sheet to its pre-crisis trend is that a large balance sheet may lead to an undesired distortion of the yield curve.[37] This occurs when the central bank's balance sheet, as in the case of the Federal Reserve's and the ECB's, includes large quantities of medium and long-term assets. By reducing the supply of long-term assets available to the private sector, term premia are compressed and, therefore, medium and long-term yields fall. This may be beneficial when monetary policy has exhausted its conventional room for manoeuvre and, indeed, this has been one of the main transmission channels for

37 See Bullard (2017).

asset purchase programmes; by reducing long-term interest rates they stimulate investment and, thus, aggregate demand. However, in a context of normalisation of the economic outlook, with interest rates no longer constrained by their lower bound, the flattening of the yield curve may be less justified.

Second, the larger the balance sheet, the greater the financial risk for the central bank itself, especially when the maturities of its assets and liabilities differ. The price of assets, such as medium and long-term government bonds, may vary due to changes in risk and term premia, or in the risk-free short-term nominal interest rate. The liabilities (basically cash and bank reserves), on the other hand, are short-term, and their nominal value is very stable. Thus, the larger the size of the central bank balance sheet (and the longer the maturity of its assets) in relation to its capital, the greater the risk of imbalance between the value of the assets and the value of the liabilities on the central bank's balance sheet. From an economic perspective, the importance of a possible situation in which the book value of the central bank's assets falls below that of its liabilities is debatable; by definition, most central bank liabilities are not callable (as in the case of cash) or can be settled in cash (as in the case of bank reserves), the creation of which is controlled by the central bank itself.

Potentially more problematic is a situation of so-called "intertemporal insolvency" of the central bank, which occurs when its balance sheet deficit exceeds the net present value of future seigniorage flows and it cannot rely on automatically receiving additional capital injections from the relevant fiscal authority. In this situation, the ability of the central bank to stabilise inflation may be compromised.[38] Moreover, the discretionary capital injections from the fiscal authorities needed to avoid this situation may put the central bank's financial independence in doubt. It is important to stress, however, that a hypothetical situation of intertemporal insolvency of the central bank requires an extreme scenario for the size of the balance sheet, far removed from the current situation.[39]

Against the above line of argument, there are several reasons for maintaining the size of central banks' balance sheets at their current levels or, at least, significantly above their pre-crisis levels.

First, according to some authors a large balance sheet may contribute to financial stability.[40] Currently, there is a high demand from the private sector for

38 See, for example, Sims (2016), Hall and Reis (2015) and Del Negro and Sims (2015). It should be noted, however, that central banks usually hold medium and long-term financial assets to maturity (i.e. they do not sell them earlier), which is why they value them at amortised cost, instead of market price. In this respect, it is possible to distinguish between the accounting rules of central banks and the economic analysis regarding the intertemporal solvency of central banks in the aforementioned studies.

39 For a quantitative analysis applied to the case of the United States, see Cavallo et al. (2018).

40 See Greenwood, Hanson and Stein (2016).

short-term, safe and liquid assets, as reflected in a "scarcity premium" for such assets (i.e. their remuneration is unusually low). This premium gives financial institutions a strong incentive to issue liabilities with these characteristics. Insofar as this short-term funding is used to finance long-term investment, it may lead to excessive maturity transformation by the financial sector, which may compromise financial stability. In fact, when a financial institution's assets are long-term and therefore, relatively illiquid, while its liabilities are short-term and, therefore, have to be continuously refinanced, the risk that such an institution may have difficulty renewing its funding and making payments increases, with the consequent liquidity risk and, possibly, insolvency risk. The central bank may counter excessive maturity transformation risk by issuing large amounts of bank reserves, which are more liquid and safer assets than the securities issued by private agents. On the other hand, in order for private institutions to be able to benefit from a larger supply of reserves, the deposit (or similar) facilities of central banks need to be available to institutions without a banking licence, such as investment funds. The creation of the ON RRP (Overnight Reverse Repurchase) programme in the United States, under which non-bank entities can deposit their liquidity at the Federal Reserve, goes precisely in this direction.

With a large balance sheet, the banking sector has a large amount of liquidity. A second argument in favour of a large balance sheet is that, since the cost of creating reserves is basically zero, it may be desirable to expand their supply (and, therefore, the size of the central bank's balance sheet) until banks' demand for them is sated.[41] This will be so, to the extent that bank reserves perform socially useful functions, such as facilitating payments and financial transactions. Sating the banking systems demand from reserves requires that their opportunity cost be zero, i.e. that the rate of interest on excess reserves (the DFR in the case of the ECB) is basically equal to the return on assets with the same maturity; for example, overnight interbank loans (summarised in indicators such as the EONIA). The logic of this argument is the same as that of the so-called "Friedman rule" for cash, but applied to reserves: an asset that has a zero cost of production does not need to have a positive price (opportunity cost) either.

Although it is in practice difficult to determine the level beyond which the demand for reserves is saturated, the relationship observed between excess reserves and the spread between the EONIA and the deposit facility rate in the euro area suggests that maintaining the spread at its present level (of close to zero) does not necessarily require maintaining the volume of reserves at their current levels. In fact, the evidence presented in Chart 1 of Box 3.4 shows that there may even be room to reduce the current level of excess reserves (and therefore the size of the Eurosystem balance sheet), while preserving the floor system.

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41 See Cúrdia and Woodford (2011).

A large balance sheet permits greater control over interest rates, and a gain in space above the ELB. Two further advantages of a large balance sheet derive from the above discussion. First, in so far as it entails a floor system, a large balance sheet permits the central bank to directly control short-term interbank yields, by setting the remuneration of reserves, which isolates such yields from temporary shocks in the interbank market. This may be particularly relevant in the current situation, characterised by a notable level of uncertainty regarding how the demand for reserves has changed since the crisis (owing to factors such as changes in bank regulation and, in the case of the euro, the persistence of a certain financial fragmentation) and, therefore, of how advisable it is to return to a corridor system.[42]

Second, the floor system may provide the central bank with more space to cut rates if necessary, for the following reason. It is plausible to assume that, in the long run, given the central bank's inflation target, nominal market interest rates, such as interbank rates, are independent of the size of the balance sheet. This means that in a floor system the interest rate on reserves will on average be *higher* (as it is linked to market yields), than in a corridor system. Consequently, the central bank will have more space, above the lower bound, to cut this rate in response to future crises.[43] This argument is developed in Box 3.4 and the stabilising properties of these two regimes are compared, within the framework of a macroeconomic model, when the ELB constrains interest rate policy.

Some central banks have already decided to preserve the floor system for the time being. The Federal Reserve began to reduce the size of its balance sheet in October 2017, by not reinvesting all of the securities in the portfolio of its quantitative easing programme upon their maturity, and ruling out the possibility of maintaining it at the maximum level reached in October 2014. However, in January 2019 it communicated its intention to maintain a floor system, so that the target balance sheet size will be sufficiently large for the resulting volume of reserves to allow the system to be preserved.

In parallel with the above discussion on the desirable size of the balance sheet, there has been a debate regarding the composition of the central bank's balance sheet, a particularly important question in the case of a large balance sheet. Some of the arguments made in relation to the size of the balance sheet are

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42 See, for example, Quarles (2019). Bernanke (2016, 2017) contributes a further argument to the debate on the size of the balance sheet. The demand for cash has increased partly for exogenous reasons, which justifies a larger balance sheet. This argument, however, is specific to the case of the United States and does not appear to apply to the euro area.

43 See Arce, Nuño, Thaler and Thomas (2018). Note that this argument applies to conventional interest-rate policy. In the case of unconventional monetary policy, such as asset purchase programmes, a balance sheet that is large in normal times may limit the scope to increase its size through additional asset purchases, if this becomes necessary. This is particularly relevant in the euro area, where the parameters of the APP restrict the capacity to expand the Eurosystem's balance sheet through the acquisition, for example, of government bonds.

based on the fact that, in practice, its expansion has been generated mainly through the issue of very short-term liabilities (reserves) and the acquisition of medium and long-term assets. However, looking ahead, a particular size of balance sheet is compatible with a different maturity structure both on the assets and on the liabilities side. Likewise, the proportions of public and private assets on the central bank's balance sheet can also vary.

As regards the asset maturity structure, the relatively long duration of the assets held by central banks represents a source of risk for their balance sheets. In this respect, for a given balance sheet size, the central bank may reduce its risk by shortening the average maturity of its portfolio of assets.[44] This would in turn reduce the above-mentioned yield curve distortions, to which a large balance sheet may give rise in a scenario in which conventional interest rate policy is, in principle, sufficient to achieve the desired monetary policy stance.

On the liabilities side, the expansion of the balance sheets of the main central banks has, up until now been reflected in the issue of overnight reserves. Some authors suggest the possibility of lengthening the maturity of bank reserves by, for example, issuing debt certificates with longer maturities.[45] To the extent that interbank market yields at such maturities are linked to the remuneration of such certificates, the central bank would have greater control over the longer end of the yield curve.

As for the proportions of public and private assets, recent studies suggest that, under normal conditions, central bank assets should consist mainly of government bonds and that only in situations in which the financial sector is sufficiently disrupted should the central bank also invest in private assets.[46] The argument is twofold: first, for the central bank too it is relatively costly to intermediate such private assets, as it has to invest in credit risk evaluation tools, possible NPL management, etc.: second, private asset purchases are especially effective when the financial markets are tighter. Thus, only in these situations would it be justified to acquire such private assets and incur the associated costs.[47] Moreover, as regards

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44 See Greenwood, Hanson and Stein (2016). This argument could be considered contradicted by the one explained above, offered by the same authors, in favour of expanding the volume of reserves (in so far as they are short-term and safe assets) to boost financial stability. In fact, to the extent that the central bank creates reserves to finance the acquisition of short-term assets that are similarly safe and liquid, the net effect on the total volume of such assets held by the private sector will be practically non-existent. However, the authors argue that the Federal Reserve could reduce the average duration of its bonds to a range of 2 to 6 years (as compared with the current average duration of 8.6 years) and basically achieve the same positive effect on financial stability.

45 See, for example, Reis (2016).

46 See Cúrdia and Woodford (2011).

47 Gertler and Kiyotaki (2010) suggest that, in a financial crisis, purchasing private assets is more effective than purchasing government debt, because the former has a greater impact in terms of easing financial tensions.

the solvency of the central bank (discussed above), a higher proportion of private assets usually entails greater credit risk than government debt. In this respect, the Federal Reserve, in its internal deliberations, suggested the possibility of gradually modifying the composition of its portfolio so that it is mainly made up of public debt assets.

Finally, in addition to public and private securities, central bank assets can also be made up of medium and long-term loans to banks, like those granted by the ECB within the framework of its long-term refinancing programmes (LTRO, VLTRO and TLTRO). As well as providing liquidity to the banking sector, these operations give central banks greater control over long-term interest rates, especially in a relatively banked economy like the euro area's.

4 Conclusions

This chapter has examined two basic aspects of the future setting in which monetary policy will be designed and applied in the main advanced economies. First, central banks will face a scenario in which their interest rates will foreseeably fluctuate around average levels which are relatively low and therefore close to their lower limit, leaving scant room for rate cuts in response to future crises and recessions. This phenomenon is closely related to the fall in the so-called "natural interest rate" in recent decades, mainly as a result of adverse demographic developments. These factors, should they persist in the future, will continue to put downward pressure on the natural interest rate and, given the inflation targets of central banks, on nominal rates.

The chapter explores to what extent changes in basic monetary policy strategy may help to alleviate the lower bound constraint on interest rates. This matter will be particularly important if the fall in the natural interest rate persists in the future and the non-standard tools used since 2008 in the current strategic framework (such as large-scale asset purchases and guidance on the future course of the various instruments) are not sufficiently effective.

Although the various alternative strategies have notable theoretical advantages, their probable costs, associated risks and, in particular, the absence of practical experience with them mean that their possible effects must continue to be analysed in greater depth. In any event, it should be noted that a reassessment of monetary policy strategy (as by the ECB in 2003, or by the US Federal Reserve in 2012 and periodically by the Bank of Canada) is relatively common among central banks of the advanced economies, and that the available evidence on the secular fall in the natural interest rate argues strongly for reconsidering this strategy in the future. A final important point is that it is the responsibility of other areas of economic policy to take measures to help natural interest rates to recover, such as the implementation of structural reforms to increase productivity growth.

The size of the balance sheets of the main central banks has reached record levels as a result of the various quantitative easing measures adopted since the beginning of the global crisis. Looking forward, these central banks face the dilemma of maintaining their balance sheet size at its current level or returning to the trend before the crisis. A key factor emerging from the debate is the following. To the extent that central bank liabilities continue to consist mainly of (short-term) bank reserves, the choice between a large balance sheet and a small balance sheet is substantially equivalent to that of whether to retain the current floor system (with interbank market returns tied to the remuneration of reserves) or return to the pre-crisis corridor system (with a small volume of reserves and short-term interbank returns fluctuating within a corridor formed by the rates on the central bank's credit and deposit facilities). In this respect, preserving the floor system has certain benefits in terms of improved control over short-term market interest rates, more leeway to reduce interest rates in response to a crisis, etc. However, in the case of the Eurosystem, it would in principle be feasible to keep this system with a volume of excess reserves below the present level.

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Box 3.1

THE ESTIMATED NATURAL RATE OF INTEREST

The natural rate of interest (hereafter denoted r*) is defined as the real rate of interest which would be observed in an equilibrium scenario in which prices and nominal wages are perfectly flexible. Thus defined, it is not a directly observable variable and the economic literature reports various ways to estimate r* from observed data. The most commonly used method is to estimate an econometric model inspired in the neo-Keynesian theoretical framework, consisting of an aggregate demand equation (IS curve), according to which the gap between observed output and its natural level (output gap) depends on the gap between the observed real rate of interest and the natural rate of interest, and of a Phillips curve relating inflation to the output gap.[1]

Although this model has been widely used in the literature, it is recognised that it tends to produce inaccurate estimates of the natural rate of interest.[2] Chart 1 illustrates this problem for the United States: the confidence bands (at a confidence level of 90%) around the estimated r* are very wide (around eight percentage points in total). In addition, recent work demonstrates that the accuracy of the standard model estimates declines significantly when the IS and Phillips curves are relatively flat.[3] The reason is that, when the slopes of both curves are equal to zero, the path of the natural interest rate cannot be identified from the available data, and the model is defined as *unobservable.*[4] In practice, the literature estimates of the slopes of the IS and Phillips curves often tend to be near zero, which gives rise to inaccurate estimates of r*.

A recent study by Fiorentini, Galesi, Pérez-Quirós and Sentana proposes an alternative methodology for measuring r* more accurately, based on a model which decomposes the observed real rate of interest as the sum of a transitory component and a permanent one, where the second component is identified as the natural rate of interest (such that the transitory component is the gap between the observed and natural rates of interest).[5] The underlying idea in this approach is that the natural rate of interest is that which would prevail in a hypothetical situation of the economy in which all temporary shocks are dissipated. This methodology allows more reliable estimates of r*, even when the IS and Phillips curves are flat.

It can be seen in Chart 2 that the estimates of this model, obtained from annual data for the period 1891-2018 in 17 advanced economies show a decrease in the average natural rate of interest from the beginning of the 20th century to the decade starting in 1960. Subsequently, from the mid-1970s there is an increase which lasts until the end of the 1980s. This was followed by a gradual fall from the early 1990s which has continued almost uninterruptedly to the present, so that an average natural rate of interest for the economies analysed now seems to be negative.

What factors explain the rise and subsequent fall in the natural rate of interest? Fiorentini *et al.* estimate an error correction model with panel data which postulates a long-term relationship between the observed real rate of interest and a set of indicators of the historical behaviour of the main theoretical determinants of r*: i) changes in productivity growth, which affect the propensity to invest; ii) demographic changes, which affect the aggregate propensity to save or the labour force participation rate of the economy, and iii) risk factors, which may increase

1 See T. Laubach and J. C. Williams (2003), "Measuring the natural rate of interest", *Review of Economics and Statistics,* No 85, pp. 1063-1070, and K. Holston, T. Laubach and J. C. Williams (2017), "Measuring the natural rate of interest: international trends and determinants", *Journal of International Economics,* No 108, pp. 59-S75. Also, the model assumes that r* is the sum of two non-stationary unobserved components: the trend growth of the economy and a second component unrelated to trend growth.

2 See, for example, T. E. Clark and S. Kozicki (2005), "Estimating equilibrium real interest rates in real time", *The North American Journal of Economics and Finance,* No 16, pp. 395-413, and R. C. M. Beyer and V. Wieland (2017), *Instability, imprecision, and inconsistent use of equilibrium real interest rate estimates,* Institute for Monetary and Financial Stability, Working Paper Series 110, Goethe University Frankfurt.

3 See G. Fiorentini, A. Galesi, G. Pérez-Quirós and E. Sentana (2018), *The rise and fall of the natural interest rate,* Working Paper 1822, Banco de España.

4 See R. E. Kalman (1960), "On the general theory of control systems", Proc. First International Congress on Automatic Control, Moscow.

5 See Fiorentini *et al.* (2018), *op. cit*.

uncertainty and thus affect r* by changing the propensity to save.[6]

This panel model predicts an increase and subsequent fall in the natural rate of interest from the 1960s, as can be seen in Charts 3 and 4 for the United States and the euro area, respectively. Upon decomposing the individual contribution of each factor, the demographic change proves to be most significant in explaining the rise and fall in the natural rate of interest. However, the

The charts show the natural rate of interest for the advanced economies using various econometric models.

Chart 1
US NATURAL RATE OF INTEREST. STANDARD MODEL (a)

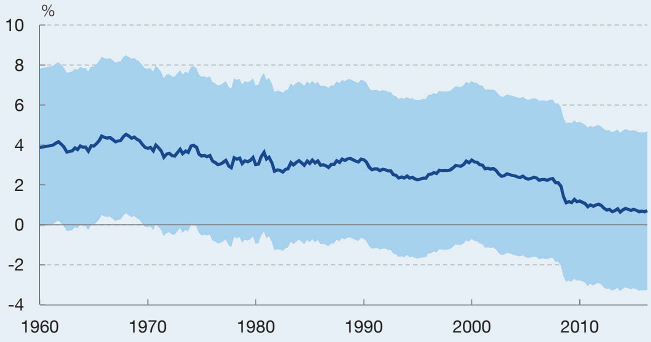


Chart 2
HISTORICAL BEHAVIOUR OF THE NATURAL RATE OF INTEREST. "LOCAL LEVEL" MODEL (b)

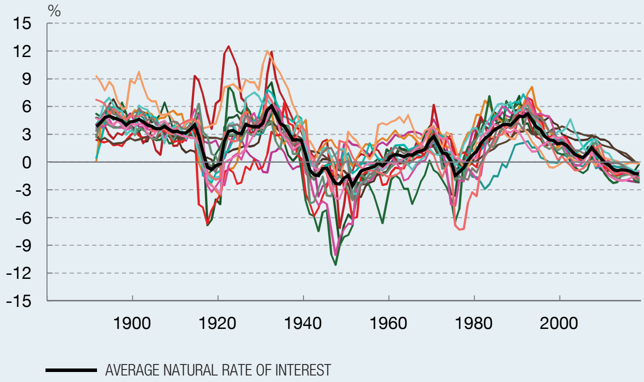


Chart 3
US NATURAL RATE OF INTEREST. ERROR CORRECTION MODEL (c)

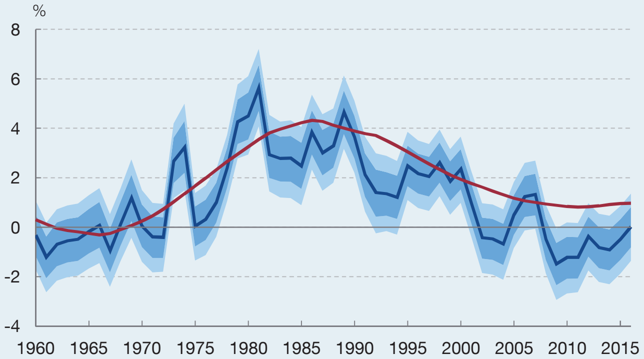
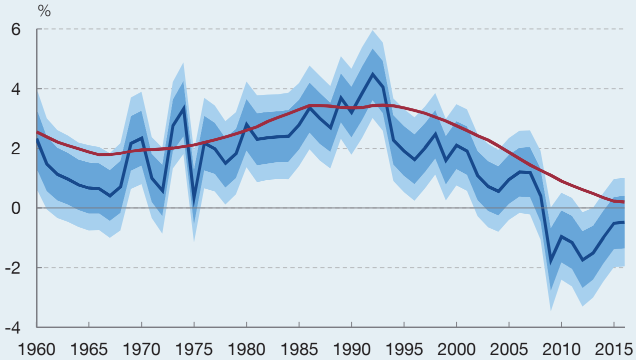


Chart 4
EURO AREA NATURAL RATE OF INTEREST. ERROR CORRECTION MODEL (c)



NATURAL RATE OF INTEREST DEMOGRAPHIC FACTORS

SOURCES: Banco de España, based on the model of Holston, Laubach and Williams (2017), and Fiorentini, Galesi, Pérez-Quirós and Sentana (2018).

a The bands indicate a confidence level of 90%.
b The black line is the average of the countries.
c The bands indicate confidence levels of 68% and 90%.

6 For studies which relate the natural rate of interest to productivity growth, demographics and risk factors, see, respectively, R. J. Gordon (2015), "Secular stagnation: a supply-side view", *American Economic Review,* No 105, pp. 54-59, and G. B. Eggertsson and N. R. Mehrotra (2014), *A model of secular stagnation,* National Bureau of Economic Research Working Paper 20574, and E. Fahri and F. Gourio (2018), "Accounting for macro-finance trends: market power, intangibles, and risk premia", mimeo

other factors have also contributed persistently to the decrease observed in r* since the 1990s. These results suggest that the initial increase is due to the population growth prompted by the post-war baby boom, which brought a significant, albeit temporary, increase in the participation of young people in the labour market. When the baby boom ended, the ensuing gradual population ageing seems to have pushed the natural rate of interest down in both economies. This result is consistent with recent studies which have emphasised the role of demographics in explaining the behaviour of the natural interest rate.[7]

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7 See, for example, E. Gagnon, B. K. Johannsen and D. López-Salido (2016), *Understanding the new normal: the role of demographics,* Finance and Economics Discussion Series 2016-080, Board of Governors of the Federal Reserve System.

Box 3.2

DEMOGRAPHICS, PRODUCTIVITY AND THE NATURAL INTEREST RATE

Demographics takes pride of place in the debate on the structural transformations that will affect the economy in coming decades. In turn, productivity growth has been persistently low since the last downturn. This box uses an economic life cycle model[1] to illustrate the effects of both these factors on the natural rate of interest.

Since the start of the century, in most euro area countries there have been major changes in the share of population of the different age groups (see Chapter 4). According to Eurostat projections, these changes will continue in coming decades (see Chart 1). Thus, throughout this period, the proportion of young adults has decreased and is expected to continue to decrease, while the proportion of adults, which was stable in the first decade of the century, has fallen since 2010 and is expected to continue to fall in coming decades. Lastly, it is estimated that the proportion of over-65s will increase, from 22% in 2000 to 31% in 2030.

The model used combines a standard production framework and households across three stages of the life cycle: young adults (20-29 years), adults (30-65 years) and retirees (65+). The share of each age group in the population depends on fertility and mortality rates, which evolve to give the population structure depicted in Chart 1. In the model, labour income depends on age: young adults command lower wages than older ones, while the over-65s also receive labour income (although they work fewer hours than the other age groups), as well as public pensions.[2] Individuals can save either by accumulating productive capital or by buying (government or corporate) bonds.

The model is calibrated using data on wages and hours worked by age group taken from the European Household Community Panel and the OECD. These data show that labour income peaks during the adult stage (30-65 years) of the life cycle. According to European Commission estimates (2018 Ageing Report), the benefit ratio (average pension to average wage) is expected to fall from 45% to 40% for the EU countries over the next two decades. Lastly, the annual average rate of growth of total factor productivity (TFP) was 0.9% in the euro area in its first decade of existence. Since the onset of the crisis it has declined considerably, to 0.3% in annual average terms. The following simulations assume, as a conservative estimate, that TFP growth will gradually decrease, from 0.9% in 2007 to 0.6% in 2040.[3]

Chart 2.2 depicts the natural rate of interest that would result, according to the model, from these demographic patterns and productivity growth, taking as the starting point the real interest rate observed in 2007 (2.1%).[4] Lower total factor productivity growth translates into a decline in the return on investment in productive capital, which implies a drop in the natural rate of interest. In turn, the effect of demographics on the labour supply and the supply of savings affects the natural rate of interest. On the one hand, a decline in the labour supply associated with a lower birth rate drives down the labour to capital ratio, further moderating the return on capital. On the other, the sustained increase in life expectancy prompts adults to save more for their retirement (which drives down the consumption to GDP ratio, as shown in Chart 2.1), generating a further fall in the natural rate of interest. Overall, according to these simulations, the natural rate of interest would fall by 3 pp - 4 pp between 2007 and 2030.[5]

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1 H. S. Basso and O. Rachedi (2018), *The young, the old, and the government: demographics and fiscal multipliers,* Banco de España Working Paper 1837.

2 To incorporate wage differences by age into the model, it is assumed that adults are more productive than young adults and than the over-65s.

3 The figure of 0.6% is calculated as the midpoint between TFP growth observed in the last ten years and the rate of growth used in the European Commission's projections up to 2050, presented in European Commission (2018), *The 2018 Ageing Report: Economic and Budgetary Projections for the 28 EU Member States (2016-2070)*, Institutional Paper 079.

4 Under the simplifying assumption that the economy was stationary in 2007, the real interest rate (r) in that year is equal to the natural interest rate (r^*), such that $r^* = r = 2.1\%$. The real interest rate is calculated as the difference between the 3-month EURIBOR and core inflation (i.e. excluding energy prices) in the euro area. The paths of the real and natural interest rates in these simulations are very similar, and practically identical in the medium and long term, as the nominal rigidities that prevent the two interest rates from coinciding have only temporary effects.

5 G. Eggertsson, N. Mehrotra and J. Robbins (2019), in "A Model of Secular Stagnation: Theory and Quantitative Evaluation", *American Economic Journal: Macroeconimics,* 11(1), pp. 1-48, perform a similar exercise for the United States for the period 1970-2015, estimating a decline of more than 400 bp in the natural rate of interest. Y. Aksoy, H. S. Basso, R. Smith and T. Grasl (2019), in "Demographic Structure and Macroeconomic Trends", *American Economic Journal: Macroeconomics,* 11(1), pp. 193-222, using an estimated empirical model drawing on OECD country data, conclude that the natural rate of interest could fall by up to 400 bp in the United States between 2000 and 2030 owing to demographic change.

Box 3.2

DEMOGRAPHICS, PRODUCTIVITY AND THE NATURAL INTEREST RATE (cont'd)

To measure the contribution of demographics and productivity to the projected fall in the natural rate of interest two further simulations are made: the first considers that only productivity growth changes, and the second includes only demographic changes. By comparing the two it may be concluded that more than 65% of the fall in the natural rate of interest estimated in the previous exercise is due to demographic change, in keeping with the empirical findings presented in Box 3.1. The impact of demographic change is also analysed by comparing the baseline scenario with alternative scenarios

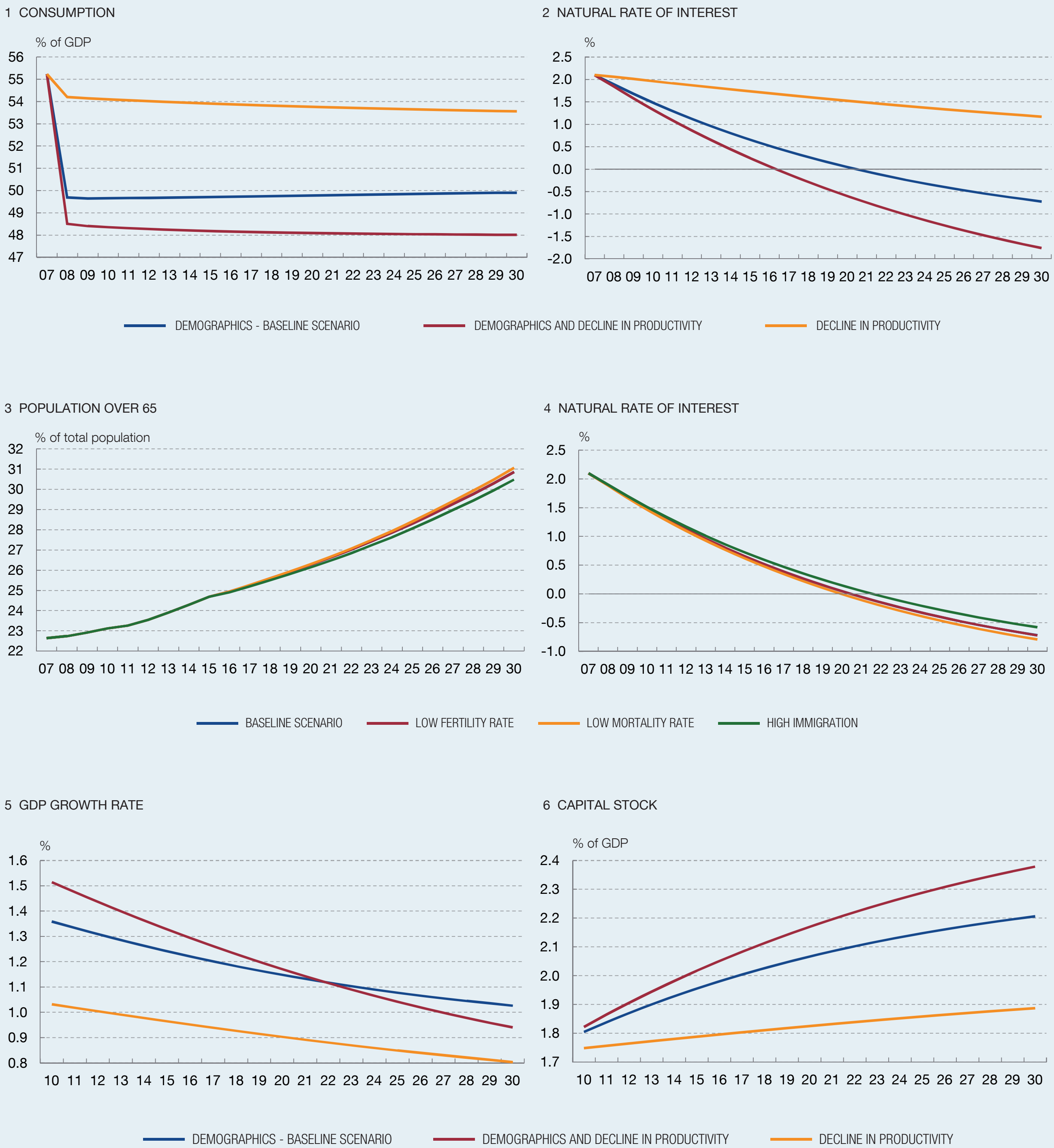
Chart 1
OFFICIAL DEMOGRAPHIC PROJECTIONS SHOW PROGRESSIVE POPULATION AGEING

The chart depicts population changes in three age brackets: i) young people (under 20); ii) adults (20 to 65); and iii) old people (over 65).

SOURCE: Eurostat.

Chart 2
MACROECONOMIC IMPACT OF DEMOGRAPHIC CHANGE AND DECLINE IN PRODUCTIVITY

The chart depicts the simulation of the impact of demographic change in the euro area using the Basso and Rachedi model (2018).



SOURCE: Banco de España, drawing on the Basso and Rachedi model (2018).

Box 3.2
DEMOGRAPHICS, PRODUCTIVITY AND THE NATURAL INTEREST RATE (cont'd)

that envisage lower fertility and mortality rates and higher immigration (see Charts 2.3 and 2.4).[6] These simulations show that, in general, the sensitivity of natural interest rates to the different demographic scenarios considered in 2030 is quite low (25 bp at most).

Lastly, aside of the impact on the natural rate of interest, it is important to examine the effects on GDP growth and capital accumulation (see Charts 2.5 and 2.6). The lower natural rate of interest coincides with an increase in capital accumulation, on account of higher savings and lower labour supply. Yet despite the higher level of capital, GDP growth falls continuously over the entire simulation horizon, owing to the lower growth in TFP and the labour supply.

6 Specifically, the assumptions used in each alternative scenario are as follows: 1) lower fertility: a 20% decline in fertility rates across all the projections; 2) lower mortality: a gradual decline in mortality rates by age and sex; and 3) higher migration: a 33% increase in net immigration throughout the projection period.

Box 3.3

ASSESSMENT OF THE ALTERNATIVE MONETARY POLICY RULES USING THE JoSE MODEL

This Box uses the JoSE (Joint Spain-EuroArea[1]) model to study the quantitative implications of various monetary policy strategies for the frequency, duration and associated costs of ELB (Effective Lower Bound) episodes. JoSE is a dynamic general equilibrium model of a monetary union with two economies (Spain and the rest of the euro area) which incorporates the usual nominal, real and financial frictions in models used by central banks. The model is estimated through the use of Bayesian econometric techniques and macroeconomic series of both economies.

To assess effectiveness in terms of reduction of the prevalence and cost of the ELB of each of the monetary policy rules considered, the behaviour of the economy (over a large number of quarters) is simulated in the model under each of these rules.[2] Table 1 shows the results in terms of the percentage of quarters in which the common monetary authority is constrained by the ELB, the average duration of each episode, and the losses in terms of GDP and inflation (at Monetary Union level) associated with those episodes. Chart 1 shows the distribution of the inflation simulated for each monetary policy rule.

The reference point with respect to which the various alternatives are assessed is the standard inflation targeting (IT) rule included in the estimated version of the model, specifically a Taylor rule in which the nominal interest rate responds to deviations in the year-on-year inflation from its target of 2%. This rule approximately replicates the monetary policy regime in the euro area.[3] Model simulations indicate that under this rule the economy would be at the ELB 9% of the time, and the average duration of each ELB episode would be 4.2 quarters. This generates a cost in terms of lost GDP and inflation of -0.13% and -0.11%, respectively (average of the total of the quarters).[4]

Within the inflation targeting framework, a modification usually proposed to reduce the frequency of ELB episodes is to raise the inflation target. The simulations indicate that increasing this target to 3%, for example, would

Table 1
ELB FREQUENCY AND LENGTH FOR DIFFERENT MONETARY POLICY STRATEGIES

	Percentage of quarters in ELB	Average length of ELB episodes (quarters)	GDP loss associated with ELB (%)	Inflation loss associated with ELB (%)
Inflation targeting (2%) (a)	9.0	4.2	-0.13	-0.11
Price-level targeting	4.2	2.7	-0.03	0.00
Temporary price-level targeting	6.1	3.4	0.00	0.10
Inflation targeting on 4-year average inflation	6.4	3.3	-0.09	-0.04
Inflation targeting (3%) (a)	2.2	3.1	-0.03	-0.02
Inflation targeting (2%) with quantitative easing (a)	7.0	3.6	-0.04	-0.03
Inflation targeting (2%) with stronger quantitative easing (2x) (a)	6.1	3.3	0.01	0.01

SOURCE: Banco de España, based on JoSE model.

a Coefficients of inflation targeting rules: inertia, 0.85; inflation, 2.00; GDP growth, 0.10.

1 The JoSE model has been developed and estimated by G. Almeida, S. Hurtado and O. Rachedi (2019), *JoSE: the Joint Spain Euro-Area DSGE of the Banco de España,* Occasional Paper, Banco de España, forthcoming.

2 For more details on the exercise, see G. Almeida, S. Hurtado and O. Rachedi (2019), *Monetary Policy in the New Normal: Evidence on the Euro-Area from JoSE,* Occasional Paper, Banco de España, forthcoming.

3 See S. Gerlach and G. Schnabel (2000), "The Taylor Rule and Interest Rates in the EMU Area", *Economic Letters,* 67, pp.165-171.

4 These simulations are based on the assumption of a long-term natural interest rate of 1%, which is higher than the current estimates of this rate in the euro area (see Chart 3.3 in the main text). The results should thus be taken as *lower* limits of the impact and average duration of binding ELB episodes.

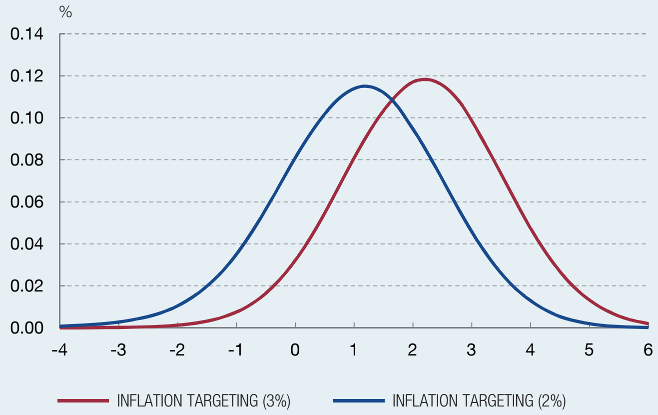
Box 3.3

ASSESSMENT OF THE ALTERNATIVE MONETARY POLICY RULES USING THE JoSE MODEL (cont'd)

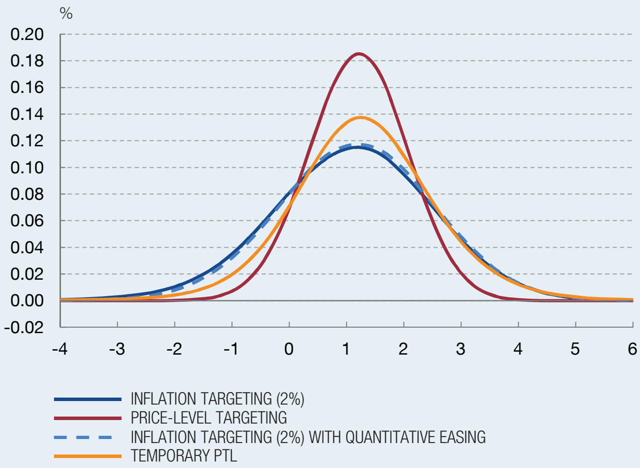
Chart 1
INFLATION RATE DISTRIBUTION ACCORDING TO MONETARY POLICY RULE

Raising the inflation target by 1 pp appreciably reduces the probability of low inflation, but the probability of inflation above 4% increases fourfold. Alternatively, a price-level targeting (PLT) rule gives a more more constrained distribution, since it reduces the probability of low inflation without raising the probability of high inflation. Quantitative easing reduces the probability of strongly negative inflation.

1 EFFECT OF INCREASING THE INFLATION TARGETING ON INFLATION DISTRIBUTION IN THE EURO AREA



2 EFFECT OF ALTERNATIVE MONETARY POLICY STRATEGIES ON INFLATION DISTRIBUTION IN THE EURO AREA

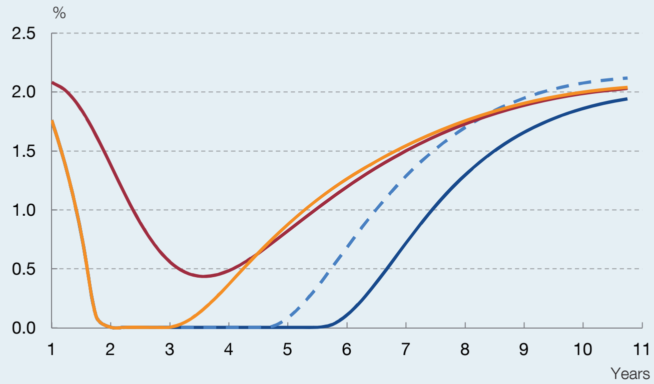


SOURCE: Banco de España, based on JoSE model.

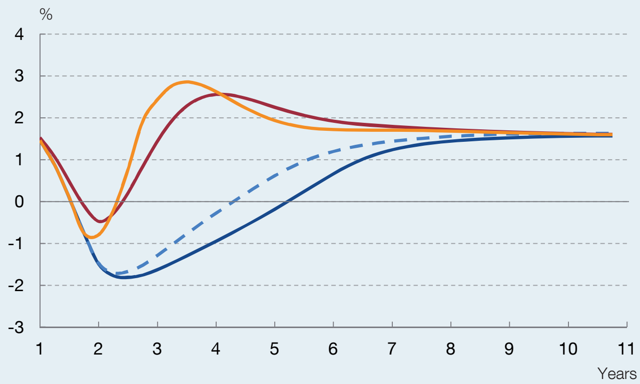
Chart 2
RESPONSE TO A FALL IN DEMAND FOR DIFFERENT MONETARY POLICY STRATEGIES

The implementation of QE along with a 2% target rule is only effective in reducing deflationary pressure when the cumulative size of the purchase programme is high. By contrast, a price-level targeting rule directly avoids the ELB through the promise of higher future inflation.

1 NOMINAL INTEREST RATE



2 INFLATION



SOURCE: Banco de España, based on JoSE model.

substantially reduce the frequency with which the ELB is reached from 9% to 2%. However, as shown by Chart 1.1, the reduction of the probability of very low inflation (typically associated with ELB episodes) is achieved at the cost of a significant increase in the probability of very high inflation.

An alternative to the inflation targeting regime would be a price-level targeting (PLT)[5] rule, in which the interest rate responds to price-level deviations from a target path, instead of responding to inflation deviations. The simulations of the model show that this rule is effective in reducing the percentage of quarters in which the economy reaches the ELB, in mitigating almost completely the associated costs in terms of GDP falls and inflation, and in substantially decreasing the variance of inflation. The mechanism through which this rule operates is that expectations of high future inflation (and thus lower real interest rates) are generated in ELB episodes in which the price level falls below its target trend due to excessively low inflation.

As noted in the main text, the PLT strategy may be difficult to apply in practice due to a possible lack of credibility of the monetary authority's commitment to offset high inflation with low inflation (and a consequent contraction in economic activity and employment) in the future.[6] In response to this criticism, Ben Bernanke[7] proposed a *temporary* PLT regime which only applies when inflation is too low as a result of a binding ELB episode (the rest of the time an IT regime prevails). According to the model used in this box, under a rule of this type the reduction in the percentage of quarters at the ELB is not as large as under the previous alternatives, but the almost total elimination of costs in terms of GDP and inflation is maintained.[8]

Another alternative somewhere between IT and PLT would be a Taylor rule responsive to inflation deviations but in terms of a relatively long moving average of, for example, four years.[9] This rule yields a reduction in the percentage of quarters at the ELB similar to that with PLT, but is less effective in eliminating the costs derived from persistent falls in GDP and from inflation when the economy hits the ELB.

Lastly, the role played by non-standard policies within the current IT framework is considered. Specifically the model combines the 2% inflation target rule with the implementation of asset purchase programmes (quantitative easing, QE), when conventional interest rate policy is constrained by the ELB. For this purpose, two different asset purchase rules are considered: one which replicates the size and duration observed in the ECB asset purchase programme (APP), and another in which the volume of asset purchases is doubled. The simulations show that these measures scarcely reduce the number of ELB episodes, but do substantially reduce their duration and, above all, the associated GDP and inflation costs: with the calibration which replicates the size of the APP, these costs are reduced to levels similar to those which would be achieved by raising the inflation target to 3%. Although this rule does not substantially reduce the probability of moderate negative inflation, it does prove effective in preventing highly negative inflation (see Chart 1.2). The most aggressive rule (which doubles the rate of purchases compared with the observed value) could potentially totally eliminate the GDP and inflation costs associated with the ELB.

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5 See L. Svensson (1999), "Price-Level Targeting versus Inflation Targeting: A Free Lunch?", *Journal of Money, Credit and Banking,* 31, pp. 277-295, and V. Gaspar, F. Smets and D. Vestin (2007), *Is Time Ripe for Price Level Path Stability?,* ECB Working Papers, 818.

6 Another view on the advisability of adopting PLT can be found in R. Barnett and R. Engineer (2000), "When is price-level targeting a good idea?", in *Price Stability and the Long-run Target for Monetary Policy,* Bank of Canada, Proceedings of a conference held at the Bank of Canada, June, pp. 101-136. The authors argue that the advantages of this regime are smaller when the inflation expectations of economic agents are aligned with recently observed inflation (backward-looking expectations).

7 B. Bernanke (2017), *Monetary Policy for a New Era,* Peterson Institute for International Economics, Washington.

8 The fact that this rule produces a negative GDP and inflation cost is made possible by the asymmetry of this policy: it responds differently to strongly negative and strongly positive shocks, which, as shown in Chart 1.2, is reflected in a reduction of the density of the left-hand tail which scarcely affects the right-hand tail of the distribution.

9 M. Nessén and D. Vestin (2005), "Average Inflation Targeting", *Journal of Money, Credit and Banking,* 37, pp. 837-863, refer to this strategy as «average inflation targeting». At the limit, a rule which responded to an infinitely long moving average of inflation would be equivalent to a PLT rule.

Box 3.3

ASSESSMENT OF THE ALTERNATIVE MONETARY POLICY RULES USING THE JoSE MODEL (cont'd)

To help explain more clearly the functioning of the various monetary rules, Chart 2 shows the response of the nominal interest rate and inflation to a combination of negative demand shocks which, under the 2% inflation target rule, push the economy to the ELB for four years. The introduction of QE of a size similar to that of the APP reduces the duration of the ELB and the deflationary pressures, but its effectiveness is initially small and only increases as the size of the central bank balance sheet grows. The PLT rule, through a promise of higher future inflation and the consequent lower ex ante real interest rates, manages to keep the economy from hitting the ELB. Lastly, the temporary PLT regime does not prevent the ELB constraint from being reached, but it does allow a rapid exit.

In summary, the aforementioned simulations suggest that rules specifically designed to address ELB episodes, such as permanent or temporary PLT, or the implementation of asset purchase programmes have an effectiveness in reducing the impact and costs of such episodes which is similar to that of other potentially more inefficient strategies such as raising the inflation target.

Box 3.4

MONETARY POLICY IMPLEMENTATION AFTER THE CRISIS: A COMPARISON OF THE CORRIDOR AND FLOOR SYSTEMS

As indicated in the main text, the expansion of the main central banks' balance sheets has prompted a *de facto* transition from an operational framework characterised by limited bank reserves (relative to minimum requirements) and by money market yields, which fluctuated within the corridor formed by the interest rates on the deposit and lending facilities, to a situation of ample reserves and yields close to their floor (the deposit facility rate). The prospect of a gradual normalisation of monetary policy confronts these central banks with the dilemma of whether to maintain the current floor system or revert to the previous corridor system. This box uses the macroeconomic model of Arce, Nuño, Thaler and Thomas (2018) to compare the stabilising properties of both systems where monetary policy is restricted by the lower bound of interest rates.[1]

Arce *et al.* propose a neo-Keynesian general equilibrium model with a detailed characterisation of the banking sector. Banks have heterogeneous investment opportunities in the model, which give rise to an interbank market where banks lend each other money. To capture this bilateralism in practice, the model assumes that in the interbank market banks which ask for and offer credit have to actively seek each other out. If they do not find a counterparty, they may use the central bank's deposit or lending facilities (as appropriate). Thus, the interbank rate always stands within the corridor formed by the interest rates on the two facilities. The exact position of the interbank rate within this corridor depends on the liquidity conditions of that market: the higher credit supply relative to demand, the closer the interbank rate will be to the floor set by the interest rate on the deposit facility. The other interest rates in the economy are linked to the interbank rate, with the result that fluctuations in this rate are passed through to the interest rates on households' deposits and firms' loans.

In the model the central bank has two ways of influencing market rates. On one hand, the central bank alters the rate on deposit and lending facilities through conventional monetary policy. Thus, for example, when it effects a downward shift in the corridor, it prompts the interbank rate to fall and, consequently, causes other market rates to decline. On the other, the central bank can have a bearing on liquidity conditions in the interbank market and, therefore, on the position of the interbank rate within the corridor through quantitative easing (asset purchase policies). For example, when the monetary authority buys sovereign bonds owned by the banks, those banks with poorer investment opportunities attempt to lend their newly obtained liquidity on the interbank market. The attendant increase in the supply of interbank credit has two consequences. First, the lending banks which manage to find counterparties are forced to accept lower interest rates. Second, the proportion of lender banks which *do not* find counterparties increases and, consequently, they are forced to deposit their funds at the central bank in the form of reserves. The model therefore explains how asset purchase programmes by the central bank push the volume of reserves higher and shift the interbank rate towards the floor, in line with the international experience described above. Chart 1 shows, for the euro area, the relationship between the amount of reserves (as a percentage of GDP) and the spread between the interbank rate (in particular, the Eurepo index of interbank yields) and the remuneration of reserves, together with the relationship as predicted by the model (the black line).

Next the model is used to compare the stabilising capacity of a floor system and a corridor system. Consider a situation in which the economy is in a steady or long-term state. In this situation, the interest rate on households' deposits and the interbank rate only depend on real factors – such as households' discount rate – and the level of the central bank's inflation target, but they *do not* depend on the monetary policy operating system (floor or corridor).[2] The interest rate on reserves in the long term does depend on this system. If the central bank uses the corridor system, the interbank rate is in the middle of the corridor and, consequently, the reserve rate is *below* the interbank rate. Conversely, if it uses a floor system, the interbank rate is the same as the reserve rate. Therefore, in the long term, the floor system means a *higher* level of the interest rate on reserves than in the corridor system

1 Ó. Arce., G. Nuño, D. Thaler and C. Thomas (2018). *A Large Central Bank Balance Sheet? Floor vs Corridor Systems in a New Keynesian Environment,* Banco de España, Working Paper 1851. As discussed in the main text, this was the fundamental mechanism for monetary policy conduct before the crisis.

2 In the model, for plausible calibrations the remuneration of households' deposits is always very close to the interbank rate and, in the floor system, it is exactly the same as the interbank rate.

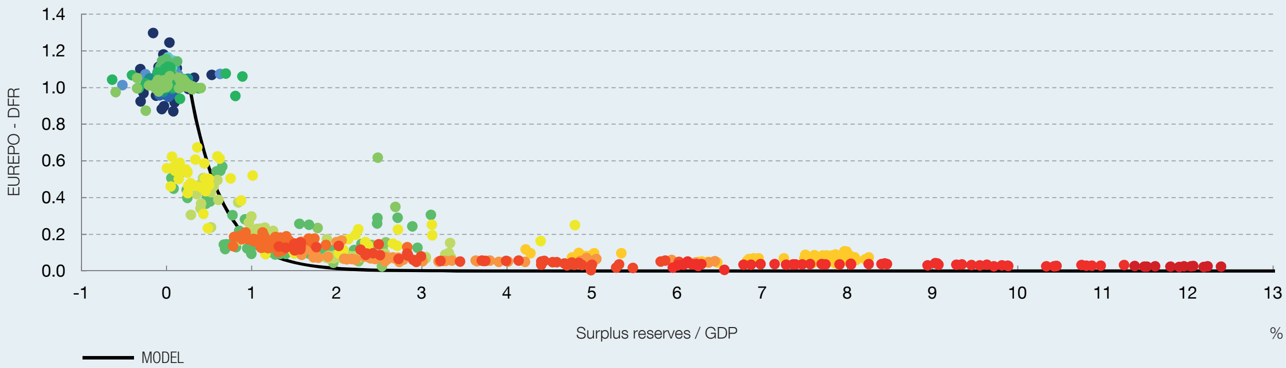
and, consequently, there will be more scope to cut it when faced with negative shocks. The magnitude of this additional headroom is equivalent to half the width of the symmetrical corridor. For example, the difference between the European Central Bank's pre-crisis deposit and lending facility rates was 200 basis points (bp); in this case, the gain in terms of room in a floor system would be 100 bp.

The red and blue lines in Charts 2, 3.1 and 3.2 exemplify this comparison by showing the economy's response to a negative demand shock in a version of the model which is calibrated for the euro area. In a corridor system scenario, where the central bank maintains its balance sheet size at low levels (the blue lines in Charts 2 and 3.1), the deflationary effect of the shock is strong enough to make the central bank reduce the rate on the deposit facility to its lower bound and hold it there for several quarters.[3] The red lines in Charts 2 and 3.2 show the same situation, but starting out from a steady state with the floor system, i.e. with a central bank balance sheet which is large enough for the reserve rate to be equal to the interbank rate at any given time and, therefore, it starts out from a higher initial level. In this case, the central bank has more room (100 bp in this example) to lower the deposit facility rate. This results in a greater fall of the interbank rate and, by extension, of other market rates. As a result of this greater stimulus, the impact of the crisis is mitigated – by reducing the decline in activity and prices – to such an extent that the central bank does not actually consider it necessary to reduce the remuneration of reserves to its lower bound.

The above comparison assumes that in the corridor system the central bank does not introduce any measures to expand its balance sheet. The dark blue broken lines in Chart 2 and the solid lines in Chart 3.3 depict a third scenario, where the central bank starts out with a corridor system but expands its balance sheet through a temporary government bond purchasing programme implemented contemporaneously with the recessionary shock. This situation would roughly mirror the recent experience of central banks in the main advanced economies. Using

Chart 1
RELATIONSHIP BETWEEN SURPLUS RESERVES AND THEIR OPPORTUNITY COST IN THE EURO AREA (a)

The chart shows the historic relationship between surplus bank reserves deposited at the ECB and the opportunity cost of these reserves, defined as the difference between the collateralised interbank interest rate (Eurepo) and the deposit facility rate (DFR). The line shows the results obtained by the economic model used.



SOURCE: Banco de España, based on the model of Arce, Nuño, Thaler and Thomas (2018).

a The colours indicate the year, from dark blue which corresponds to the beginning of the sample (1999) through to red (2019).

3 Arce *et al.* (2108) op. cit. In the model, the central bank adjusts its interest rates (assuming a constant distance between the upper and lower bounds of the corridor) so that the interbank rate, that is the central bank's operating target, follows a simple Taylor rule which responds to deviations in inflation from its target. This is so *except* when the rate on the deposit facility implementing the desired interbank rate collides with its lower bound; in this case, the central bank loses its ability to continue reducing rates to return inflation to its target.

Box 3.4

MONETARY POLICY IMPLEMENTATION AFTER THE CRISIS: A COMPARISON OF THE CORRIDOR AND FLOOR SYSTEMS (cont'd)

Chart 2
MAIN MACROECONOMIC VARIABLES

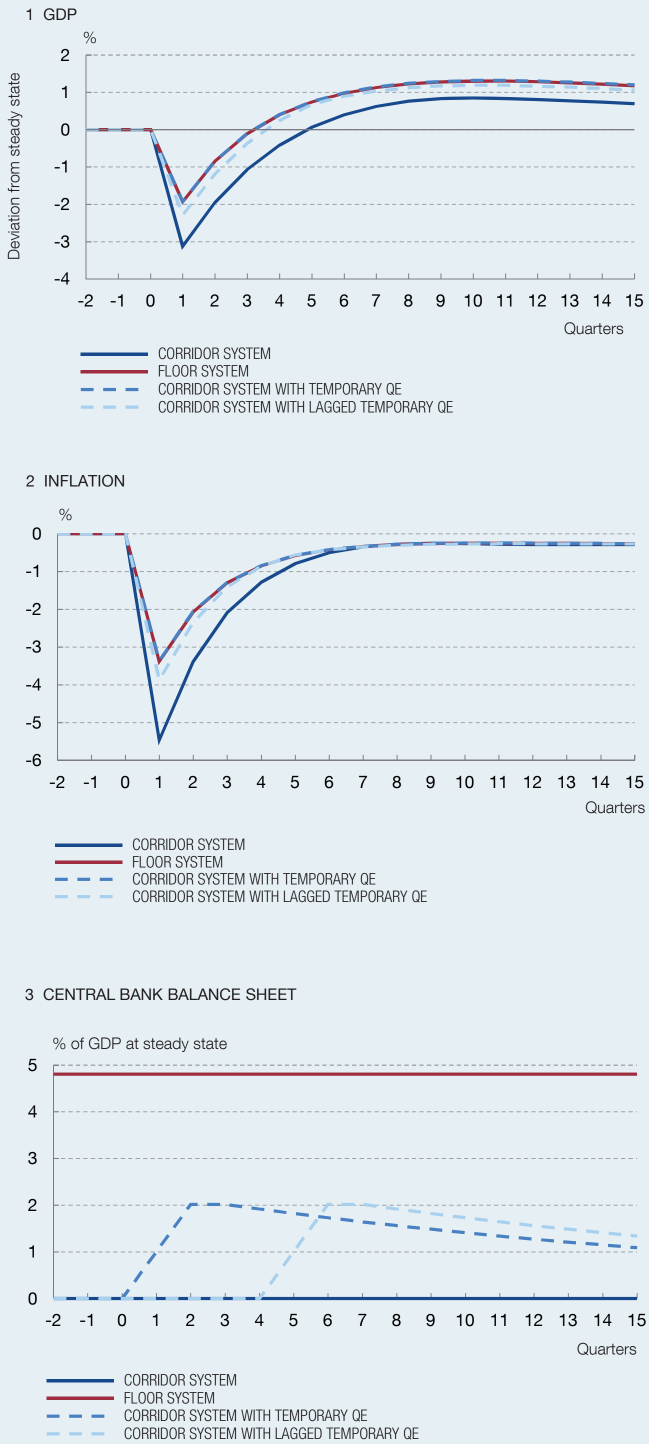
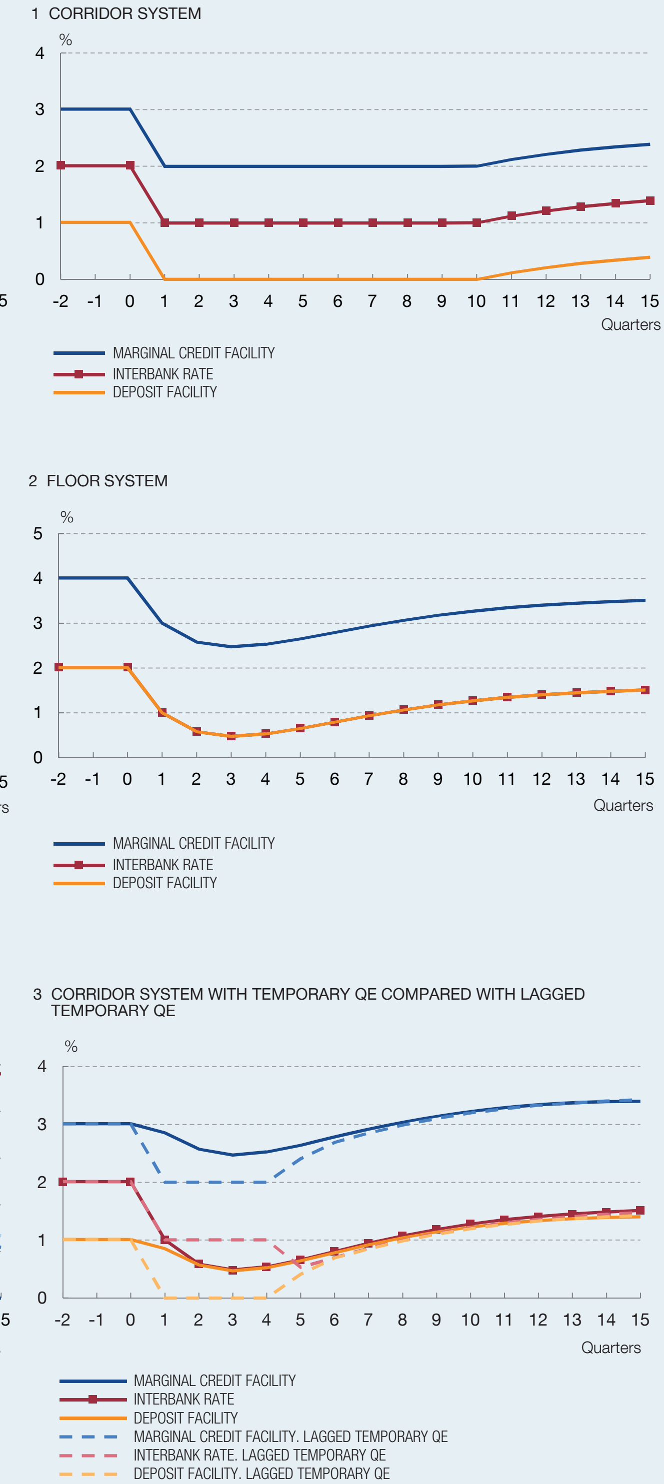


Chart 3
POLICY AND INTERBANK INTEREST RATES IN A CORRIDOR/FLOOR SYSTEM



SOURCE: Banco de España.

this measure, the central bank manages to squeeze the spread between the interbank and reserve rates and, therefore, achieves an additional decline in the interbank rate and in other market rates. As a result of the attendant additional stimulus the stabilisation of GDP and inflation is similar to that in the floor system. However, this equivalence hinges crucially on the central bank having the ability to trigger its asset purchases as soon as the adverse shock arises, something which may be complex in practice (for example, for operating or institutional reasons). The light blue broken lines in Chart 2 and the broken lines in Chart 3.3 show an alternative scenario where the central bank starts to purchase assets a year after the recession has begun. In this case, the stimulus is smaller and, consequently, GDP and inflation fall more than in the two above-mentioned cases.

In short, a floor system provides direct control of market interest rates and more room to cut benchmark rates in response to negative shocks. Although a corridor system which implements temporary asset purchase programmes can achieve very similar monetary stimulus, these programmes must be expedited. In practice, however, the triggering and implementation of asset purchase programmes may be delayed, which reduces their effectiveness. The opposite is the case with interest rate policy, which is, operationally speaking, generally less complicated to change.