Steering interest rates amidst large structural surplus liquidity: a tale of three central banks

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Abstract

This paper focuses on as to how three central banks, viz. the United States Federal Reserve (US Fed), the European Central Bank (ECB) and the Reserve Bank of India (RBI), steered interest rates in the face of large surplus liquidity. This study finds that it is challenging to steer the interest rate in the middle of the corridor when there is large surplus liquidity. However, the floor of the policy corridor (the ECB and the RBI) and the interest rates on excess reserves (the US Fed) prevented overnight interest rates from collapsing. As such, the relationship between interest rates and surplus liquidity was found to be non-linear, i.e. beyond a certain threshold, surplus liquidity had no material additional impact on interest rates.

Keywords Steering of interest rates · Structural surplus liquidity · Liquidity management

JEL Classification E43 · E58

1 Introduction

Central banks in many advanced and emerging economies follow interest rate targeting framework under which they steer short-term interest rate in the overnight inter-bank market—the operating target—in line with their policy rate decisions. Central banks periodically set policy interest rates, which signal their intention of the level of the operating target. The changes in the operating target are transmitted to the entire spectrum of interest rates and asset prices, which then help achieve ultimate objectives of price stability and growth. In order to make sure that the operating target remains close to the policy rate, central banks need to supply only that much liquidity as is demanded by the system. If liquidity supplied is more than the demand, the operating target may fall below the policy rate with attendant implications for other

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interest rates in the system and ultimate objectives of monetary policy. Conversely, if liquidity supplied is less than the demand, the operating target may trade above the policy rate. Thus, active day-to-day liquidity management is a *sine qua non* for the successful conduct of monetary policy.

After the global financial crisis (GFC) in 2008, central banks in many advanced economies (AEs), especially the United States (US) and the Euro area, infused large liquidity first to restore normalcy in dysfunctional financial markets and then to support economic activity after interest rates reached effective lower bound (ELB).¹ Liquidity was infused through large-scale asset purchase programmes (LSAPs), the so-called quantitative easing, so as to bring down long-term interest rates and encourage private sector lending directly. That is, central banks in these countries used their balance sheets as a tool of monetary policy to promote economic activity. The balance sheet of the US Federal Reserve (US Fed) expanded five times from US Dollar (USD) 0.9 trillion in January 2008 to USD 4.5 trillion in January 2015 and that of the European Central Bank (ECB) 3.5 times from EUR 1.3 trillion in January 2008 to EUR 4.6 trillion in October 2018. This surge in the central banks' balance sheet size and the quantum of bank reserves affected the conduct of monetary policy operations of these central banks (Bernanke 2016).

On November 8, 2016, India demonetised its high-value currency notes constituting about 86.9% of total currency in the circulation. Demonetisation did not impact immediately the balance sheet of the Reserve Bank India (RBI) as demonetised notes continued to be its liabilities. However, as old currency notes returned to banks, a large part of it remained as deposits with the banks, flushing the system with large surplus liquidity.²

The question that arises is as follows: How did central banks in these countries steer interest rates in the context of large liquidity? Since the contexts of surplus liquidity and the operating procedures of monetary policy were different in these three economies, the challenges were also different. The ECB and the RBI followed a corridor system, which provided a floor and ceiling to short-term interest rates. Large liquidity did not pose much of a challenge to the ECB as it was intentional, and the lower bound of the corridor ensured that the operating target did not collapse. The large surplus liquidity in India was the unintended outcome of demonetisation of high-value currency notes. Hence, it became a challenge to steer overnight interest rates close to policy rate. On the other hand, the operating system in the US did not have a floor and the US Fed wanted to create a lower bound or floor on the federal funds rate to have an effective control of interest rates, especially when it had to raise the interest rates in the economy (FOMC 2016). The US Fed, therefore, set up a floor and also a sub-floor to have effective control over interest rates. In the above backdrop, this paper examines as to how the three central banks, viz. the US Fed, the ECB and the RBI, steered interest rates in the face of unprecedented surplus

¹ Many central banks in the advanced economies again injected large liquidity into their financial systems in the more recent period to mitigate the adverse impact of the Covid-19 pandemic. This paper, however, deals only with the issue of large liquidity injected immediately after the global financial crisis.

² The RBI also injected large surplus liquidity again beginning June 2019 and the surplus liquidity became more pronounced beginning February 2020, when the Reserve Bank injected large liquidity to mitigate the adverse impact of the Covid-19 pandemic. This period, however, is not considered in this paper.

liquidity,³ i.e. it assesses the marksmanship in keeping an effective control over the benchmark rate or the operating target amidst large surplus liquidity.

This study finds that it is challenging to steer interest rates in the middle of the corridor in the face of large surplus liquidity. However, all the three central banks were able to keep the benchmark rates within the corridor (the ECB and the RBI) or target range (the US Fed) even in the face of unprecedented surplus liquidity.

The paper is organised in six sections: Section 2 provides the theoretical underpinnings of liquidity management framework followed by most central banks (CB) and compares the corridor and floor systems of liquidity management. Section 3 details the developments which led to large surplus liquidity in the United States, Euro area and India. Section 4 delineates the challenges posed by large surplus liquidity in steering short-term interest rates and the measures undertaken for ensuring an effective control over them. Section 5 empirically evaluates as to how far the three central banks were able to have an effective control over short-term rates. Section 6 sums up the key findings and sets out some final reflections.

2 Liquidity management frameworks: corridor versus floor systems

Many central banks use inter-bank overnight call rate as the operating target of monetary policy. For ensuring that the operating target remains aligned to the policy rate, many central banks follow a corridor system under which the central bank endeavours to steer interest rates in the overnight market by actively managing liquidity. However, in order to ensure that rates move within the narrow range, they provide a corridor of lower bound and upper bound around the target rate. Interest rates in the overnight money market are determined by the demand for and supply of bank reserves. The demand for reserves varies inversely to the overnight interest rate. When the interbank rate is high, the demand for central bank reserves will be low as the opportunity cost for holding surplus reserves will also be high and *vice-versa*. Hence, the demand curve is downward sloping.

However, the supply curve is independent of interest rates and is hence vertical (S_0). This is because if the central bank is to meet the target rate in the inter-bank market, it must supply as much liquidity to the system at that rate as is demanded by the system. Reserves provided more (or less) than demanded will pull down the rate below (or above) the target. That is, if the policy rate of the central bank is to be in middle of the corridor, it must supply only as much reserves as there is demand so that the supply curve crosses the demand curve in the middle of the corridor. However, the demand curve becomes flat at the upper bound and the lower bound. This is because the central bank is willing to provide any amount of reserves at the upper bound, which ensures that rates in the inter-bank market do not breach the upper bound. Likewise, the central bank is ready to absorb any amount of reserves at the

³ Excess liquidity in the banking system refers to excess of available liquidity over the need for liquidity arising out of autonomous factors and reserve requirements. Excess liquidity always stays with the central bank. It is either held in the current accounts of commercial banks maintained with central bank or in the deposit facility provided by the central bank (ECB 2017).

Fig. 1 Reserve demand and supply curve under corridor and floor systems. *CB* Central Bank

lower bound so that interest rates do not fall below the lower bound. While it is the endeavour of the central bank to keep overnight rates at the target or in the middle of the corridor, some sudden shocks may make inter-bank rates move away from the target. Thus, the corridor ensures that rates do not move much even in the face large liquidity shocks (Fig. 1).

In a floor system, the central bank could supply any amount of reserves to the banking system without being concerned as interest rates in overnight call money market will remain generally aligned to the policy rate or the floor. As shown in Fig. 1, there is no change in the rate when the supply of reserves increases from S_2 to S_3 . However, under a floor system, the lower bound, which is normally the deposit rate, becomes the effective policy rate consistent with monetary policy objectives and the central bank can operate with two independent tools, viz. interest rate and liquidity management. Thus, while the corridor system allows the central banks to align the target rate close to the policy rate, in a floor system, the central bank chooses the lower bound as the effective policy rate so that it can provide any amount of liquidity to the system.

3 Factors driving surplus liquidity in the US, Euro area and India

Traditionally, sources of surplus liquidity have been (1) large current account surplus; (2) large capital inflows and (3) in some cases lending to the Government by the central bank. Surplus liquidity could also arise on account of relaxation in cash reserve requirements. Surplus liquidity arising on account of these factors is transitory. However, in last 10 years, some advanced economies and India witnessed surplus liquidity, the scale and duration of which were unprecedented.

After the GFC, central banks in major AEs, such as the US Fed and the ECB, infused large liquidity to banks as short-term money markets froze and failed to redistribute liquidity. To ensure smooth functioning of short-term money markets, central banks expanded their existing liquidity facilities by elongating the maturity of their lending operations, broadening the list of collaterals, expanding the set of counterparties and relaxing other terms of lending to address the problem of impaired monetary transmission. Simultaneously, economic activity also slowed down sharply. To support economic activity, central banks reduced their policy rates and in the case of major AEs policy rates reached ELB. However, even this was not sufficient as these economies faced bleak economic prospects. Therefore, in order to bolster their economies, central banks in many AEs, especially the US Fed and the ECB, used their balance sheets as a tool of monetary policy by resorting to large asset purchases.

3.1 The US Fed

In the US, the Federal Open Market Committee (FOMC) sets a target for the federal funds rate (fed funds rate) consistent with the dual mandate of maximum employment and stable prices. Responding to the global financial crisis, the US Fed reduced

Fig. 2 Total assets and reserves—US Fed. Data Source: Fed Economic Data, Federal Reserve Bank of St. Louis

the fed funds rates to 0–0.25% in December 2008. To achieve the committee’s target funds rate, traditionally the US Fed had relied on open market operations (outright purchases) to supply the reserves (liquidity) required to meet the demand. However, in the beginning of 2008, the US Fed embarked on a massive balance sheet expansion. Initially, the focus was on restoring normalcy in financial markets by providing liquidity to key credit markets and lending to financial institutions. However, as signs of a severe recession became clear, a large-scale asset purchase programme (i.e. quantitative easing) was put in place. As a result, the size of the balance sheet of the US Fed expanded five times between 2008 and 2015. A large expansion of the balance sheet on the asset side resulted in a large increase in excess reserves held by banks from USD 0.02 trillion in August 2008 to USD 2.6 trillion in October 2015 (Fig. 2). Excess reserves represented the structural surplus liquidity in the system.

3.2 The ECB

In the Euro area, inter-bank markets froze after the GFC due to doubts about the solvency of counterparties. Hence, banks with surplus liquidity were not willing to redistribute the liquidity through inter-bank lending as they were doing before the GFC. Hence, the ECB switched to a system of fixed rate full allotments (FRFAs) in October 2008, whereby banks could get any amount of liquidity. Following this, banks wanted to have more liquidity than necessary in order to be insured against hitches in accessing liquidity in the money market (ECB 2014). This, therefore, resulted in excess liquidity in the system. Excess liquidity declined sharply after 2012 following the easing of financial strains. However, in the beginning of 2013, the ECB started making active use of its balance sheet by introducing asset purchase programme to increase the monetary base for strengthening monetary transmission and securing price stability. The balance sheet of the ECB also expanded more than

Fig. 3 Total assets and excess liquidity—ECB. Note: Excess liquidity includes deposits at the deposit facility at the ECB net of the recourse to marginal lending facility, plus current account holding in excess of minimum reserve requirements. Data Source: ECB Statistical Data Warehouse

three times in the last 10 years (Fig. 3). As a result, large excess liquidity was also created in the Euro area banking system.

3.3 The RBI

On November 8, 2016, the Government of India withdrew from circulating the currency notes of Rupee (INR) 500 and INR 1000 denomination—constituting about 86.9% of total currency in circulation. This did not impact immediately the balance sheet of the RBI as demonetised high-value currency notes continued to be its liabilities.⁴ However, as demonetised notes returned to the banking system, a large part of such notes remained with banks as deposits, resulting in large structural liquidity in the banking system. Surplus liquidity⁵ increased from INR 111 billion in October 2016 to peak at INR 7010 billion by January 2017, before tapering gradually thereafter (Fig. 4). Unlike in AEs, large liquidity in India was not the result of an expansion in the balance sheet of the central bank.

⁴ Of the total demonetised notes of INR 15,417.93 billion, INR 15,310.73 billion, i.e. 99.9%, returned to the banking system (RBI 2018).

⁵ Structural surplus liquidity represents net Liquidity Adjustment Facility (LAF), excess Cash Reserve Ratio (CRR) balances and Market Stabilisation Scheme (MSS) bonds which could be accessed from the RBI's database (<http://www.rbi.org.in>). This could not be adjusted for movements in government cash balances on which data are not available.

Fig. 4 Surplus liquidity—RBI. Data Source: Authors' estimates based on RBI data

4 Large surplus liquidity: challenges faced and measures initiated

4.1 The US Fed

At the time of the GFC, the US Fed did not follow the corridor system for steering interest rates unlike the ECB and the RBI. The discount window of the US Fed did provide the upper bound to interest rates, but it was irrelevant in the context of large surplus liquidity. What was relevant in the face of surplus liquidity was the deposit facility or a lower bound or floor, which, however, the US Fed did not have. In a situation of large surplus liquidity, the US Fed needed some floor to have an effective control over interest rates. This was provided by the Financial Services Regulatory Relief Act of 2006 which empowered the US Fed to pay interest on reserves. The Act originally authorised the US Fed to pay interest on balances held by or on behalf of depository institutions beginning October 1, 2011. However, this date was brought forward to October 1, 2008 by the Emergency Economic Stabilisation Act, 2008. The Fed initially set the rate paid on excess balances as the lowest targeted federal funds rate less than 75 basis points (Afonso et al. 2011). It was expected that paying interest on excess reserves (IOER) should create a lower bound to the fed funds rate (Dudley 2018). In the next few months, however, it became clear that interest rate on excess reserve balances was not enough to establish an effective floor. As a result, the FOMC gradually narrowed the difference between the lower bound of the target fed funds rate and the rate paid on reserves. The interest rate paid on required and excess reserves was reduced to 0.25 percentage points when the fed funds rate target by the FOMC was lowered to 0–0.25% by December 2008 (FOMC 2008). Paying interest on excess reserves was akin to a deposit facility instituted by several other central banks, which had formally adopted the corridor system, under which fixed rate of interest is paid on liquidity parked. However, unlike other central banks, the US Fed remunerated surplus liquidity at the upper end of the target range of the policy rate. Since banks have no incentive to lend below the interest rate paid

on deposits with the US Fed, interest rate paid on such deposits was expected to provide a floor to interest rates in the inter-bank money market.

With the institution of IOER, even though the fed funds rate traded in the target range, it was lower than the interest rates on excess and required reserves. The main reason for the fed funds rate trading below the IOER was that several non-depository institutions did not have access to accounts at the US Fed to earn interest on their surplus balances. Although some Government Sponsored Enterprises (GSEs) were eligible to maintain accounts with the Reserve Banks, they received no interest on the reserves held in those accounts (Kahn 2010). The persistent difference between the IOER and the fed funds rates was a concern for the Fed as it worried about the control over interest rates when the “lift off” (raising of rates by the US Fed) would occur. Hence, the FOMC needed supplementary tools to exercise better control over interest rates during the “lift off” phase. To address this problem, the US Fed in September 2014 indicated that it intended to use overnight reverse repurchase agreement (ON-RRP) facility as a “supplementary tool” to have a better control over the fed funds rate. The FOMC also indicated that it “intended to use an ON-RRP facility only to the extent necessary and will phase it out when it was no longer needed to help control the fed funds rate” (FOMC 2014). Hence, when the FOMC raised the fed funds rates to a range of 0.25–0.50% in December 2015, it also decided to undertake ON-RRP at an offering rate of 0.25%.⁶ The offering rate on RRP has since moved in line with the lower level of the target range of the fed funds rate. ON-RRPs are offered to a greater number of counterparties, including money market mutual funds and GSEs, which are significant lenders in the money market, thereby providing an opportunity to these institutions to park their surplus cash balances with the US Fed. Any counterparty that is eligible to use the ON-RRP facility will be unwilling to lend to others at a rate lower than the ON-RRP rate just as any depository institution is unwilling to lend to any counterparty at a rate lower than the IOER. Thus, the ON-RRP facility for non-banking institutions was akin to payment of interest on excess reserves for banks or depository institutions. Thus, the IOER sets the floor and ON-RRP sets the sub-floor, below which interest rates were not expected to fall (FOMC 2014).

4.2 The ECB

Several measures adopted by the ECB to restore normalcy in the inter-bank market led to significant decline in the overnight inter-bank rate (EONIA), and it started trading significantly below the main refinancing operations rate. At first, this raised some issues on signalling of the monetary policy stance to the market, as it could be interpreted as the central bank’s inability to effectively control the overnight interest rates (Beirne 2012). This could dent the credibility of the central bank. Keeping

⁶ The Fed started the test ON-RRP operations in September 2013 to gain operational experience, and in September 2014, the FOMC indicated its intentions to set a target range for the fed funds rate by adjusting the IOER and using ON-RRP operations as a supplementary policy tool to control the fed funds rate (Frost et al. 2015; FOMC 2014).

this in view, the ECB narrowed the width of the corridor of standing facilities. The underlying idea was to maintain the monetary policy credibility, even as excess liquidity could put some downward pressure on overnight market rates (Beirne 2012). In 2010, the ECB announced the implementation of the Securities Markets Programme (SMP). The liquidity injected by SMP was sterilised in order to attain better control over the short-term interest rate (Trichet 2011; Bordes and Clerc 2012). Later, it was widely accepted that EONIA traded at the bottom of the corridor and that the Deposit Facility Rate (DFR) became de facto the relevant policy rate.

4.3 The RBI

In India, large surplus liquidity arising out of demonetisation of high-value currency notes posed a major challenge to the RBI. Unlike the US Fed and the ECB, which consciously injected primary liquidity with a view to restore normalcy in the money market initially and promoting economic activity later, large liquidity expansion in the case of India was an unintended consequence of demonetisation. Therefore, unlike the US Fed and the ECB, the RBI instituted conventional and unconventional instruments to absorb large surplus liquidity. First, the RBI initially absorbed surplus liquidity through its regular liquidity window. However, as deposits with the banking system and consequently surplus liquidity surged, the RBI applied an incremental cash reserve ratio (ICRR) of 100% as a temporary measure for a fortnight (between September 16 and November 11, 2016), which helped drain of about INR 4000 billion excess liquidity from the system. Second, the central government enhanced the limit of market stabilisation scheme (MSS)⁷ bonds from INR 300 billion to INR 6000 billion on December 2, 2016. With this, the Reserve Bank withdrew the ICRR. Third, open market sales of cash management bills (CMBs) were undertaken under the MSS to drain the excess liquidity. Fourth, variable rate reverse repos of various tenors were conducted. On January 4, 2017, liquidity absorbed reached the peak level of INR 7956 billion (comprising INR 2568 billion absorbed through reverse repos and INR 5466 billion through CMBs under the MSS) (Fig. 5). Fifth, despite these measures, however, the operating target continued to be traded below the repo

⁷ “The market stabilisation scheme (MSS) scheme was launched in April 2004 to strengthen the RBI’s ability to maintain the stability in foreign exchange market and enable the conduct of monetary policy in accordance with its stated objectives. The ceiling on the amount of securities issued under the MSS is mutually agreed upon between the Government and the Reserve Bank from time to time by way of a Memorandum of Understanding (MoU) under the MSS. The government bills/bonds issued by way of auction under the MSS have all the attributes of existing treasury bills and dated securities. The amount of bills and securities issued for the purpose of MSS is matched by an equivalent cash balance held by the Government with the Reserve Bank, thus, having only a marginal impact on the revenue and fiscal deficits of the Government to the extent of interest payment on bills/securities outstanding under the MSS. The cash management bills (CMBs) issued under the MSS are non-standard discounted instruments, generally issued by the Government to meet the temporary mismatches in their cash flows. CMBs have the generic character of Treasury Bills but are issued for maturities of less than 91 days. Hence, they can be issued to absorb excess liquidity during the period of large surplus conditions, as has been the case after demonetisation” (RBI 2017, pp. 17; RBI 2004a, b).

Fig. 5 Liquidity management—RBI. Data Source: Adapted from the Monetary Policy Report, October 2017, RBI and updated with the recent information

Fig. 6 Fed funds rate and IOER—US Fed. Data Source: Fed Economics, Federal Reserve Bank of St. Louis

rate of the RBI. With a view to better aligning the operating target with the repo rate, the policy rate corridor was narrowed from ± 50 basis points (bps) to ± 25 bps in April 2017 (RBI 2017).

5 Relationship between surplus liquidity and operating target: empirical estimates

5.1 The US Fed

In the case of the US Fed, the effective fed funds rate had consistently traded below the IOER though within the target range set by the Fed. It was only after June 2018

that the fed funds rate had hovered around the IOER reflecting the decline in surplus liquidity in the system. The institution of ON-RRP facility allowed the Fed to keep the interest rate within the target range. Between August 2014 and November 2018, excess reserves declined by USD 1 trillion from USD 2.7 trillion to USD 1.7 trillion, which helped better align the effective fed funds rate to the floor provided by IOER (Fig. 6). For the first time since December 2008, the FOMC set the interest rate paid on required and excess reserve balances 5 basis points below the upper end of the target range for the federal funds rate in June 2018 (1.95% as against the target range of 1.75–2.0%, which was later reduced further to 10 bps (2.40% as against the target range of 2.25–2.50%) in December 2018 (FOMC 2018). This was expected to promote trading in the federal funds market at rates within the FOMC's target range (FOMC 2018).

The relationship among interest rate set by the central banks, overnight money market rates and surplus liquidity is empirically examined in a Vector Auto Regression (VAR) framework. VAR has become quite common in examining the transmission channels of monetary policy because it does not need a full understanding of the structure of the economy, largely data dependent and imposes minimum theoretical restrictions (Bagliano and Carlo 1998). Some studies have used VAR framework for examining the impact of short-term policy interest rates on financial markets, for instance, Amisano et al. (1997) for Italy, Redward and Saarenheimo (1996) for Finland and Pétursson (2001) for Iceland. These studies use VAR framework to identify the effects of monetary policy transmission to financial markets using representative interest rates. This framework is applied separately to each of the three central banks, viz. the US Fed, the ECB and the RBI, to examine the effect of short-term interest rates set by these central banks on overnight money market rates accounting for the impact of liquidity conditions.

In the case of the US Fed, *IOER*, excess reserves with Fed (*EX_RES_US*)—representing the liquidity conditions—and effective fed funds rate (*EFFR*) are used as the key variables in VAR. Since US witnessed a prolonged period of excess liquidity mainly due to quantitative easing in response to the global financial crisis, monthly data from January 2009 to August 2018 were used. The data on *IOER*, *EX_RES_US* and *EFFR* were taken from the Federal Reserve of St. Louis (fred.stlouisfed.org). All the variables were found to be non-stationary—integrated of order 1—in the sample period. Since the variables were non-stationary, it was first attempted to estimate endogenous system of variables in an error correction framework. The 3-variable vector error correction model (VECM) was found to be unstable (the coefficient of error correction term was found to be positive and significant). Hence, a VAR was formulated using the variables in the first difference form— $[\Delta IOER, \Delta EX_RES_US, \Delta EFFR]$. The lag length of the variables was chosen based on Bayesian information criterion (BIC) and overall model properties. The regression diagnostics were found to be satisfactory, i.e. (a) there was no residual auto correlation and (b) all Eigen values were inside the unit circle. The generalised accumulated⁸ impulse

⁸ As the VAR was run in differences, accumulated impulse response function provides a response equivalent one-unit shock in the policy rate.

Fig. 7 **a** Accumulated response of change in EFFR to change in IOER shock (1 ppt). **b** Accumulated response of change in EFFR to change in liquidity shock (USD 1 trillion). Source: Authors' estimates; *ppt* percentage points

Fig. 8 Historical decomposition of *EFFR*. Source: Authors' estimates. Note: "Rest" includes the impact of *IOER*, deterministic component and the residuals; *ppt* percentage points

response functions (GAIRF) of $\Delta EFFR$ to a unit shock in $\Delta IOER$ and changes in excess reserves are presented in Fig. 7a, b, respectively.

Further, as stated by Sims et al. (1990) "the common practice of attempting to transform models to stationary form by difference or cointegration operators whenever it appears likely that the data are integrated is in many cases unnecessary". Hence, following Dua et al. (2003), the VAR was also run with variables in levels. The results were broadly similar.

Fig. 9 Non-linear fit of spread (*EFFR*–*IOER*) and excess reserves—US Fed. Source: Authors' estimates

Figure 7a suggests that the transmission of the *IOER* to *EFFR* is almost complete as the ratio of accumulated impact to the accumulated response over a period of 24 months is close to one. The changes in excess liquidity are found to be affecting the $\Delta EFFR$ negatively and significantly (Fig. 7b). The role of liquidity represented by excess reserves is further examined by generating the historical decompositions⁹ of *EFFR* (Fig. 8). Fig. 8 suggests that surplus liquidity posts the GFC contributed negatively to *EFFR* up to 15 basis points at its peak.

The VAR estimates provide an average and linear description of the contribution of excess liquidity to the evolution of *EFFR*. The possible variation in the relationship of excess liquidity and market rates can be estimated by fitting a non-linear function. For identifying the non-linear relationship, a set of 34 non-linear functions¹⁰ on the spread between *EFFR* and *IOER* (Y) and excess liquidity conditions (X) was estimated and the one with the largest $\bar{R}^2$ was identified. The Rational Curve ($Y = (102.74 - 0.24 \times X) / (1 + 1.52 \times X - 0.00006 \times X^2)$) approximates the relationship with the highest $\bar{R}^2$ (0.92) (Fig. 9).

Figure 9 shows that an increase in excess liquidity led to widening of negative spread (between *EFFR* and *IOER*). However, the relationship is non-linear; the impact of large excess liquidity on the spread reduces significantly beyond a point. For testing this non-linearity and estimating the threshold value, a threshold regression was estimated with spread as the dependent variable and excess liquidity

⁹ For generating the historical decompositions, VAR Toolbox 2.0 developed by Ambrogio Cesa-Bianchi has been used. The codes are available at <https://sites.google.com/site/ambropro/MatlabCodes>. This toolbox uses routines from Econometrics Toolbox for Matlab by James P. LeSage (Available at <https://www.spatial-econometrics.com/>).

¹⁰ We fit "Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, Compound, S-curve, Logistic, Growth, Exponential, Vapor Pressure, Reciprocal Logarithmic, Modified Power, Shifted Power, Geometric, Modified Geometric, 4th order Polynomial, Hoerl, Modified Hoerl, Reciprocal, Reciprocal Quadratic, Bleasdale, Harris, Exponential Association, Three-Parameter Exponential Association, Saturation-Growth Rate, Richards, Morgan-Mercer-Flodin, Weibull, Sinusoidal, Gaussian, Heat Capacity and Rational" curves as per the Stata codes provided by Liu (2010).

Fig. 10 Main refinancing operations rate and EONIA—ECB. Data Source: ECB Statistical Data Warehouse

conditions as the independent variable. Logistic Smooth Transition Regression (LSTR) model was used to estimate the unknown threshold value of the excess liquidity (Teräsvirta 1994, 1998). The estimation procedure was as followed by McAleer and Marcelo (2008) and Hillebrand et al. (2013), which uses a quasi-maximum likelihood (QML) estimator. The empirical estimates¹¹ suggest that the impact of excess liquidity on the spread declined sharply but did not turn insignificant when excess liquidity crossed the estimated threshold level of USD 1.7 trillion.

5.2 The ECB

The ECB does not have an explicit interest rate target, unlike several other central banks. The ECB never specifically mentioned a single short-term interest rate as its operational target. Nevertheless, operating framework of monetary policy is designed in such a way that the overnight market rate usually remains aligned to the middle of the corridor provided by the rates under standing facilities (Soares and Rodrigues 2013). EONIA, an unsecured money market rate, was referred by many practitioners as an important benchmark to assess the monetary transmission (Praet 2017). In the case of ECB, EONIA has by and large traded below the main refinancing operating rate (MRO) since April 2009 and has been hugging the lower bound of the corridor most of the period since early 2012 (Fig. 10).

As in the case of the US Fed, for the ECB also, all variables (*MRO*, *EX_LIQ_ECB* and *EONIA*)—where *MRO* is the main refinancing operations rate, *EX_RES_ECB* is the excess reserves of ECB and *EONIA* represents the overnight benchmark market rate—were found to be non-stationary, i.e. integrated of order 1. The Johansen tests for cointegration suggested that the variables were not cointegrated. Therefore,

¹¹ For estimating the multiple regime threshold model, the Matlab codes developed by Marcelo C. Medeiros available at <https://sites.google.com/site/marcelocmedeiros/Home/codes> has been used.

Fig. 11 **a** Accumulated response of change in *EONIA* to change in MRO rate shock (1 ppt). **b** Accumulated response of change in *EONIA* to change in liquidity shock (EUR 1 trillion). Source: Authors' estimates; *ppt*: percentage points

Fig. 12 Decomposition of *EONIA*. Source: Authors' estimates. Note: “Rest” includes the impact of MRO rate, deterministic component and the residuals

a first difference VAR was estimated with ΔMRO , ΔEX_RES_ECB and $\Delta EONIA$ for the period January 2009 to August 2018. The regression diagnostics of no residual auto correlation and Eigen value stability conditions were satisfied. The GAIRF¹² of $\Delta EONIA$ to a unit shock in ΔMRO and changes in excess reserves are presented in Fig. 11a, b. As in the case of US Fed, alternatively, the VAR was also run with variables in levels. The results were broadly similar.

In the case of ECB, the changes in excess reserves do significantly impact the overnight market interest rate but only at 90% level. In Euro area, market fragmentation is often cited as a sign of impairment in monetary policy transmission to money markets (Eisenschmidt et al. 2018). The historical decomposition¹³ of *EONIA*

¹² As the VAR was run in differences, accumulated impulse response function provides the response equivalent one-unit shock in the policy rate.

¹³ For generating the historical decompositions, VAR Toolbox 2.0 developed by Ambrogio Cesa-Bianchi has been used. The codes are available at <https://sites.google.com/site/ambropo/MatlabCodes>. This toolbox uses routines from Econometrics Toolbox for Matlab by James P. LeSage (Available at <https://www.spatial-econometrics.com/>).

Fig. 13 Non-linear fit of spread (*EONIA*–*MRO*) and excess liquidity—ECB. Source: Authors' estimates

generated from the VAR suggests that excess liquidity contributed to lower overnight market interest rates up to 60 bps at its peak below the MRO rate (Fig. 12).

As in the case of US Fed, a non-linear fit was also estimated between the spread between *EONIA* and the *MRO* rate (Y) and the excess liquidity (X) following the same procedure (Fig. 13). The Rational Curve ($Y = (0.05 - 0.0009 \times X) / (1 + 0.0007 \times X - 0.0000007 \times X^2)$) provided the best fit¹⁴ with $\bar{R}^2 = 0.63$.

Figure 13 indicates that the increase in excess liquidity conditions led to widening of negative spread (between *EONIA* and *MRO*), but beyond a point large excess liquidity had no substantial incremental impact on the spread. Threshold regression,¹⁵ with spread as the dependent variable and excess liquidity as the independent variable, suggests that the impact was significant and negative below the estimated threshold of EUR 815 billion. However, beyond this threshold, the negative impact completely vanishes, with further excess liquidity having no significant impact on *EONIA*.

5.3 The RBI

In the case of India, the post demonetisation period provides a good empirical framework to assess the impact of excess liquidity conditions on short-term rates. In the case of the RBI, the operating target (weighted average call rate—WACR) traded below the repo rate (Fig. 14).

This was so even after the corridor was narrowed. On an average, the WACR traded below the repo rate by 30 basis points at its peak after demonetisation

¹⁴ Estimated based on the Stata codes developed by Liu (2010).

¹⁵ For estimating the multiple regime threshold model, the Matlab codes developed by Marcelo C. Medeiros available at <https://sites.google.com/site/marcelocmedeiros/Home/codes> has been used.

Fig. 14 Repo rate and the operating target—RBI. Data Source: Data Base on Indian Economy, RBI

Fig. 15 Average spread of WACR over the repo rate. Data Source: Data Base on Indian Economy, RBI. ppt percentage points

(Fig. 15). As the surplus liquidity continued till May 2018, the operating target continued to be traded below the repo rate.

To empirically evaluate the impact of liquidity, a VAR was formulated using the following variables—[*REPO*, *LIQUIDITY* and *WACR*—for the monthly data from January 2015 to November 2018. *REPO* is the repo rate; *LIQUIDITY* is a measure of liquidity conditions and *WACR* is the weighted average call money rate, which is the operating target. During this period, the variables were found to be stationary. Hence, VAR was estimated in levels. Many studies in the Indian context have found out that the monetary policy transmission to money markets is instantaneous and almost complete. Further, as a control variable, the volumes in the call money markets (*VOL*) is used. The *REPO*, *WACR* and *VOL* are as available in the Database on Indian Economy (DBIE), RBI. The lag length of the variables was chosen based on BIC and overall model properties. The regression diagnostics of VAR were found

Fig. 16 **a** Response of *WACR* to *REPO* shock (1 ppt). **b** Response of *WACR* to *LIQUIDITY* Shock (INR 1 trillion). Source: Authors' estimates; *ppt*: percentage points

Fig. 17 Decomposition of *WACR*. Source: Authors' estimates. Note: “Rest” includes the impact of Repo rate, deterministic component and the residuals

to be satisfactory, i.e. (a) there was no residual auto correlation and (b) VAR was stable—all Eigen values were inside the unit circle. The GIRF of *WACR* to a unit shock in repo rate and liquidity conditions are presented in Fig. 16a, b, respectively.

Figure 16a suggests that the transmission of the repo rate to the *WACR* is instantaneous and almost complete. Excess liquidity impacts the *WACR* negatively and significantly (Fig. 16b). To ascertain the role of excess liquidity, the VAR was used to generate the historical decompositions¹⁶ of *WACR* (Fig. 17). Fig. 17 suggests that

¹⁶ For generating the historical decompositions, VAR Toolbox 2.0 developed by Ambrogio Cesa-Bianchi has been used. The codes are available at <https://sites.google.com/site/ambrogiomatlabcodes>. This toolbox uses routines from Econometrics Toolbox for Matlab by James P. LeSage (Available at <https://www.spatial-econometrics.com/>).

Fig. 18 Non-linear fit of spread (*WACR-REPO*) and liquidity—RBI. Source: Authors' estimates

surplus liquidity (during November 2016 to April 2018) contributed negatively to the *WACR* up to 30 basis points.

The estimation of the non-linear curve of spread between the *WACR* and the *REPO* (Y) and the excess liquidity (X) following the approach used in the earlier two cases is presented in Fig. 18. The Rational Curve¹⁷ ($Y = (-0.07 - 0.00008 \times X) / (1 + 0.0003 \times X - 0.00000002 - X^2)$) reasonably fits the data with $\bar{R}^2 = 0.69$. The curve flattens as excess liquidity soars, suggesting that large excess liquidity had no substantial incremental impact beyond a point on the spread (Fig. 18).

The threshold regression¹⁸ between spread (between *WACR* and *REPO*) and excess liquidity suggests that the estimated threshold¹⁹ was INR 4.4 trillion. Below the threshold, the negative impact of excess liquidity on the spread was statistically significant. However, the impact was not different from zero when excess liquidity was above INR 4.4 trillion.

6 Summing up and some reflections

The experience of three central banks (the US Fed, the ECB and the RBI) underlines that it is challenging to steer interest rates in the face of large surplus liquidity. Therefore, these central banks had to take corrective measures to ensure effective control over overnight rates. While the US Fed created a floor and a sub-floor to have more effective control over interest rates, the RBI imposed 100% incremental cash reserve ratio and narrowed the policy corridor. The Government of India also enhanced the ceiling of MSS bonds to enable the RBI to absorb large surplus

¹⁷ Estimated based on the Stata codes developed by Liu (2010).

¹⁸ In this case, episodes of only surplus liquidity were considered.

¹⁹ For estimating the multiple regime threshold model, the Matlab codes developed by Marcelo C. Medeiros available at <https://sites.google.com/site/marcelocmedeiros/Home/codes> has been used.

liquidity from the banking system. The ECB adjusted the policy corridor, especially in the period after the GFC to ensure that it did not lose control over short-term interest rates. Despite these measures, in all the three country cases, benchmark rates traded significantly below the policy rate (in the case of the US Fed and the RBI) and hugged the floor (in the case of ECB²⁰).

However, despite large surplus liquidity, all the three central banks were able to keep overnight interest rates within the target range (the US Fed) or the policy corridor (the ECB and the RBI). The relationship between the large liquidity and interest rates is non-linear, i.e. beyond a certain threshold, surplus liquidity has no material additional impact on the spread due to the floor provided in each country. Even though large surplus liquidity did impact benchmark overnight interest rates, an effective floor provided in each of the three countries prevented them from collapsing, by making short-term interest rates insensitive to supply of reserves or liquidity. That is, the floor enabled all the three central banks to divorce monetary management from liquidity management. This also means that with a floor, central banks could operate two independent tools, viz. the interest rate and liquidity supplied. The non-linear impact as well as the estimated thresholds are of policy relevance in the context of balance sheet reduction, especially for the US Fed. The estimated thresholds suggest that the US Fed could reduce excess reserves to USD 1.7 trillion and the ECB to EUR 815 billion without having any significant impact on overnight interest rates. In other words, these estimated thresholds provide guidance as to the smallest possible size of excess reserves to keep overnight interest rates close to the floor. In the case of India, INR 1 trillion of surplus liquidity on an average lead to 4 bps reduction in the WACR up to INR 4.4 trillion. The impact of surplus liquidity becomes insignificant beyond INR 4.4 trillion.

While in India, liquidity position has since normalised and WACR is now broadly aligned with the policy repo rate, the debate that has begun in advanced economies as to which package makes more sense, i.e. (1) the pre-2008 system—a thin balance sheet and steering of overnight rates through the shortage of supply of bank reserves or (2) the present system that comprises a large liquidity surplus and steering interest rates through interest rate on excess reserves or through deposit facility or a floor system (Bernanke 2016). The FOMC felt that a floor system is “likely to be relatively simple and efficient to administer, straightforward to communicate, and effective in steering interest rate control across varied circumstances” (FOMC 2016). Dudley (2018) argued for the floor system for two reasons: First, a floor system is relatively simpler than a corridor system with respect to conducting the operations. In a floor system, the setting of interest rates on excess reserves or on a deposit facility is sufficient to steer overnight interest rates. In contrast, a corridor system compels the central bank to generate accurate forecasts of liquidity (bank reserves) and then supply those reserves through open market operations daily to achieve the operating target. Second, a corridor system impacts the capacity of the central bank to provide the types of lender of the last resort (LOLR) backstop facility if the liquidity to be provided is large as in such cases it needs to drain reserves in a timely manner to maintain an effective control

²⁰ As EONIA hugged the floor, the DFR became de facto the relevant policy rate.

over short-term interest rates. Cœuré (2016) also argued that tighter financial regulations after the global financial crisis such as the liquidity coverage ratio (LCR) have increased the demand for short-term safe instruments, which may require a framework where the central bank needs to separate the level of reserves from the policy rate. In its meeting on January 30, 2019, the FOMC decided to continue with an abundant supply of reserves. Further, it strongly believed that the IOER “provides good control of short-term money markets rates in a variety of market conditions and effective transmission of those rates to broader financial conditions” (FOMC 2019, pp 3–4). It also believed that “higher reserve holdings were an important element of the stronger liquidity position that financial institutions must now hold” (FOMC 2019, pp 4).

There are, however, also some serious concerns with a floor system: First, a large liquidity supplied under a floor system is against the principle of a lean balance sheet of a central bank. Second, a floor system expands the footprints of central banks in short-term money markets, thereby hampering intermediation activity. This is because large liquidity creates an incentive for banks to trade with the central bank rather than with the other banks. Third, there is also a risk that excess liquidity flows to unproductive uses and artificially boosts the asset prices. Fourth, persistent large surplus liquidity has brought about a major change in the behaviour of market participants, whereby they have become used to large liquidity and resist any attempt to reduce large surplus liquidity. Fifth, excess liquidity created by central banks in advanced economies also spills over to emerging economies, resulting in large volatility in capital flows and boom and bust cycles in these economies.

The choice of a particular framework will depend on several country specific factors and the larger macroeconomic objectives that a central bank wants to achieve. While the US has moved to a floor system, it needs to be seen as to how central banks in other advanced economics, especially those that have resorted to large quantitative easing, adjust their operating frameworks.

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Compliance with ethical standards

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