

Evaluating Monetary Policy Operational Frameworks

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I. Introduction

Monetary policy becomes real through financial operations of the central bank with the rest of the world—and in particular with financial institutions. “Signaling” or “open mouth operations” of central banks are only relevant if they affect expectations regarding actual financial market operations. Therefore, a perception that the role of central bank market operations had in some sense to be rediscovered through the financial crisis would be surprising. Central bank financial market operations have been the central banks’ portal to reality ever since the creation of central banks in the 17th century. Operational frameworks (OFs), i.e., the financial instruments and related rules and practices for monetary policy implementation can be designed to be more or less effective, transparent and efficient. If poorly designed, not only the achievement of a central bank’s monetary policy objectives is put at risk, but in addition the efficiency and stability of the financial system can be undermined. Consider four examples of the relevance of OFs from the last 150 years.

First, before 1914, in the “*classical*” age of metal based currencies, two central bank market operations issues were extensively debated and eventually better understood: 1) the question how to address a

bank run through central bank credit and outright purchase operations (the lender of last resort, as treated by Bagehot 1873), and 2) “how to make bank rate effective,” i.e., how to ensure that there is actual central bank control of short-term market rates, and not only of their own policy rates (see in particular King 1936). On both, history illustrates abundantly how a poor understanding of issues related to central bank operations led to wrong decisions and economic costs. Despite the improved understanding toward the end of that period, both topics remain a challenge until today, as for example 1) moved again to the forefront in 2008, and 2) was the key issue in the Federal Reserve’s liftoff in 2015.

Second, the *unstable 25 years after 1914* were characterized by war financing, gold standard suspension and inflation, and later by the temporary costly restoring of the gold standard in a world of unprecedented international imbalances and eventually the deflation and breakdown of financial stability in the early 1930s. Central banks improvised and innovated considerably on their market operations, with more or less success. While the eventual failure to restore normality and sustainable growth is explained also with macroeconomic problems (such as the inability to swiftly solve war debt and reparation issues), also poor central bank operations made their contribution, such as the failure to collaborate through inter-central bank credit operations (e.g., Toniolo 2005), and renewed hesitations of central banks to act as lender of last resort (LOLR), in particular during the bank runs of the early 1930s. Moreover, this period witnessed the birth of reserve position doctrine (e.g., Meigs 1962), which would determine the (arguably misleading) textbook version of monetary policy implementation for almost the rest of the century.

Third, the period 1960-1990 could be called the “*baroque*” age of OFs, which from today’s perspective seems to have been overburdened with an excessively complex monetary policy implementation (reserve requirements with various ratios that were frequently changed, various excess reserves concepts that were all supposed to matter, poorly defined standing facilities and last but not least various direct control measures such as, e.g., ceilings to retail deposit interest rates that banks could charge). The reserve position doctrine

remained the textbook logic of monetary policy implementation and transmission. Kneeshaw and Van den Bergh (1989) provide a survey of the evolution of OFs since the 1970s. The root causes of the oversophistication of OFs during this period seem to have been unrealistic academic doctrines combined with an overestimation of central banks' policy making capabilities.

1990 to 2007 could be called the “*modern*” age of OFs, in which much simplification could be achieved and the pre-1914 view that monetary policy implementation is about controlling short term interest rates was fully rehabilitated. For example, the Fed eventually, after 80 years, set again the interest rate on the Discount Facility (which is a “Lombard” facility in initial terminology) to above the federal funds target. The design and launch of the OF for the multijurisdiction euro area was a noteworthy event and can probably be considered as a success resulting from careful preparatory discussion and review of experience (see e.g., European Monetary Institute 1997).

In sum, getting central banks' OFs right always mattered and will continue to matter. The recent crisis confirmed this, and is certainly a good occasion to take stock and to revisit how to design and assess OFs.

Relevant literature on OFs can be found in particular in the following four formats: *First*, official or semiofficial descriptions of OFs and monetary policy implementation by central banks: Some central banks explain their operational frameworks in book chapters like Chapter 2 of Danmarks Nationalbank (2009) or Chapter 4 of ECB (2011). Meulendyke (1998) describes U.S. monetary policy implementation in the second half of the 20th century. The New York Fed publishes an annual report on the conduct of monetary policy operations (see Federal Reserve Bank of New York 2016). *Second*, comparative studies of OFs including assessments: Borio (1997) remains the most comprehensive survey at a specific moment in time, and a landmark as first systematic comparative study of modern frameworks. IMF (2004) focuses on the case of emerging markets. Ho (2008) provides a comparison of OFs in Asian countries and selected other economies. Also Bindseil and Nyborg (2008) surveyed frameworks just before the financial crisis. Blenck et al. (2001), Bindseil (2004a) and Friedman and Kuttner (2010) limit the comparison to

a few central banks. Sellin and Sommar (2014, Chapter 5) provide a recent systematic comparative study. A number of further surveys focus only on one aspect of the operational framework, like the collateral framework (e.g., Chailloux et al. 2008; Cheun et al. 2009). *Third*, academic work: There is a significant number of focused academic studies on specific monetary policy framework or implementation topics. Some literature is surveyed, e.g., in Bindseil (2004), (2014a) or Sellin and Sommar (2014, Chapter 2). The practitioner will find some of the academic studies to provide useful intuition and guidance on real world decisions. *Fourth*, speeches by central bankers on post-crisis OF design, such as Coeuré (2013) or Potter (2016).

The current paper, drawing from these four types of literatures on OFs, will provide a general review of the objectives and options of OF design. Section II first briefly reviews the pre-2007 experience and summarizes the beliefs on OF design at the eve of the financial crisis, and, second, tries to identify key lessons from the crisis. On that basis, Section III revisits the objectives of OF design and criteria how to assess and compare the performance of alternative OFs. Sections IV, V and VI each go deeper into one area of OF design: Section IV revisits techniques to control the operational target (“liquidity management”), Section V deals with the central bank balance sheet structure and the role of an outright portfolio, while Section VI covers the collateral framework and the LOLR. Section VII draws conclusions.

When aiming at deriving universal principles for OF design or even universal OF specifications, on a number of occasions this paper will reach apparent *limits relating to fundamentally different philosophies* of central banks or of individual authors. As Georg Simmel described it in his famous introduction to the *Philosophy of Money* (2014/1900, 51):

“Every area of research has two boundaries marking the point at which the process of reflection ceases to be exact and takes on a philosophical character. The pre-conditions for cognition in general, like the axioms of every specific domain, cannot be presented and tested within the latter domain, but rather they call for a science of a more fundamental nature. The goal of this science, which is located in infinity, is to think without preconditions—a goal which the

individual sciences deny themselves since they do not take any step without proof, that is, without pre-conditions of a substantive and methodological nature.”

Three (somewhat related) philosophical issues, or at least issues beyond the “science” of OF design, will be encountered in this paper, namely with regard to 1) what attitude the central bank should take toward financial exposures to the government; 2) what “neutrality” means in terms of central bank collateral eligibility and asset allocation decisions, and 3) how ambitious, activist and complexity friendly (or, alternatively, skeptical, humble and simplicity-oriented) a central bank should be in its OF design. All of these three questions seem to be suitable for being analyzed and judged further on the basis of a more fundamental analysis, but for the present paper it was concluded to accept them as given “philosophical” views.

In Appendix A, the conclusions from Sections IV, V and VI are translated into “scorecards” which are constructed to be used for stand alone, or comparative assessments of existing OFs. This is an attempt to verify that the findings indeed can be translated into real-world guidance. The scorecards are lists of statements, which, if fully affirmed, give a high score, and if fully rejected, a low one. Finally, Appendix B describes a simulation approach that is extensively used in Section IV to understand how various parameters determine the effectiveness of the control of the overnight interest rate (while preserving money market activity).

II. The 2007 Consensus and Lessons from the Last Nine Years

Following others (e.g., Blanchard et al. 2014, when discussing post-crisis macroeconomic thinking), this section first tries to summarize the 2007 consensus on OFs (subsection II.i) to then review the main lessons from the crisis (subsection II.ii).

II.i. The 2007 Consensus on OF design

Any review of OFs is confronted with the rift created by the financial crisis that started in 2007. The pre-2007 world had witnessed convergence in the search of the best OF, and OFs determined monetary policy implementation practices. In contrast, after 2007,

monetary policy implementation practice was dominated by countless idiosyncratic nonstandard measures and the OF concept had therefore less relevance. This subsection provides a brief summary of what appears to have been the 2007 consensus among central banks on OF design. Seven key elements can be highlighted.

1. *Desirability of having a single and well-defined operational target for day-to-day monetary policy implementation.* While there had been a lot of confusion on the concept before the 1990s, in 2007 a clear understanding of the operational target had emerged, being a variable that 1) can be controlled on a day-by-day-basis by the central bank without creating undue volatility in other financial market prices; 2) is a meaningful starting point of the transmission mechanism, i.e., its impact on the ultimate target of monetary policy is relevant and sufficiently predictable; 3) can be decided by the monetary policy decision making body, be communicated to the public and gives sufficient guidance for implementation officers.
2. *The best operational target (at least for advanced economies) is a short-term interest rate.* Bindseil (2004b) describes the 20th century struggle to rediscover this. Sellin and Sommar (2014, 124) or Ho (2008, Section III) provide overviews of the details of operational target choices by central banks. Blanchard et al. (2014, 5) summarizes the macroeconomic beliefs behind the 2007 consensus on short-term interest rates as operational target.
3. *OFs should in principle be simple.* In the 1980s, a trend set in to overcome the complexities of the “baroque age” of monetary policy implementation, and in 2007 there seemed to be a consensus that OFs should be parsimonious. The trend could have continued further, as there was still scope for streamlining of OFs, but it was stopped by the crisis.
4. *A separation principle (or “dichotomy”) applies between 1) the macroeconomic analysis and the setting of the operational target level, and 2) its implementation through monetary policy operations.* A full dichotomy means that the overnight interest rate is the single gate between monetary policy implementation

and the rest of the transmission mechanism. Conditions for this being viable (and optimal) are: 1) distance from effective lower bound for the overnight rate; 2) sufficient arbitrage and stability of relations between overnight rate and rest of the interest rate structure; 3) normal market access of indebted (solvent) agents.

5. *Credit open market operations with allotment volumes set by the central bank are the standard tool to steer liquidity conditions* (i.e., to steer the scarcity of banks' reserves with the central bank, and thereby the short-term interbank interest rate). Credit operations have maturities up to three months and both variable-rate and fixed-rate tenders were used (e.g., Bindseil and Nyborg 2008, 753).
6. *Reserve requirements are (in advanced economies) a tool for smoothing daily autonomous factor liquidity shocks without having to take recourse to daily open market operations.* Reserve requirements are remunerated at close to the target rate (i.e., at close to market rates; an exception was the United States in which remuneration of excess reserves was only allowed in principle by Congress in 2006 and effective as of Oct. 1, 2008). Reserve maintenance periods have a length between one week and one month. For emerging economies (often with large foreign reserves) other monetary control functions of (nonremunerated) reserve requirements remained relevant (overviews in e.g., Bindseil and Nyborg 2008, 757; or Ho 2008, 12). Another part of the central banking community (Sweden, Canada, New Zealand, Australia, etc.) had opted for daily open market operations and no reserve requirement system, and were able to achieve similar or even better control of short term interest rates (Sellin and Sommar 2014).
7. *A symmetric standing facilities corridor around the target interest rate is the preferred approach to the day-to-day control of the overnight interest rate.* The choice of the width of the standing facilities corridor is seen as a reflection of a trade-off between desired interest rate control and the need to avoid that the central bank becomes an intermediary in the money market. Two

variants had emerged (e.g., Bindseil and Nyborg 2008, 256), in combination with the existence or not of reserve requirements: 1) Symmetric *narrow* (± 25 basis points) standing facilities corridor with a daily open market operation at the target rate such as to guide the interbank market rate. This simple and effective approach was applied e.g., in Australia, Canada and New Zealand. 2) Reserve requirements with averaging, relatively *wider* symmetric corridor (± 100 basis points). Large monetary areas have shown a preference for this second approach. The Federal Reserve remained again an exception as without a deposit facility or the ability to remunerate excess reserves, it could obviously not opt for a symmetric corridor approach.

In three other important fields, convergence of views and practices had *not* taken place in 2007, partially linked to the heterogeneous philosophical views on monetary policy implementation mentioned in the introduction:

1. *Role of an outright monetary policy portfolio and the optimal size of the banking system's liquidity deficit vis-à-vis the central bank* to be covered through credit open market operations. While for example the Fed only covered around 5 percent of its asset side through credit open market operations; for the Eurosystem this number stood at around 50 percent.
2. *Sovereign exposure*: while some central banks (the Fed) considered it natural to fill large parts of their asset side with government debt (revealing that they see themselves in some sense as part of the official sector, so that their approach implies a lean consolidated official sector balance sheet), others believe that, at least in their own case, the implied interconnectedness between the central bank and the government would be problematic.
3. *Collateral and counterparty sets*: First, some central banks opted for a narrow (e.g., the Fed) and others for a broad (e.g., Eurosystem) collateral set for open market credit operations. Second, central banks had different approaches with regard to the pooling versus segregation of collateral sets. While e.g., the Fed had very distinct sets for credit open market

operations versus discount window lending, the Eurosystem had the same set for all its lending operations toward banks. Third, some central banks relied on a broad counterparty set for open market credit operations (e.g., Eurosystem), while others on a narrow one (e.g., the Fed).

After 2007, we witnessed the global financial crisis, countless non-conventional monetary policy measures by central banks, most central banks of advanced economies hitting the zero lower bound, large scale asset purchase programs implying banking systems in excess liquidity for years and the new regulatory universe that was created to prevent future crises. Analyzing monetary policy implementation during these years as an application of previously existing OFs does not seem particularly useful. The need to differentiate the pre-2007 world from what came afterward is also illustrated by the term of “unconventional” (or “nonstandard”) monetary policy measures, which did not seem to have existed before 2007 (although of course unconventional lender of last resort activities are described extensively already in Bagehot (1873) and attempts by central bank to target long-term interest rates also have been seen previously). Conventional monetary policy measures and tools could be defined as those which aim at the control of the standard operational target, i.e., short-term interest rates. Nonconventional measures must therefore aim at something different than the short-term interest rate, but at e.g., 1) term spreads (or, equivalently, long-term risk free rates); 2) liquidity and credit spreads (or, equivalently, interest rates on various non-risk free instruments); 3) financial stability for the sake of supporting the monetary policy transmission mechanism.

II.ii. Lessons from the Last Nine Years

The normalization of financial conditions will not simply bring us back to 2007 views on OF design. First, the financial system will not move back to its 2007 state, due to the crisis experience itself, regulation and further technological change. Second, the scale of the events culminating in 2008 inspired the views of both practitioners and academics on what an OF needs to achieve. Consider below five key requirements that OFs will need to be able to cope with in the future, which all had less prominence before 2007.

OFs Need to Support the Ability to Address Possible Future Crises Forcefully and Quickly

The economic and monetary developments since 2007 seem to have validated the forceful and quick reactions of central banks to the crisis. If anything, the persistence of low-growth and disinflationary tendencies of the last years suggest that central banks could possibly have hesitated even less in moving short term interest rates quickly toward the effective lower bound and to launch unconventional measures. For the future, this implies the importance of the OF supporting the ability of the central bank to act forcefully and quickly in the case of a renewed serious crisis. Therefore, a future OF should also be assessed against its ability to allow, and be compatible with, the various nonstandard measures that might be needed again at some stage. This includes that a future OF should support the preservation of relevant human capital of central bank staff, possibly by confronting staff regularly with more demanding parts of financial markets (e.g., credit markets, less liquid instruments; the best way to preserve human capital is obviously to operate in these markets). The ability to act quickly and the preservation of knowledge should cover in particular those measures that seem to have been effective, such as: 1) LOLR and “market maker of last resort” (MMLR) operations; 2) large scale asset purchase programs; 3) attractive long-term credit operations (including “fixed rate full allotment” and “targeted” variants); 4) currency bridges (LOLR in foreign currency based on swap agreements between central banks). The potential future crisis measures could be classified as being part of the long-term OF, or they could be seen as something outside the OF, i.e., “on the shelf,” that could be activated at any time but which is too unlikely to be displayed in permanence as an element of the OF.

Post-Crisis OF Should Allow to Push Somewhat Lower the ‘Effective Lower Bound’

On March 30, 2016, Ireland issued a 100-year bond at a yield of 2.35 percent and the U.S. 10-year Treasury yield a historical low in July 2016 at below 1.40 percent, both illustrating the present consensus that interest rates will stay low for long. Reasons for that include in particular expectations of lower trend growth (“secular stagnation”),

ageing society and the implied current excess of savings, and the high credibility of central banks as inflation fighters gained gradually since the early 1980s (see e.g., Blanchard et al. 2014; and Haldane 2015, for related discussions). Moreover, the last years have reminded us that financial intermediation spreads increase substantially during financial crises, requiring extra central bank accommodation to compensate this effect. Blanchard et al. (2014, 8) believe that in 2008, the policy-adequate short-term interest rate would have been as low as between -3 percent to -5 percent. Finally, new regulation may contribute to structurally increase financial intermediation spreads. These factors imply a higher likelihood that the zero lower bound (ZLB) for short-term interest rates will be in the future a recurring constraint to monetary policy. The ZLB relates in particular to the problem that bank notes are not remunerated, and that in case of negative interest rates applied on deposits, the depositors may withdraw deposits and hoard cash. This is inefficient and also increases the liquidity deficit of the banking system vis-à-vis the central bank (and thereby reduces liquidity buffers of banks). Different solutions outside the design of the OF have been proposed for overcoming this, such as in particular 1) increasing the inflation objective from 2 percent to 4 percent so as to hit the ZLB less frequently (e.g., Blanchard et al. 2014), 2) abolishing paper money, or finding a solution to apply negative rates to it (e.g., Goodfriend 2000; and Buiters 2009). The majority view among central bankers is that both of these measures would be too radical or problematic. Therefore, the question arises whether in the context of the OF design, the ability to go slightly negative, i.e., to push rates to the so-called “effective lower bound” (ELB, with $ELB < 0$) can be supported. Indeed, the experience of the last few years has been that negative interest rate policies (NIRP) are to some extent feasible and effective, with some central banks going as low as setting the operational target interest rate to -75 basis points, without this creating an acute increase of the demand for bank notes, at least so far. Indeed, NIRP may be regarded as continuation of standard monetary policy. There is also no reason to believe, that in negative territory the nominal interest rate loses its ability to serve as allocation mechanism. The last years have shown that financial market functioning does not change fundamentally in negative territory. Of course there may be some

temporary transition effect and adjustment needs, e.g., relating to IT systems and contractual and legal frameworks supporting negative interest rates. Moreover, securities markets may need some adjustments to either avoid securities with negative coupons (by relying more on issuance above par), or by making negative coupons possible. Also the question of negative interest rates on indexed retail mortgage loans raises adjustment issues. (All these issues obviously need to be solved only once, i.e., if hitting the ZLB becomes a recurring phenomenon, these “investments” can be amortized over several cycles).

Besides the ELB determined by bank notes, another ELB, kicking in even earlier, has recently gained prominence. The argument relates to the observation that if retail deposit rates cannot become negative, then bank profitability may suffer from negative rates. This could lead banks to increase rather than decrease their lending interest rates as the central bank cuts its operational target interest rate further. It is to be noted that such effects also occur with low rates, i.e., low positive capital market rates also reduce the “seigniorage” income of banks (e.g., Greenwood, Hanson and Stein 2015) from issuing deposits relative to capital market rates. Therefore, models of the transmission mechanism of monetary policy in bank based systems should generally take into account that lowering interest rates lowers seigniorage income of banks, and therefore exerts downward pressure on profits with possible side effects on the transmission of policy rates to bank lending rates. Brunnermeier and Koby (2016) present a microeconomic analysis of this issue.

In case of large excess reserves of banks with the central bank (e.g., reflecting a large scale asset purchase program) combined with negative remuneration of excess reserves (such as applied in e.g., Denmark, Japan, Sweden, Switzerland or the euro area), bank profitability could suffer in addition from the negative carry between bank liabilities and these excess reserves. A number of central banks have acknowledged this to be a potential issue and have tried to address it with an OF innovation, namely through so-called excess reserves tiering systems which exempt a part of the excess reserves from the application of negative interest rates. The idea is that a tiering system would allow the combination of 1) negative rates still effective at the

margin and therefore passed on to money and capital markets, and 2) the exemption of parts of the excess reserves moderating negative effects on bank profitability that could weaken the effectiveness of NIRP. By disconnecting the two, the transmission of NIRP to bank lending rates could be improved, and the ELB (at which further rate cuts are no longer effective in terms of lowering funding costs of the real economy) could be lowered. The need to further study tiering systems and to possibly have blueprints for them available for future possible use is therefore one concrete OF lesson from the recent (or ongoing) ZLB experiences. If tiering systems allow pushing down the ELB by 25, 50 or even 100 basis points, then they really would make a difference in a world in which the ELB is considered a major macroeconomic issue (as prominent macroeconomists have argued).

Avoid Contributing to the Buildup of Future Financial Crisis

One key element of the official sector's strategy to make a repeat of the 2008 financial crisis less likely has been Basel III (with in particular higher capital requirements, the idea of countercyclical capital buffers, the leverage ratio and liquidity regulation). However, some observers have also raised the question what role monetary policy and its implementation might have played in terms of favoring the excessive leverage which is said to have contributed to the crisis. The Fed has, for example, been criticized for holding interest rates too low in the first half of the last decade and for having overlooked the buildup of the subprime mortgage problem (see e.g., Danthine 2012, for a survey of views regarding central bank contributions to the buildup of the financial crisis). That said, the Fed's pre-2007 OF has not been criticized for having contributed to the crisis. In contrast, Buiter and Siebert (2005) argued that the European Central Bank (ECB) collateral framework would have contributed to artificial sovereign spread compression in the euro area and thereby could have undermined market discipline (Bindseil and Papadia 2006, provided some counterarguments). Nyborg (2015) also argues that the ECB collateral framework could be detrimental to financial stability as it would undermine market discipline.

More generally, the extent to which banks anticipate to have access to the central bank as lender of last resort should indeed influence

banks in their decisions to undertake maturity and liquidity transformation (see e.g., Bindseil 2013). Therefore, as the 2008 crisis is usually interpreted as a consequence of excessive such transformation (seen as a symptom of “moral hazard”), one may ask whether perceptions of banks regarding central banks’ readiness to act as LOLR (as also built in for example in the collateral framework) could have been part of the problem. The facts however do not seem to support this intuition. The origin of the liquidity crisis has been in particular in the United States, and the Fed had a rather restrictive LOLR framework. Also, the crisis then spread to countries with very diverse LOLR frameworks without the latter appearing to have explanatory power.

The design of the OF would ideally be supportive to the banking system’s ability to provide maturity and liquidity transformation at the service of society, while not going as far as to facilitate *excessive* leverage and moral hazard. If prominence is given to the moral hazard problem, then an OF could include central bank tools providing incentives against such a behavior—in addition to regulation. This will be taken up in Section VI.

Technical Progress That Took Place Both Before and After 2007

The last decades have seen unprecedented IT developments, which strongly affect a practical and information intensive activity like monetary policy implementation. First, there could be *direct* effects of IT progress on OF design in the sense that technological constraints at the level of the central bank to construct an optimal OF can be overcome. Second, progress in IT and communication have some *indirect* effects on the OF, for instance via implied progress in market infrastructures, payment systems and settlement links, which would change the demand for excess reserves and collateral scarcity.

Cope With the New Regulatory Environment and Its Implications on Financial Markets

Post-crisis prudential and market regulation have profound effects on market functioning and market liquidity. Ramifications of liquidity regulation proved complex and some believe that liquidity regulation could make liquidity stressed banks rely more, and not less, on central banks (despite the fact that the initial intention was

the opposite; see e.g., Bindseil and Lamoot 2011). The Committee on the Global Financial System (CGFS) (2015, 2) concludes as follows with this regard:

“Many of the new regulations will increase the tendency of banks to take recourse to the central bank as an intermediary in financial markets—a trend that the central bank can either accommodate or resist. Weakened incentives for arbitrage and greater difficulty of forecasting the level of reserve balances, for example, may lead central banks to decide to interact with a wider set of counterparties or in a wider set of markets.”

Also, market liquidity is expected to decline at least in a number of market segments with implications on OF design. For example CGFS (2015, 15) predicts that money market turnover will shrink as a consequence of new regulation while the volatility of money market rates will increase. Negative effects of regulation on bond market liquidity have also recently received considerable attention (e.g., PwC 2015; CGFS 2016; Trebbi and Xiao 2015) with mixed evidence. Key OF-related question in this context will be: 1) What are the implications on OF design of a possible strong additional demand by banks for reserves with the central bank for the purpose to fulfill liquidity regulation? For example, can this undermine the optimality of the symmetric corridor approach? This question is analyzed for example by Bech and Keister 2015, who conclude that indeed central banks may have to adjust the way they control the overnight interest rate. 2) If certain money market segments shrink particularly due to regulation (e.g., the unsecured money market), could this imply the need to change the choice of the operational target (e.g., move to a secured interbank rate)? 3) Should the central bank tolerate that recourse to central bank credit by some banks increases as a consequence of regulation, or should it go against it either by adjusting the OF to strengthen disincentives, or by requesting changes to regulation? 4) Should central banks in the OF design and monetary policy implementation practice, facilitate or not banks' fulfilment of Basel III liquidity ratios? There is surprisingly little clarity among central bankers how to answer in particular the last two questions.

III. Guiding Principles to Evaluate Alternative OFs

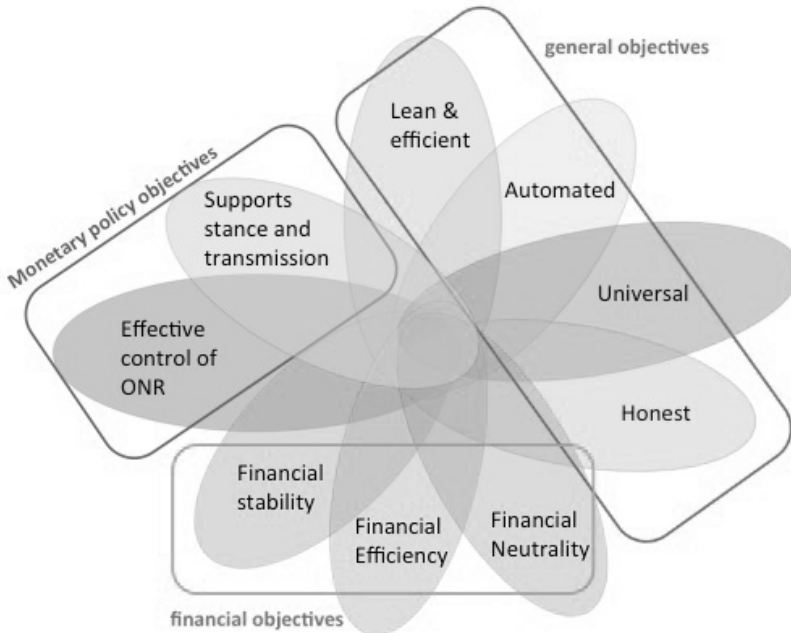
How should one evaluate the performance of pre-crisis OFs, and what objectives should we aim at when designing the future post-ZLB/post-excess liquidity frameworks? On some occasions, central banks have been explicit on the principles that they applied to derive their OFs, such as for example the Federal Reserve System (2002, 1-1), or the ECB (2011, 94-95). Borio (1997 9-10) argues that frameworks 1) need to be effective (i.e., allow to have “adequate control over monetary conditions”), 2) that their design also matters because it has “significant implications for the organization and functioning of money and even capital markets as well as for asset price volatility” and 3) that they need to be explained well as misunderstandings about monetary policy implementation are often the source of monetary economic misconceptions. In the past, it has however also often been argued in different variants that it is difficult to come up with general criteria to guide the design of OFs, whereby this view has been articulated according to the following variants.

- *Relativism.* According to this view, the optimal framework depends on circumstances. For example the Board of Governors (1994, 35) argued that “In general, no one approach to implementing monetary policy is likely to be satisfactory under all economic and financial circumstances. The actual approach has been adapted at various times in light of different considerations, such as the need to combat inflation, the desire to encourage sustainable economic growth, uncertainties related to institutional change, and evident shifts in the public’s attitudes toward the use of money. When economic and financial conditions warrant close control of a monetary aggregate, more emphasis may be placed on guiding open market operations by a fairly strict targeting of reserves. In other circumstances, a more flexible approach to managing reserves may be required.” Such arguments seem to have been overstretched in the past and random or history-related heterogeneity across central banks of similar monetary areas or across time were too conveniently rationalized.

- *Agnosticism.* The lack of clear conclusions on OF design in the literature seems to reflect a lack of conviction or faith into our ability to come to firm conclusions in this field. As the Bank of England (2015) put recently in its research agenda, there remain “big questions” in many fields of central banking, including in monetary policy implementation. The inherent difficulties in any social science and specifically the multiple equilibriums and nonlinearity in financial markets should indeed suggest a humble attitude on optimal OF design. On the other side, much of monetary policy implementation appears to be of manageable complexity, relative to other issues in economics or science, and there do not seem to be good reasons to be particularly fatalistic.
- *Claim of irrelevance:* According to this view it does not really matter anyway; only the outcome matters in terms of monetary stance, and this can be achieved through many OFs. While Borio (1997) was strongly affirmative with regard to the usefulness of studying OF design, Borio (2001, 5) seems to be closer to such an irrelevance view: “Just as there are a hundred ways to skin a cat, so there are a hundred ways to implement monetary policy. These may differ considerably in terms of the interest rates that are the focus of policy, the range of instruments employed, the frequency of operations, the spectrum of counterparties and other technical elements. Such differences reflect a mixture of purely historical factors and different views regarding the fine balance between the pros and cons of the various choices.”

Any paper on designing OFs should obviously be motivated by the desire to contradict such views and to work toward a universal idea of how a good OF should be designed. In the rest of this section, nine evaluation criteria of OFs (or objectives of OF design) will be presented, that will guide the subsequent discussion in Sections IV-VI. We group the nine evaluation criteria into three categories: monetary policy, financial and fundamental, as visualized in Figure 1. We are looking ideally for an OF in the intersection of the nine objectives. In practice, there will be trade-offs, and how these will translate into good compromises will also depend on the environment.

Figure 1
Evaluation Criteria (objectives) of OF Design and Criteria for OF Assessment



Effective Control of the Overnight Interest Rate (ONR)

The first and most important objective against which to evaluate an OF is its effectiveness from the perspective of the degree of control of the operational target of monetary policy. In normal times, this means essentially the ability to control short term interest rates and can be measured by comparing an announced operational target interest rate with the actual market interest rate. An early example of a cross-comparison of the mean and volatility of deviations from actual short-term interest rates from target rates is Ayuso, Haldane and Restoy (1997) and a comprehensive update can be found in Sellin and Sommar (2014, 128 and 132). These studies indicate that systematic deviations of overnight rates from the operational target rate seem to be limited in almost all cases (in the one digit basis point area), suggesting the effectiveness, on average, of interest rate control. Most of the time, the volatility of the spread is also limited, and when it is not (such as in the United Kingdom before 2006), such volatility

is still not systematically transmitted beyond the shortest maturity. Interestingly, Ayuso, Haldane and Restoy (1997) had still come to different conclusions, namely that (p. 20):

“We have found a significant volatility transmission effect from overnight to longer term money market rates for France, Spain and the UK. This evidence is supportive of the importance attributed by most central banks to achieving a reasonable level of stability in the very short-term money markets. It follows that since overnight interest rate volatility is not completely internalized in that market, it is likely to influence real-saving and investment-decisions.”

While these conclusions do not seem to be validated by more recent data (e.g., by Sellin and Sommar 2014), they recall why the control of short-term interest rates matters and is to be seen as an important objective of OF design.

Supports Stance and Transmission of Monetary Policy

This second monetary policy objective of OF design is important as well, but less obvious in its implications than the previous one. One could even deny the relevance of this objective if one believes that the overnight interest rate should be the only operational target of monetary policy and that the rest of the transmission mechanism is, in normal times, not a matter of monetary policy implementation, but an issue of monetary macroeconomics that finds its way back to monetary policy implementation only indirectly, i.e., via its impact on setting the optimal level of the overnight interest rate. However, as Sections V and VI will argue, monetary conditions are also inevitably affected by other elements of the OF, namely the lender of last resort (LOLR) content of the OF, and the duration, credit and liquidity risk contained in a possible outright portfolio held by the central bank. Therefore, these other elements of the OF should at least not interfere with the stance and transmission of monetary policy, and, if applicable (e.g., at the zero lower bound), should possibly support it.

Leanness ('Efficiency,' Parsimony')

A framework should allow achieving the objectives of monetary policy implementation with few simple instruments, avoiding complexities

and redundancies. How opposed one feels toward complexity is a matter of taste, or of philosophy, as mentioned already in Section I. In any case, most would today agree that frameworks should avoid the baroque architecture and multitude of instruments that prevailed in the 1960s and 1970s. Synonyms for “lean” in this sense are “efficient” and “parsimonious.” Moreover, a complex OF is often also opaque, and benefits more sophisticated market participants who are in a better position to understand, or who have the economies of scale making it worth investing in understanding. It thereby encourages investment into “foreknowledge” in the sense of Hirshleifer (1971) which is inefficient from society’s perspective. Compared with the preceding decades, monetary policy implementation approaches in the period 1990-2007 were relatively well focused and transparent (see subsection II.i). Still, particularly central banks from the large monetary areas had preserved in 2006 the luxury of a number of complexities. First, the use of reserve requirements with averaging to absorb liquidity shocks created a nontrivial intertemporal structure of reserve demand. Second, operational frameworks were often specified in such a way that significant discretion was exerted in conducting open market operations (see the next point on automation).

Automation (Strict Reliance on Rules, Avoidance of Discretion in Monetary Policy Implementation)

Automation, i.e., being strictly rule-based, requires having achieved a high level of understanding of the economic relationships at stake. Discretion may sometimes be unavoidable, but often actually reflects inability on the side of the central bank to understand well and “pre-program” its interaction with the market. “Rules versus discretion” has been an important topic in monetary macroeconomics for decades (e.g., see Fischer 1988; Taylor 1999). Compared to macroeconomics, monetary policy implementation in advanced large monetary areas does not appear so complex that it could not, at least to a very large extent, be rule-based. As one example, central banks before 2007 normally used auction procedures in which the allotment decision contained discretionary elements. When bidding in such auctions, banks had to speculate about what quantity the central bank would allot. It seems preferable that central banks rely on automated allotment procedures, such as fixed-rate full allotment, or variable-rate tenders with

pre-fixed allotment volume derived mechanically from forecasts of autonomous factors.

Universality

A framework should ideally allow an efficient control of the operational target and achieve other objectives *across different financial and macroeconomic environments*. Ideally, a universal framework could thus be applied to diverse settings across various dimensions (high/low/negative interest rates, monetary tightening/monetary easing phase, liquidity surplus/deficit of the banking system; financial stability/stress phase, large/small economy, advanced/emerging/developing economy, free/managed float, oligopolistic versus competitive banking system, more/less regulation). Universality is desirable because it avoids renewed and never-ending trial and error across time and across monetary areas.

Often, central banks have defended changes in their frameworks or differences relative to frameworks in other countries by saying that one approach cannot fit all, and that they had to adapt to the environment in which they operate (what was referred to above to as “relativistic”). Also non-central bank authors have doubted the feasibility of a universal OF. Borio (1997) argues that “changes in operating procedures have been ... substantial, having been driven by ... significant changes that have taken place in the structure of financial markets as well as in the broader economic and political environment.” Ho (2008) asks “how much diversity remains? And perhaps more interestingly, why does this diversity remain?” (p.2). She concludes (p.3): “This paper finds that, while a number of common themes and practices can be identified, there is no unique ‘best’ way to implement monetary policy. Even among just the four major industrial economy central banks in the sample, considerable differences still exist, reflecting, inter alia, differences in the domestic financial environment, history, legal and regulatory constraints, and even political philosophy.”

Overall, it appears that a large part of past differences between OFs of large advanced monetary areas (such as the United States, Japan, the United Kingdom and the euro area) lacked a good justification,

i.e., could not be attributed to different environments. Sometimes it is argued that differences could be justified by the dissimilarity of bank-based and capital-markets-based financial systems, but the link to the details of the OF has never been elaborated in detail. Whether OF universality could also cover the case of very different financial systems (e.g., of significantly less developed economies) is admittedly less clear.

Honesty

Borio (1997) notes that monetary policy implementation has given “rise to potential misconceptions among parts of the academic profession” whereby he seems to have in mind what Basil Moore (1989) called “verticalism” (and Meigs 1962, “reserve position doctrine”). Also Borio considers that “a proper understanding of operating procedures could throw light on the ultimate power of the central bank to affect monetary conditions, on its source, changing characteristics and reach.” One may want to translate that into “if academic authors and central bankers fail to have the right understanding of the basic logic of monetary policy operations, how confident can one be that their monetary macro-models make sense?” An *honest* OF can be defined as one that can be explained sincerely and convincingly not only to experts in monetary economics, but also to microeconomists, financial market experts, bankers and central bank practitioners. Examples of nonhonest communication on monetary policy implementation have been noted on a few occasions. Consider briefly two 20th century examples which have both to do with “verticalism”:

- *The initial fabrication of reserve position doctrine after 1919.* Friedman and Schwartz (1963, 250), who are otherwise no supporters of interest rates as operational targets, are astonished by the fact that e.g., in the 1921 annual reports of the Board of Governors, explicit discussion of the Fed’s aggressive hiking of interest rates after November 1919 and the implied deflation and recession is avoided: “It is hard to escape the conclusion that ... this ... is designed to turn aside criticism without either meeting them or making explicit misstatements ... For example, in the whole nine-page section, neither the words “discount rate” nor any synonyms occurs ... It is natural

human tendency to take credit for good outcomes and seek to avoid the blame for bad. ”

- *The Volcker episode of nonborrowed reserves targeting (1979-82).* Although Volcker is the hero of breaking the trend toward ever higher inflation in the 1970s and putting inflation on a declining path toward price stability, today's views on the Fed's operational target choice in the 1979-82 episode (“nonborrowed reserves”) tend to be critical. For instance, Goodhart (2001) and Mishkin (2004) argue that the whole approach was just about avoiding the Fed to take responsibility for the necessary strong hiking of interest rates to bring down inflation, and the associated economic effects such as a strong rise in unemployment (such critical views had already been articulated in the 1980s and 1990s). In the words of Goodhart (2001), the episode, “if properly analyzed, reveal that the Fed continued to use interest rates as its fundamental *modus operandi*, even if it dressed up its activities under the mask of monetary base control ... there was a degree of play-acting, even deception ...” The “smokescreen” created by Volcker would thus have been simply a necessary condition for bringing inflation to an end under conditions of imperfect central bank independence. The price would have been to give up at least temporarily the principle of honesty.

Financial Efficiency (in the Sense of Central Bank Income and Risk Taking)

For a given achievement of the other objectives, the central bank should aim at an adequate financial return on the enormous resources with which it is normally endowed (relating to bank note issuance, reserve requirements and capital). If two frameworks allow for the same degree of achievement of policy objectives, but the first leads to higher financial returns than the second, then the second cannot be efficient. Actually, the central bank has considerable leeway from the policy perspective in choosing its assets, as the scarcity of central bank reserves (and hence their price, the overnight rate) can be steered essentially at the margin (and even at the margin it can be steered with different financial instruments). Financial *risk taking* can also

be subsumed under financial efficiency of central bank asset choices: expected returns have to be put in relation to risk taking, whereby the central bank specificities (not being subject to liquidity risk, having a long investment horizon, having probably no outstanding skills and agility in credit risk management) should be duly reflected.

Financial Neutrality, Including Exposures to the Government

Choices with regard to the OF (including the collateral framework) and central bank asset composition should avoid having “distorting” effects on the relative prices of financial assets— a relevant issue because of the (potential) scale of central bank assets and the significance of central banks in financial stress situations.¹ In two dimensions, opposing philosophies continue to prevail on how in practice to understand the objective of neutrality. The first dimension relates to the relationship between the central bank and financial liabilities of the government, while the second has to do with the general financial preferences of the central bank. Consider the two subsequently. With regard to the *treatment of government liabilities*, the “central bank independence” view states that the central bank should treat the government as a normal issuer and certainly not overweight, or preferably underweight its role in outright portfolios or in the collateral framework. Otherwise, it would subsidize the government by lowering the government’s funding costs relative to other debtors, and the central bank will make itself dependent of the government or even fall under “fiscal dominance.” Under the opposite “consolidated official sector” view, the central bank should aim at a lean consolidated official sector balance sheet. This approach implies a preference of the central bank for exposures to the government. Large holdings of private assets would be considered under this approach to distort private debt instruments’ prices to the upside relative to state debt. Unfortunately, both views, which may also be called the “German” and the “U.S.” philosophies, lead to opposite conclusions on neutrality.² With regard to the second dimension, *the revealed financial preferences*, the first view states that a central bank behaves neutrally if it acts like an average investor (“average investor doctrine”), while the second view would argue that the central bank is unique (in particular it is never subject to liquidity risks and is considered credit-risk free

by its counterparties) and should reflect this in idiosyncratic preferences toward financial assets (“idiosyncratic fundamentals doctrine”) as the alternative to ignore these unique features would be artificial and in this sense distorting. In sum, with respect to financial neutrality including the attitude toward exposures to the government, each central bank needs for the time being to be assessed against the philosophical principles it has adopted. This is not to deny that some doctrines eventually make more sense than others, in particular in the context of specific central banks.

Financial Stability and Financial Market Functioning

The OF should support financial stability. For example, the OF should set incentives for banks to run a sound and secure funding model, and it should contribute to, and not undermine, the functioning of various financial market segments. Five dimensions of the credit operations of the central bank appear important in this respect: 1) the variety of assets which are eligible as collateral and the haircuts applied; 2) the set of counterparties which have access to refinancing; 3) the size and/or frequency with which the central bank offers refinancing opportunities to banks; 4) the readiness of the central bank to conduct so-called “emergency liquidity assistance” (ELA) operations, or to provide “marketwide” assistance; 5) the readiness of the central bank to possibly act as “market maker of last resort” through outright purchases in securities markets. It is crucial to distinguish the ex-ante and the ex-post dimensions in this respect. *Ex ante*, the anticipation by banks and debtors of a supportive central bank attitude may on the positive side support the maturity and liquidity transformation services that the financial system can deliver to society, but on the negative side lead possibly to overleveraging and underpricing of risk. *Ex post*, supportive measures tend to be useful to preserve financial stability and avoid large scale economic damage relating to widespread default in a crisis and the associated destruction of organizational capital. Supportive ex-post measures might also be counterproductive if they contribute to “zombify” the economy, i.e., allow the undue preservation of banks and corporates with low productivity or unsound structures.

It is therefore often argued that the ideal OF with respect to supporting financial stability is one that allows the central bank to be supportive in a systemic crisis, while at the same time ensuring to the extent possible that this is not excessively anticipated by market participants and translated into excessive leveraging (see e.g., Acharya and Viswanathan 2011). There are two challenges in translating this into practical advice to central banks: first, what is “excessive” leverage, and second, how to prevent financial institutions from building expectations regarding ex-post central bank supportiveness and to behave accordingly? One answer to the second challenge is constructive ambiguity, which however has a number of drawbacks. Another answer, at least in theory, to *both* challenges, is Basel III regulation, and in particular liquidity regulation and the leverage ratio. First, the regulation establishes what it deems to be “excessive” leverage and liquidity transformation, and second regulation prevents banks to go beyond it. Of course, designing good liquidity regulation is challenging. Liquidity transformation is a subtle economic activity, and standardizing and centralizing important parts of it through regulation will come with efficiency losses (e.g., König 2015). Therefore, it will remain important that the OF contributes itself to the right balance between supportiveness and counterincentives against excessive reliance on the LOLR, as a contribution to financial stability and efficiency, and not leave all the burden to regulation. In theory, regulators and central bankers should both assess this and reflected it in OF and regulatory approaches that avoid inconsistencies or contradictory elements. For example CGFS (2015) explores tentatively some of the related issues.

Relating closely to the ex-ante contribution to financial stability, the operational framework *should not undermine incentives for active interbank and capital markets*. This should be achieved normally if the central bank does not constantly intermediate the financial system and has an accordingly short balance sheet, and only transacts with the market to provide in net terms the counterpart of the monetary base. If the central bank buys, for instance, large amounts of assets outright such that all banks are in excess liquidity (such as is the case for many central banks in 2010-16), then all banks will tend to use at the margin for day-to-day liquidity management the central bank’s

deposit facility (or remuneration of excess reserves), and there will be little interbank market activity. Also, if the central bank liquidity provision is extremely elastic for any single bank (also because of a very wide collateral set), then the banks are tempted to steer their liquidity to a large extent by increasing or reducing their recourse to central bank credit, instead of adjusting permanently through interbank and capital markets. It should be taken into account that a solid interbank and capital market access cannot be gained at short notice, as the readiness of investors and other banks to have exposure to a certain name has to be built up over time. Nyborg (2015) also pleads strongly for OFs, and in particular collateral frameworks, to not undermine market discipline.

An active interbank money market seems desirable for a number of reasons: *First*, it allows measuring easily the short term interest rate and thereby the degree of achievement of the operational target of monetary policy. To some extent, short-term interest rates can also be measured in money markets beyond the traditional interbank market (e.g., corporate-to-bank money markets and short-term bank debt markets), as far as existent. Recent efforts on the measurement of short-term money market rates in, e.g., the United States and the euro area, have gone into this direction and suggest that traditional interbank markets might possibly be less crucial than assumed previously for this purpose (for the case of the euro, see e.g., EMMI 2015). *Second*, it has been argued that interbank money markets are useful because they incentivize banks to cross monitor each other, which strengthens the market mechanism (e.g., Blasques et al. 2016). Of course, incentives for monitoring banks should also be to some extent effective through other bank funding markets (e.g., short-term paper, bond and equity markets). But it seems plausible that interbank markets, as a peer-to-peer market, have something particular in this respect. If monitoring is effective and long term relationships (and sufficient limits) are in place, this can also support financial stability as temporary capital market funding stress or deposit outflows affecting a single banks that are not due to fundamentals could be compensated by interbank money markets. *Finally*, an active interbank money market provides evidence of netting of the liquidity needs of the banking system before recourse is taken to central bank

credit. In this sense, an active money market is equivalent to the avoidance of central bank intermediation between banks and the additional exposure of the central bank associated with it.

Conclusions on Objectives and Assessment Criteria of Operational Frameworks

This section developed a set of ex-ante objectives of OF design, which at the same time can serve as ex-post evaluation criteria for frameworks in practice. The measurability of the fulfillment of the assessment criteria varies. Still, in most cases it appears relatively straightforward to assess concretely features of existing frameworks against these objectives and criteria. Of course often parameter choices by central banks invoke trade-offs between objectives. For example, there will be trade-offs between effectiveness of the control of the operation target and preserving money market activity (see Section IV), or between leanness and universality, etc. One may therefore have to give weights to the different objectives to derive an optimal OF for a given environment. The next three sections of this paper, devoted each to one key aspect of OF design, will be guided by the objectives developed in the present section.

IV. Control of the Operational Target

IV.i. Introduction

Central bank “liquidity management” is the use of open market operations to control the scarcity of reserves of banks with the central bank in a way to have their price (the overnight interest rate) close or equal to the operational target level. As summarized in subsection II.i, according to the 2007 consensus, this is most effectively done within a corridor set by standing facilities (central bank credit operations at pre-announced rates that banks can take recourse to at their initiative). Models of controlling short-term interest rates through open market operations with a corridor set by standing facilities can be found e.g., in Woodford (2003), Whitesell (2006), Ennis and Keister (2008), Friedman and Kuttner (2010) or Bindseil (2014). In practice, a corridor approach needs specification along the following five key dimensions: 1) Reserve requirements of a certain size with averaging or no averaging (in the former case normally less than

daily open market operations, in the latter case daily open market operations); 2) Symmetric versus asymmetric setting of the operational target within the corridor (and associated to this, symmetric or asymmetric liquidity management); 3) Width of the corridor (e.g., 50, 100 or 200 basis points); 4) Open market operations: fixed rate full allotment or allotment amount set by the central bank; 5) Size of liquidity deficit of the banking system that is covered with central bank short-term credit operations.

The assessment of the effectiveness of choices made should be done against the criteria established in Section III. The rest of Section IV proceeds as follows. Subsection IV.ii revisits reserve requirements with averaging and comes to the conclusion that they may not be part of the optimal long-run OF. Subsection IV.iii restates why a symmetric corridor may be superior to an asymmetric one. Subsection IV.iv recalls the fundamental trade-off between market turnover and interest rate control inherent in the setting of the width of the standing facilities corridor. Subsection IV.v discusses tender procedures. Subsection IV.vi analyses the size of the liquidity deficit of banks to be covered through central bank credit operations. Subsection IV.vii discusses “target rate limited access” (TARALAC) facilities, which may be regarded as an alternative to reserve requirements or narrow corridors. Subsection IV.viii concludes.

IV.ii. Reserve Requirement with Averaging

The various objectives and specifications of reserve requirements are recalled e.g., in Goodfriend and Hargraves (1987) or Bindseil (2014, chapter 8). Currently, the following three objectives are still regarded as potentially relevant: 1) Averaging to stabilize the overnight rate within the reserve maintenance period without the need to conduct daily open market operations. This is the most prominent objective of reserve requirements in industrialised countries. It obviously requires that an averaging period (i.e. the reserve maintenance period) is defined. 2) Change structural position of the banking system vis-à-vis the central bank. For example, if a central bank (e.g. of an emerging economy) has cumulated large foreign reserves, it may use required reserves to absorb the implied excess reserves of the domestic banking system. 3) Unremunerated reserve requirements

may stabilize (or counter-incentivise) money creation by “taxing” it. Moreover, this may, again in the case of large foreign reserves, help the central bank to counterbalance a large negative carry (and hence structural unprofitability).

A survey of the specifications of reserve requirement systems can be found in the OF surveys mentioned in Section I. Close to 2007, there had been a number of remarkable innovations pioneered in particular by the Bank of England (voluntary system; end of maintenance period narrow corridor; fulfilment corridor). Also the Federal Reserve had eventually got the approval from Congress to remunerate required reserves. The ECB improved its system after four years by aligning intermeeting periods with reserve maintenance period, which stopped instabilities in reserve demand and the bidding behavior of banks (as described e.g., in Ayuso and Repullo 2003). While overall, progress toward an efficient and well-designed reserve requirement averaging system had been achieved, it can still be argued that reserve requirements with averaging are a fundamentally complex way to achieve more overnight stability without daily open market operations. As Perez-Quiros and Rodriguez (2006) have illustrated, calculating through the optimal reserve fulfilment path over a maintenance period is far from obvious—even under simplifying model assumptions. Indeed, every day of the reserve maintenance period is different, and the interest rate path during the remainder of a reserve maintenance period depends on history within the reserve maintenance period. It should therefore be explored whether in future OFs these complexities could not be overcome by relying, instead of on reserve requirements, on other tools to achieve a sufficient degree of interest rate stability (e.g., daily open market operations, narrower corridor, TARALAC facilities).

IV.iii. The Symmetric Corridor Approach

The evolution of the corridor approach in practice and the related history of thought is summarized e.g., in Bindseil and Jablecki (2011) or in Sellin and Somar (2014). The *symmetric* corridor approach had become the standard in 2007 and indeed seems to have specific advantages, which can be illustrated by reviewing four alternatives to it:

1. *Mixed asymmetric approaches* (e.g., in which the target rate is at three-quarters versus one-quarter distance to the two standing facility rates). This approach suffers relative to the symmetric one from requiring the central bank to predict (in the case of the central bank taking the open market operation allotment decisions) higher order moments of autonomous factor shocks to steer rates precisely. Moreover, intraday patterns of autonomous factor shock volatility do matter. In other words, a mixed asymmetric corridor approach is more complex for both the central bank and for market participants, and will likely, despite higher resources devoted by both sides to optimizing within this framework, lead to more interest rate volatility. Even with a full ex-ante understanding of the probability distribution of autonomous factor shocks, ex post the ONR will obviously not show a symmetric distribution within the corridor.
2. *Fully asymmetric approaches* (floor or ceiling approaches) in which the target rate is set to be equal (or very close) to one of the standing facility rates. Compared to this approach, the symmetric corridor approach has the advantage to better support interbank money market activity. Under a fully asymmetric approach, by definition banks have only weak or no incentives to trade in the market as the market rate is very close or equal to the relevant standing facility rate (this is equivalent to saying that because most banks are in the same liquidity position, the pricing of the few trades with the few banks who are on the other side of the market will reflect the huge aggregate imbalance). There is no solution to this problem in a fully asymmetric approach and in particular not in the new regulatory world in which interbank exposures are subject to higher capital costs, so that the hurdle for interbank transactions is anyway high.
3. *Approaches which steer overnight rates within a corridor of two same-sided standing facility rates.* The classic approach of central banks up to 1914 was to steer short-term interbank rates in a corridor set by two liquidity providing standing facilities: a discount facility (in which banks could sell trade bills satisfying certain

criteria) and a Lombard facility (an overnight lending facility based on a broad collateral set), priced at 100 basis points above the discount facility. In 2015, the Fed announced and started to apply as its post-liftoff approach a somewhat similar logic based on two liquidity absorbing facilities. Specifically, the Fed set a target range for the federal funds rate that is 25 basis points wide. The IOER (interest on excess reserves) rate and the offering rate associated with an overnight reverse repo facility constitute the top and bottom of the target range, respectively. While this “two same-sided standing facilities” approach has probably been optimal in the pre-1914 world and for the Fed’s liftoff from the ZLB in the context of large excess reserves, it seems to have drawbacks (compared to the symmetric corridor approach) which make it less obvious as a future long-term optimal approach. Indeed, this approach relies on the idea that the less attractively priced of the two facilities is accessible without binding limits in terms of counterparties and collateral (the latter relevant only for liquidity providing operations), while the more attractively priced of the two facilities must be constrained by some access limitations (only a limited set of counterparties, in the case of liquidity providing operations possibly also scarcer collateral). Interbank rates will fluctuate between the two, and the position within the corridor will depend on: 1) How strong are effectively the access constraints to the more attractively priced facility (how limited is the number of counterparties, how constrained are they in arbitraging, in case of a providing facility how scarce eligible assets are). 2) How big is the liquidity deficit or surplus that needs to be covered by the two facilities (the lower the necessary recourse, the closer the interbank rate will be to the constrained, more attractively priced facility). In the case of the pre-1914 OFs, mainly availability of eligible trade bills for the discount facility was a constraint that often pushed the interbank overnight rate to levels above the discount facility rate. In the case of the Fed’s liftoff, as Potter (2015) explains, “bank only access to IOER, credit limits imposed by cash lenders, and other impediments to market competition, and the costs of balance sheet expansion associated with arbitrage activity” all contribute to the fed funds

rate to be below the IOR rate (for the ex-ante design of the liftoff framework, see Frost et al. 2015). Obviously, it is challenging to steer the overnight rate very precisely through this approach as the position of the overnight rate within the corridor is driven by various institutional and quantitative factors that have effects which are difficult to predict with precision. This being said, the Fed has been impressively successful with this technique in achieving a stable federal funds rate after liftoff (see e.g., Federal Reserve Bank of New York 2016, 11-12).

4. Finally, *approaches with only one standing facility as the Fed's pre-2007 approach* are effectively asymmetric mixed approaches as one can interpret them as including a deposit facility at a zero interest rate. Depending on the absolute level of the operational target, and assuming that the credit facility rate is always 100 basis points above the target rate, the asymmetry of the effective corridor obviously varies with the stance of monetary policy, which seems inconvenient and which violates the separation principle.

One may therefore conclude that in relative terms, the symmetric corridor continues to perform well to reach the objectives of OF design discussed in Section III.

IV.iv. Key Parameters of Corridor Approaches

Corridor systems require in particular the specification of at least one parameter which then determines the volatility of overnight rates and the money market turnover (and associated with the latter, the degree of intermediation by the central bank). In the case of symmetric approaches, the key parameter is the width of the corridor. In the case of a fully asymmetric approach (e.g., a floor system), this is the average amount of recourse to the facility at the operational target interest rate (the width of the corridor is also relevant, but not as important as in the symmetric corridor approach). In the case of a TARALAC facility (see subsection IV.vii), it is both the width of the corridor set by penalty rates and the limit (the “quota”) applying to the TARALAC facility.

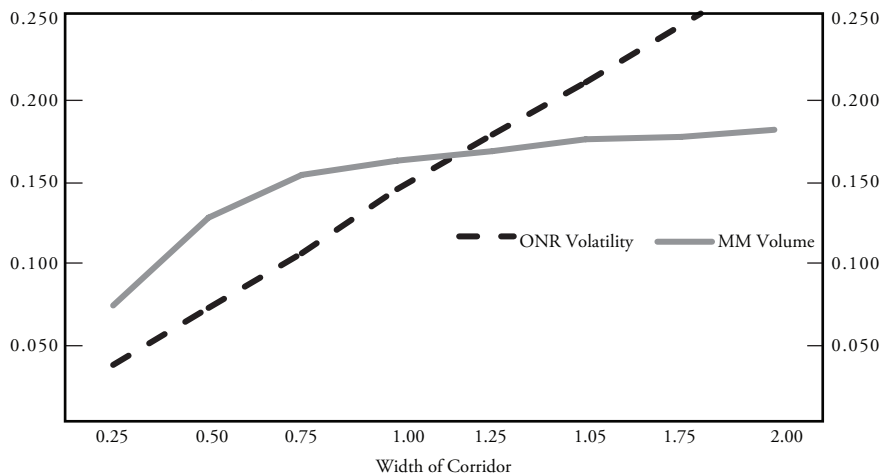
In Section 6.2 of Bindseil (2014), based on Bindseil and Jablecki (2011), a basic simulation approach is explained to understand the

role of the width of the corridor for the control of the overnight rate and the preservation of interbank money market activity. In the rest of Section IV of the current paper, a similar approach will be used to capture a few trade-offs in the design of the framework for the control of the operational target (see Appendix B for a description of the simulation tool covering also the case of a TARALAC facility). Chart 1 shows the result of a simulation of the impact of the (symmetric) corridor width (x-axis) on overnight rate volatility and money market turnover (y-axis).

The concave turnover and linear volatility (both as function of corridor width) suggest that there is an optimum interior solution for the choice of the corridor width.

This simulation approach can also be used to better understand the *drawbacks of an asymmetric approach*, such as a floor system, which were already mentioned in subsection IV.iii. Table 1 assumes that the central bank wants to move from a symmetric corridor approach (width of corridor: 200 basis points) to a floor system in which the overnight rate is supposed to be at 5 basis points above the deposit facility. All liquidity shocks have an initial volatility of 0.5 (see Appendix B for explanations). Column I shows the system under the symmetric corridor approach. The neutral open market operations volume is 1, the overnight rate volatility is 0.29 and the money market volume is 0.19. Column II shows the system under the new asymmetric approach. The open market operations volume needs to be increased to 4 to achieve an average interest rate around 5 basis points close to the deposit facility. The money market volume declines by around 70 percent. Scenario III-V confirm the other weakness of asymmetric approaches: volatility patterns of liquidity factor shocks impact on the level of overnight rates, and therefore any change of volatility patterns requires an adjustment of the volume of open market operations to ensure that the operational target remains at the adequate level. In scenario III, it is assumed that the pre-money market aggregate autonomous factor shock has four times the volatility of the post-money market aggregate shock, while in scenario IV it is the other way round. In both cases, the open market operations volume required to keep the overnight rate 5 basis points

Chart 1
Expected Money Market Turnover and Interest Rate Volatility as Functions of Corridor Width*



*Underlying specification: no TARALAC facility, volatilities of all liquidity shock variables are set to 0.5; level of interbank market transaction costs is 10 basis points. See Appendix B.

Table 1
Symmetric Corridor versus Floor Approach*

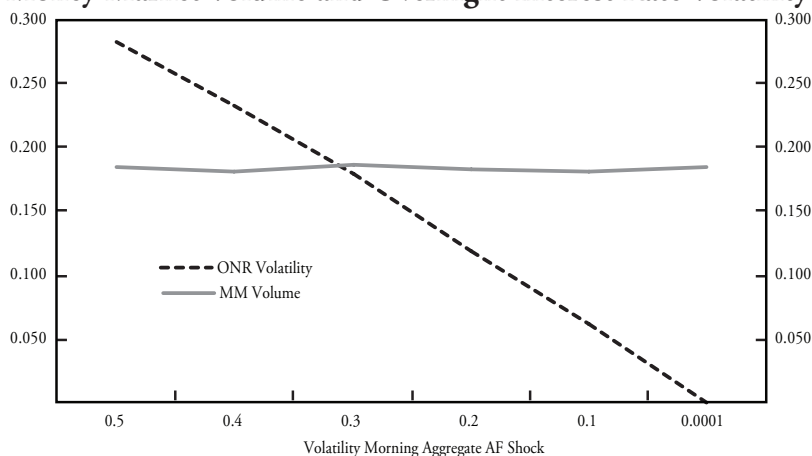
Scenario	I	II	III	IV	V
OMO Volume	1.0	4.0	5.8	9.0	5.5
AF shock pre-MM Std-dev	0.5	0.5	2.0	0.5	0.5
AF shock post-MM Std-dev	0.5	0.5	0.5	2.0	0.5
Rel Liqu Shock Std-dev	0.5	0.5	0.5	0.5	1.0
MM transaction cost	0.1	0.1	0.1	0.1	0.1
Width of corridor	2.00	2.00	2.00	2.00	2.00
Money Market Implications					
Interest rate volatility	0.29	0.09	0.18	0.02	0.14
Average MM volume	0.19	0.05	0.03	0.01	0.10
Average interest rate	0.99	0.05	0.05	0.05	0.05

*For latter: impact of relative volatility of liquidity shocks on adequate open market operation volume

above the deposit facility rate has to increase—in scenario III to 5.8 and in scenario IV to 9. Again in both cases, money market volumes are even lower than in scenario II. In scenario V, the aggregate autonomous factor shocks are again like in scenarios I and II, but the relative liquidity shock has doubled in size. In this case, the adequate open market operation volume moves to 5.5. That volatility patterns of liquidity shocks matter for the adequate allotment volume is an issue as changes of volatility of liquidity shocks are unlikely to be predictable and therefore will undermine the precision of interest rate control under any asymmetric approach (recall that under a symmetric approach, volatility patterns do not matter for the adequate open market operations volume). Of course, this problem could be solved by constantly providing huge excess liquidity, such as in the example constantly setting the open market operation volume to 10. Then, all the changes of volatility patterns captured in the scenarios below do not matter for the control of the overnight rate (the average overnight rate will never exceed 2 basis point), but the price is that interbank money market activity will be quasi-nonexistent.

One may wonder in how far the *timing of a daily open market operation can influence the volatility of the overnight rate and the turnover in the money market*. The timing of the open market operation can be relevant for the extent to which the morning autonomous factor shock has been revealed and can therefore be compensated by the central bank in the open market operation volume. This is equivalent to a decline of the effective volatility of the pre-money market aggregate autonomous factor shock. The following chart shows how the money market volume and the overnight rate volatility evolve if the effective volatility of the morning aggregate shock declines gradually, starting from the parameter values of scenario I in Table 1. The result shown in Chart 2 seems promising, i.e., it seems that a solution has been found to obtain a full control of overnight rates without impairing money market volumes. Eventually what matters is that when trading in the interbank market, banks do not believe to have any information suggesting biased end of day liquidity conditions. This

Chart 2
Money Market Volume and Overnight Interest Rate Volatility*



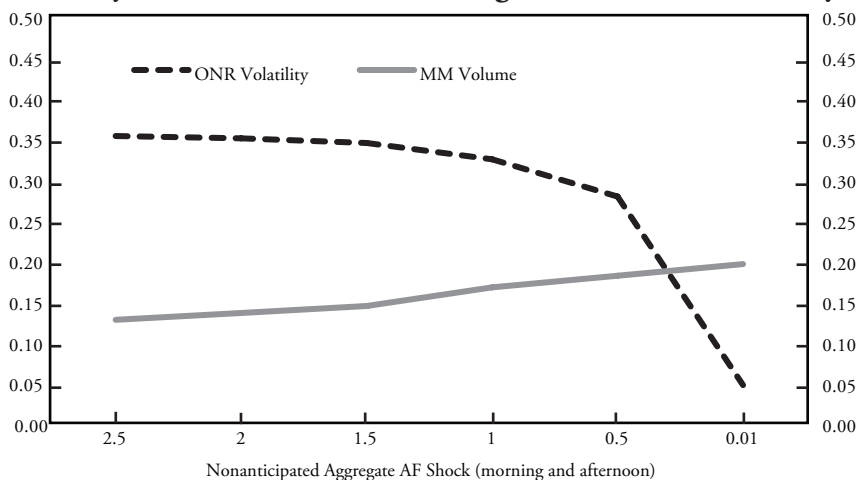
*As a function of the volatility (or unpredictability) of the morning aggregate autonomous factor shock

can indeed be achieved to some degree by good forecasting of autonomous factor shocks and a not too early conduct of the open market operation in the course of the day. The remarkable effectiveness in controlling overnight interest rates by a number of central banks not applying reserve requirements and averaging has likely been based on this approach (e.g., Australia and Canada, see Sellin and Sommar 2014, 128).

Finally, it is important to note that reducing both autonomous factor shocks by improving forecasts and thereby anticipating better (and reflecting in open market operations volumes) both the morning and the afternoon autonomous factor shocks also has positive effects, although less linearly on the side of overnight volatility and somewhat more on the side of money market volume. Chart 3 illustrates this by varying the size of the nonanticipated absolute liquidity shock, for a given level of the relative liquidity shocks. The chart varies on the x-axis the volatility of both absolute liquidity shocks, while assuming for the rest of the parameters the same values as in the previous base case.

This result also confirms the usefulness of aggregate autonomous factor forecasting for the overnight rate volatility/money market volume trade-off.

Chart 3
Money Market Volume and Overnight Interest Rate Volatility



*As a function of the volatility of nonanticipated absolute liquidity shocks for given relative liquidity shocks
 Notes: Underlying specification: no TARALAC facility, volatilities of relative liquidity shocks at 0.5; level of inter-bank market transaction costs is 10 basis points—see Appendix B.

IV.v. Tender Procedures, Maturity Structure and Size for Credit Operations

Superiority of Automated Allotment Mechanisms

The fundamental problem with discretionary allotment decisions is that banks will have to try to anticipate not only how other banks will bid, but also the allotment decision of the central bank. However, thinking through the equilibrium between the central bank's use of discretion and the bidding behavior of counterparties is almost impossible. Neither bidders nor the central bank are likely able to solve this problem in a meaningful way and to coordinate well on an equilibrium. In addition, incentives are created to spend resources on foreknowledge, more sophisticated players are rewarded, and overall transparency is reduced. Also, it is not clear what discretion can really aim at (for analysis of central bank auctions see e.g., Välimäki 2003; Ayuso and Repullo 2003; Nautz and Oechsler 2003; or Bindseil, Nyborg and Strebluaev 2009).

Options for Automated Tenders

There are two options regarding automated tender procedures: In *fixed rate full allotment*, the interest rate is set by the central bank

and the banks get whatever they bid for (assuming that they have sufficient collateral). The difference to a standing facility is that the tender is only offered at specific points in time. The fixed-rate-full-allotment approach has been applied by the Eurosystem to almost all credit operations since 2008. The second automated tender procedure is *variable rate fixed volume* as applied for example by the Eurosystem in all its longer-term refinancing operations (LTRO) between 1999 and 2008 (the tender volume is pre-announced before the bidding starts, and the marginal rate is therefore automatically set by the intersection between the vertical supply curve and the demand curve). The *main advantages of the fixed-rate-full-allotment approach are*: 1) Fixing the rate seems a logical consequence (in the intrapolicy meeting period) if the overnight rate is the operational target. 2) It is even simpler than variable rate fixed volume (no need for bidders to think about at what rate to bid or about how other bidders will bid, no need for the central bank to predict liquidity needs and to calibrate allotment amounts). 3) In case the new Basel III regulation makes banks' demand for excess reserves unpredictable as some have argued, the fixed-rate-full-allotment approach allows banks to address autonomously the issue. *Advantages of the variable-rate-fixed-volume approach are*: 1) It solves a specific potential problem of the fixed-rate-full-allotment approach that banks cannot coordinate bids in a way to ensure that the aggregate bid matches the actual aggregated liquidity needs—even if a common forecast of aggregate needs is available. At least, the aggregate bid in fixed-rate-full-allotment operations will contain some noise term which will affect liquidity conditions (Välämäki 2003). This problem will be material if the relative liquidity shocks are large and difficult to distinguish at the individual bank level from aggregate shocks. 2) Some may argue that the fixed-rate-full-allotment approach makes the life of banks too easy in terms of central bank reliance (however, the mechanisms against such excess reliance could be more targeted than introducing variable rate tenders for this purpose). 3) Some authors have argued that the variable rate tenders are more market oriented and allow the central bank to extract more information on markets and banks. Overall, it seems premature to conclude for short-term credit operations in a universal manner in favor of one or the other automated tender

procedures, although the relative advantages of the fixed-rate-full-allotment approach may have grown because of the difficulties for the central bank to predict the demand for excess reserves resulting from new Basel III regulation (see CGFS 2015). Variable-rate-fixed-volume tenders should in any case be used for longer-term credit operations, i.e., those going beyond the forthcoming meeting of the policy decision-making body.

Frequency and Maturities of Credit Operations; Number of Credit Operations Outstanding in Parallel

An effective but parsimonious approach can probably be based on two regular operations. With some daily liquidity buffer available, this could be a combination of one week and three months credit operations (as the Eurosystem practiced it between 2003 and 2007, whereby the three-month operations were conducted on a monthly basis so that always three of them were outstanding). In the absence of a buffer, daily operations with overnight maturity are needed in addition. Relevant factors for choosing an overall time architecture of regular tender frequencies and maturities are: 1) Time series properties of autonomous factors and of their forecast errors. 2) Total size of expected average liquidity deficit to be covered with credit operations. The larger the liquidity deficit, the more operations of decent size can be outstanding in parallel. 3) Perception of rollover risks by banks: if allotments per counterparty are considered uncertain (as it is the case under variable rate tenders) banks may have a preference for limiting rollover risks, suggesting benefits of keeping the size of single operations limited.

In any case, parsimony should remain a guiding principle. Also, misconstructions should be avoided in which the tender sizes drift apart, as it can happen when overlapping credit operations (e.g., weekly operations with two-week maturity) are used to address temporary autonomous factor fluctuations.

Size of Liquidity Deficit of Banks Toward Central Bank To Be Covered by Short-Term Credit Operations

The size of the liquidity deficit of banks toward the central bank that needs to be covered by short-term credit operations is determined by

the sum of outright portfolio holdings and long-term credit operations, relative to autonomous factors. The larger the liquidity deficit to be covered by short-term credit operations, the 1) higher the roll over risk for banks (unless the operations are conducted as fixed-rate-full-allotment, which minimizes roll-over risks); 2) the shorter (everything else equal) the average duration of central bank assets (with its consequences on the risk-return characteristics of central bank balance sheets and the central bank's contribution to maturity transformation); 3) the more broad based the direct transmission of policy rates to market rates (which may be important in less efficient markets); 4) the larger the buffers for short-term changes in autonomous factors that ensure that short-term credit operations remain of meaningful size; 5) the larger the potential for *relative* central bank intermediation within the LOLR function of the central bank (see Section VI). These various dimensions create trade-offs which need to be looked at carefully for any specific environment.

Amount of Reserves Provided via Longer-Term Credit Operations

The optimal amount of reserves provided via longer-term credit operations should also be considered within specific trade-offs, and in particular: 1) for a given amount of total credit operations, banks perceive longer-term operations to reduce roll-over risks; 2) longer-term operations may be appreciated by banks in the post-crisis world as they support the compliance with liquidity ratios; 3) a larger share of longer-term credit operations in all credit operations reduces the flexibility of the central bank to react to (nonanticipated) large autonomous factor changes.

IV.vi. Target Rate, Limited Access (TARALAC) Facilities

Reserve requirements with averaging provide buffers against daily autonomous factor shocks which allow the central bank to achieve a high degree of stability of the overnight interest rate without daily open market operations. However, as noted above, reserve requirements with averaging are complex and have dynamic properties within the reserve maintenance period. This section therefore summarizes an approach advanced, for example, by Bindseil and Würtz (2008, 31-37) as "TARALAC" and actually applied since 2007 in New Zealand—as

“Tiering” system—and since 2013 in Norway—as “Quota”—system. A third term that also has on substance a similar meaning is the one of a daily remunerated reserve requirement system with “fulfilment band” i.e., in which penalty rates do not kick in immediately in case of under or overfulfillment of required reserves, but only if the fulfilment falls out of a band, such as e.g., +/- 10 percent around the exact reserve requirement figure. An advantage of a TARALAC facility relative to a reserve fulfilment band could obviously be that the former does not need to be based on a reserve requirement system.

In New Zealand, every bank gets its reserves with the central bank remunerated at the target rate for an amount up to its tier allocation and beyond that at the level of a deposit facility rate, i.e., 100 basis points below (Nield 2008). “Tier allocation [is] determined primarily by revealed demand and behavior in the payment system—individually allocated tiers up to \$100 million, \$250 million, then increments of \$250 million to \$1500 million, and in steps of \$500 million thereafter” (Nield 2008, 13).

Norges Bank, prior to 2011, had a floor system, but found that it made “the redistribution of reserves in the interbank market function poorly” (Norges Bank 2016). The two objectives to move to a quota system were accordingly “to stop the growth in bank reserves” and “generate more interbank market activity in the overnight market.” Norges Bank (2014, 6) also notes that the drawback of a symmetric corridor model would be that “it places considerable demands on liquidity management by the central bank, which must at all times steer toward zero reserves in the banking system.” According to Norges Bank (2016), the quota system “is a compromise between a floor system and a corridor system ... only a certain amount of each bank’s deposits with the central bank—a quota—is remunerated at the key policy rate.” Norges Bank (2016) explains further that “Like the floor system, the quota-based system is a system with surplus reserves (the central bank aims to keep banking system reserves above zero). Any forecasting errors will therefore affect market rates to a lesser extent than under a corridor system.”

Recall very briefly the logic of a TARALAC facility (following Bindseil and Würtz 2008, 31-33). Assume again that the central

bank operates in a symmetric approach, i.e., the target interest rate i^* is in the mid of a corridor set by the credit and deposit facilities. Moreover, assume that $i^*=0.5$ and $i_D=0$, $i_C=1$ (the rate of the deposit facility and of the credit facility, respectively) and that there is only one TARALAC facility, namely a credit facility offered at an interest rate $i_\psi=0.5$. Let the quota (i.e., the maximum amount of credit provided by the standing facility at the target rate) of a representative bank be ψ . For risk-neutral banks, the interbank rate should simply be the weighted average of the three possible end-of-day marginal costs of funds, the weights being the perceived respective probabilities of recourse to each of the three facilities. The “fundamental” equation determining the interbank rate is $i=P(\text{“short”})i_C+P(\text{“TARALAC”})i^*+P(\text{“long”})i_D$, whereby $P(\text{“short”})$ is the probability perceived by market participants to have to take recourse to the credit facility at day’s end, $P(\text{“TARALAC”})$ is the probability that the TARALAC facility is used, but not exhausted, and $P(\text{“long”})$ is the probability of ending the day with excess reserves beyond ψ , i.e., with recourse to the deposit facility. Interbank rates should be equal to the target interest rate if $P(\text{“short”})=P(\text{“long”})$. For symmetric probability distributions, this means that open market operations need to have injected an amount of reserves equal to the sum of autonomous factors minus one-half of the quota ($-\psi/2$). Obviously, the larger the quota (ψ), the larger the probability that it will be sufficient to absorb the shocks and therefore the lower the probability that banks will need to have recourse to either of the penalty facilities, and the more stable the overnight rate will be. If rate stability was the only criterion, then the higher the quota, the better. Unfortunately, activity in the interbank overnight trading also depends on the quota, and the higher the quota, the lower incentives will be to trade in the market. In fact, the whole idea of limiting the access to a facility at the target rate reflects the idea that such a limit supports the interbank market. The money market turnover—interest rate volatility trade-off can be simulated again with the one-day model explained in Appendix B. Chart 4 provides the results by varying on the x-axis the size of the quota ψ .

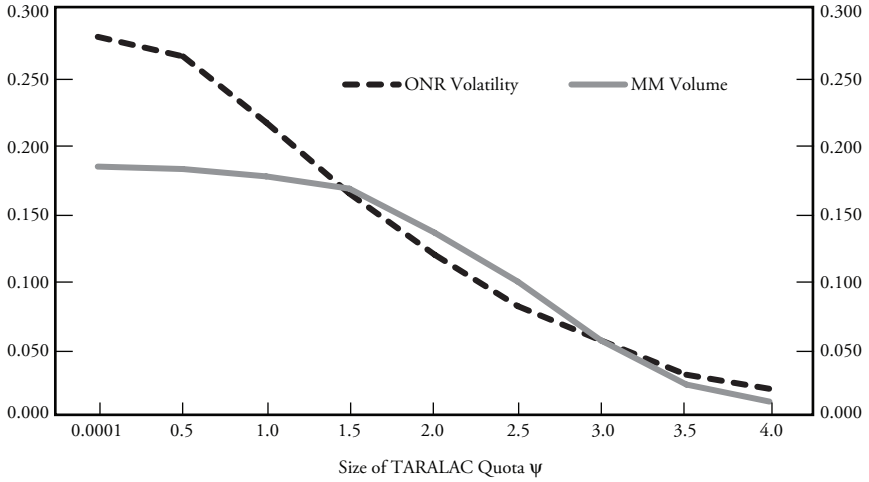
Both the money market volume and the volatility of the ONR decline monotonously with the TARALAC quota. An element of concavity in the money market volume could again suggest that an

interior optimum of the quota size exists. It could be argued that the merits of a TARALAC approach relative to reserve requirements with averaging also depend on the time series properties of autonomous factor innovations and the volatility patterns of autonomous factors.

Finally we briefly explore whether the combined use of the two parameters—width of the corridor and size of the TARALAC facility—really make a difference. The basic test compares the trade-off between money-market turnover and ONR volatility that can be achieved without a TARALAC facility with the one that can be achieved with a TARALAC facility. Specifically, we compare the trade-offs for the case of all liquidity shock volatilities being equal to 0.5, and interbank transaction costs being 10 basis points. Different corridor widths are simulated for two alternative cases with regard to a TARALAC facility: 1) No TARALAC facility; 2) a TARALAC facility with a quota Ψ of 1. Chart 5 seems to suggest that in this chosen case, the TARALAC facility does not allow improving the trade-off, i.e., it would be a redundant tool in the case of these environmental parameter values and assumptions. The absence of a TARALAC facility could simply be compensated by a narrowing of the corridor. Of course, this redundancy result does not need to be universal but may depend on the specific setting.

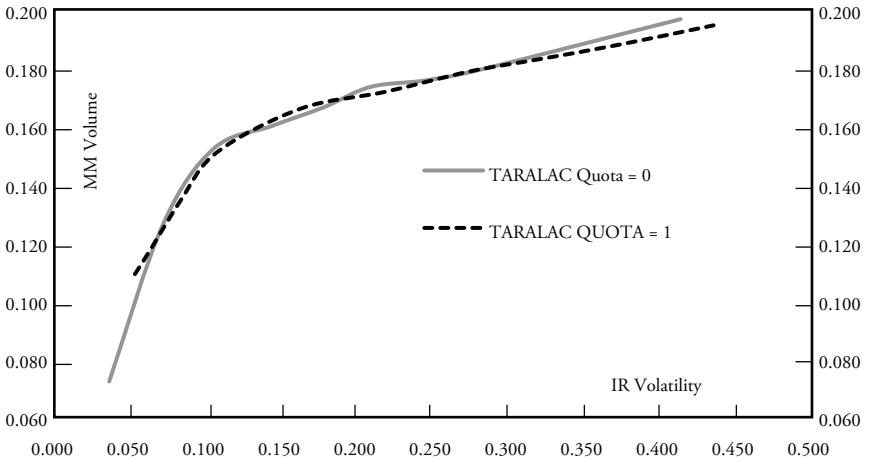
Finally, it is interesting to check *how a TARALAC facility and the width of the corridor interact for a lower than daily frequency of open market operations*. This can be tested with the simulation approach by cumulating all autonomous factor shocks between the last open market operation and the relevant money market session. If we assume that the open market operation on day 1 targets the average amount of autonomous factors over an n days horizon, then the assumption that autonomous factors follow a martingale implies that the same open market operation volume is chosen regardless of whether the horizon is one day or n days with $n > 1$. Assume that the aggregate autonomous factor shocks in the morning and afternoon of each day each have a volatility of σ_d and that all these independent shocks cumulate over time. Then if the open market operation is on the morning of day 1, at the moment of the market session on day n there have been $(n-1)2+1$ independent and identically distributed shocks with volatility

Chart 4
Money Market Turnover and Overnight Rate Volatility
as Functions of Quota ψ



Note: Liquidity shock volatilities have been set to 0.5, interbank transaction costs to 10 basis points and the width of the interest rate corridor to 100 basis points—see Appendix B.

Chart 5
Money Market Turnover and Overnight Rate Volatility*



*Efficient combinations that can be achieved by varying the width of the corridor, 1) without TARALAC facility; 2) a TARALAC facility with a quota $\Psi=1$.

Note: Liquidity shock volatilities have been set to 0.5, interbank transaction costs to 10 basis points and the width of the interest rate corridor to 100 basis points—see Appendix B.

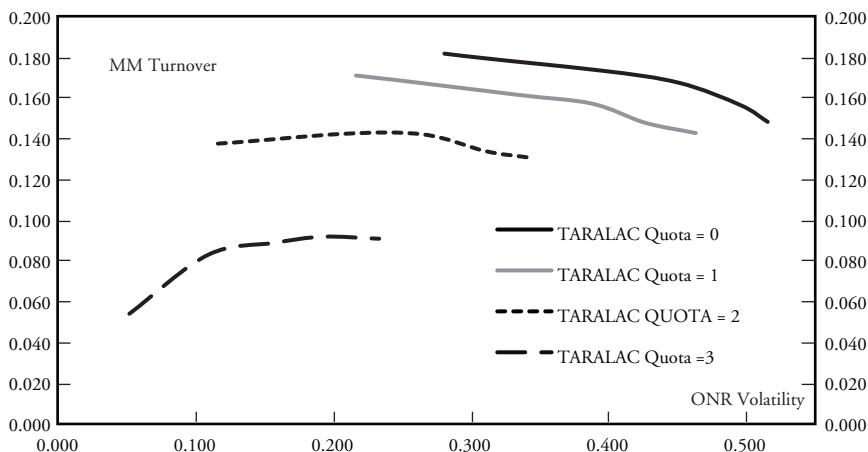
σ_d cumulating, meaning that the pre-money market shock has a cumulated volatility $\sigma_d \sqrt{(n-1)2+1}$. If we take, for example, the case of a five-business-day period covered by the open market operation, this would mean that on day 5 everything is exactly as if the open market operation is in the morning of day 5, but the morning liquidity shock has a volatility of σ_d while the afternoon aggregate autonomous factor shock has a volatility of σ_d . This will obviously mean more interest-rate volatility. Chart 6 shows how, for a standing facilities corridor of 200 basis points, the money market turnover—overnight rate volatility pair evolve over the course of a five-day period covered by a single open market operation. The starting point of each line from the left represents day 1, the endpoint on the right represents day 5. This is shown for four quota sizes of a TARALAC facility (0, 1, 2, 3). Regarding the other parameters, we assume that the single (morning aggregate, afternoon aggregate, relative) autonomous liquidity factor shocks have a volatility of 0.5 and that interbank transaction costs are 10 basis points.

TARALAC quotas seem to have additional benefits in this setting. For the day of the conduct of the open market operation (left end of the four scatter lines), we observe the usual pattern that a higher TARALAC quota improves overnight rate stability but reduces money market turnover. For the subsequent days, higher TARALAC quotas allow to avoid the further dropping of money market volumes. In other words, the more days one open market operation has to cover, the more beneficial the TARALAC facility could become—at least under specific parameter constellations.

IV.vii. Counterparties to Central Bank Credit Operations

The set of counterparties qualifying for the central bank's standard monetary policy credit operations is not only a key issue for the central bank's LOLR framework (see Section VI), but can also be seen from a more narrow monetary policy perspective. In particular, the question arises whether the setting of counterparty criteria is relevant for the ability to control the overnight interest rate, or for the smoothness of the transmission of monetary policy beyond that. *If markets are perfectly efficient*, the counterparty eligibility criteria and the size of the counterparty set probably do not matter too much, apart maybe

Chart 6
Money Market Turnover and Overnight Rate Volatility*



*Over a five-day period covered by one open market operation and for four alternative levels of a TARALAC quota. Notes: Left end of each line is day 1, right end of each line is day 5. (Liquidity shock volatilities have been set to 0.5, interbank transaction costs to 10 basis points and the width of the interest rate corridor to 100 basis points).

for two considerations: 1) the set should be large enough to ensure *fully competitive behavior* of eligible counterparties when acting as intermediaries between the central bank and the rest of the financial system. 2) If bidders are individually subject to noisy signals on the otherwise common value of the good in question (central bank reserves), then it may also be useful to have a relatively high number of bidders to reduce the volatility of marginal bid rates in variable rate tenders (independently of the degree of ex-ante competition).

If markets are modestly efficient, and e.g., intermediation costs are relatively high (maybe also due to regulation) and unstable, then additional arguments for a broader counterparty set emerge. If intermediaries have increasing and unstable marginal costs, then increasing the number of entities with direct access to the central bank reduces total intermediation costs and stabilizes the first part of the transmission mechanism. Moreover, the information content of an operational target rate, such as an overnight interest rate, is likely to be improved, because those entities that do not participate to the interbank market and those who do are less likely to have very different valuations of overnight funds.

So far, only potential advantages of a broader counterparty set were mentioned. Of course there are also costs. Indeed, we do not observe central banks to grant access to an extremely broad set of counterparties, such as including e.g., corporates and natural persons. Key costs are: 1) A more diverse and large counterparty set requires more due diligence (“know your counterparty”) and monitoring work on the side of the central bank. 2) Counterparties need to be able to submit eligible collateral, i.e., it is pointless to grant access to entities that do not have or are unable to handle eligible collateral (unless they are counterparties only in terms of depositing with the central bank). 3) Granting access to entities that are not highly active in various financial market segments and that have particularly high transaction costs may eventually undermine the effectiveness of transmission as liquidity becomes fragmented. This will imply overall higher excess reserves, less predictability of aggregate liquidity needs, more absolute central bank intermediation and may eventually reduce economic efficiency and endanger financial stability.

In a financial crisis, broadening the set of counterparties having access to central bank credit will likely make sense, as the elements within the trade-off described change toward the pros of a broad set.

Additional considerations apply for the granting of access to a deposit facility. In particular, it appears that board access beyond banks could undermine financial stability (see e.g., Garrat et al. 2015, Section 6.1). When there is a general perception of banking sector risks, a broad access of nonbanks to depositing with the central bank is an invitation for withdrawing funds from the banking system. For example, deposits with central banks by official sector entities (e.g., governments and foreign central banks) significantly increased in 2008 and contributed to funding gaps of banks that the central banks then needed to fill through LOLR operations. One solution to this potential problem could be to put limits on deposits of nonbanks.

In the new regulatory environment, the trade-off has probably changed toward central banks tending to broaden their counterparty set to reflect the higher costs of intermediation in wholesale money markets. It is noted that the pre-crisis starting points of central banks were very heterogeneous, with the Fed conducting open market operations only with primary dealers, while for example the Eurosystem

was ready to operate with any regulated monetary financial institution that was willing to fulfill basic operational criteria.

V. Balance Sheet Structure and Outright Portfolio

V.i. Introduction—the Return to a Lean Balance Sheet

During the financial crisis and its zero-lower bound aftermath, central bank balance sheets of industrialized countries have gained substantially in length. In the nine months after the Lehman Brothers default, central banks intermediated the financial system through LOLR operations, while as of the second half of 2009, central banks lengthened their balance sheet mainly through large scale asset programs (“LSAPS”—in the case of the ECB, LSAPS dominated the balance sheet only as of 2015). In contrast, a perfectly “lean” central bank balance sheet can be defined as one which would have a total length close to the value of bank notes issued. While in crisis times, there are a number of justifications for lengthening the central bank balance sheet through LSAPS or LOLR operations (e.g., Curdia and Woodford 2010), a lean balance sheet is in principle positive *in normal times* as it suggests that the central bank focuses on the core of its mandate. Moreover, a lean balance sheet is a sign of well-functioning financial markets and a healthy economy because the central bank is neither used as intermediary by the banking system, nor does the central bank see a need to engage in special crisis measures such as LSAPs. Of course, there are a number of potential good reasons why central bank balance sheets may not be perfectly lean, such as, *on the liability side*: 1) reserve requirements of banks (if one believes in them as a useful instrument of monetary policy); 2) capital and reserves of the central bank (as buffer against financial risks). *On the asset side*, besides LSAPs, the need to hold large foreign reserves (e.g., as protection against future depreciation pressure, or as result of past prevention of appreciation of the currency in a peg or managed float exchange rate system) may also be a driver of balance sheet lengthening. There are also sometimes less ideal explanations for long balance sheets, such as when the central bank is not independent and is instructed by the government to monetize its unsustainable debt or rescue a nonviable industry. An outstandingly lean central bank balance sheet was the one of the Fed pre-crisis, where the total balance

sheet length was only around 1.1 times the total amount of bank notes in circulation. In general, the objective of a lean balance sheet should remain valid in the future long-term OF, even if monetary and FX policies, or in some cases auxiliary central bank tasks, can justify some lengthening. As will be argued further below, the idea that the central bank permanently injects monetary accommodation through a longer balance sheet with substantial holdings of a portfolio of less liquid assets with long maturity and possibly some credit riskiness does not appear sufficiently convincing.

V.ii. What To Do With the Not Policy Constrained Central Bank Assets?

For large advanced monetary areas, there is usually a large part of assets that are not policy constrained (“NPC assets”): the operational target can be achieved at the margin with some repo operations, and the need to hold foreign reserves is typically limited. Therefore, the central bank seems to have leeway for other considerations on asset composition (even if total assets are not expanded beyond the sum of the monetary base and capital and reserves of the central bank). For example, both the Fed and the ECB issue bank notes of more than a trillion in their respective currencies, but have foreign reserves for potential intervention purposes in the order of magnitude of far less than 10 percent of this. Also, the need for open market credit operations to steer reserve scarcity and therefore the overnight rate should not exceed say 10 percent of the amount of bank notes in circulation. This would imply that for around 80 percent of the (minimal) balance sheet length, asset composition can potentially be chosen on the basis of considerations beyond monetary and exchange rate policies, as discussed in the following.

Duration of NPC Assets

One service of the financial system to society is to undertake maturity transformation, as investors typically want to hold short-term, liquid assets, while economic projects often need financing for a long period of time. It could be argued that the central bank can contribute to this by holding long-duration assets in its balance sheet, unless specific reasons speak against it. For example, it could in particular be

argued that the central bank can take considerable duration risk into its balance sheet as central banks' liabilities tend to be rather stable (at least as long as assets can be accounted for at amortised costs). Over the last 70 years, bank note demand has been subject to no considerable downward surprises, and for the last 15 years even has grown (at least in the United States and the euro area) above nominal trend growth of GDP. Thanks to the term spread, a longer average duration of central bank assets would also support the income of the central bank and the size of its profit disbursements to the government. It goes without saying that a central bank with a substantial long-duration outright portfolio should never put into question a necessary tightening of monetary policy because this might inflict short-term losses on it via its outright portfolio (in case that the accounting treatment of the securities would foresee marking to markets).

Liquidity of NPC Assets

Related to the previous point, it could be argued that central banks should also hold assets of lower liquidity. First, as just mentioned, central banks tend to have long-term liabilities. Second, even if bank notes would suddenly shrink, central banks would never be forced to sell their assets as they can always absorb excess liquidity through liability side operations. Therefore holding less liquid assets can again be argued to be a contribution to the financial system's role to provide liquidity transformation services to society, or, taking a different perspective, it allows generating additional central bank income that will eventually be shared with the taxpayer.

Diversification and Credit Riskiness of NPC Assets

According to the CAPM, every investor should hold a combination of the market portfolio and the risk-free asset. This idea could also be applied to the NPC assets of a central bank. Of course, in reality, most investors do not hold the market portfolio, as the costs of due diligence in reality put limits to the optimum degree of diversification. One could argue that the central bank should go relatively far in its diversification in view of the scale of its NPC assets. On the other side, the central bank as public institution has organizational constraints that will make it a less agile and sophisticated

investor, implying that it should be prudent and not overestimate its ability to run a highly diversified portfolio.

Exposure to Government of NPC Assets

As explained in Section II, there are still two opposing fundamental philosophies among central banks regarding the role of government debt in the outright holdings and collateral sets of central banks (“consolidated official sector” versus “central bank independence”). Whichever of the two (or an intermediate) philosophy is adopted should have large implications on the NPC assets. The diversification considerations made in the previous paragraph obviously become less relevant under the “consolidated official sector” approach.

Neutrality of NPC Assets

The former two issues (diversification and exposure to the government) also determine what one may consider as “neutral” or “nondistorting” NPC asset allocation. In fact there is a further philosophical question that is relevant in this context: whether one believes that it is “distorting” if the central bank, as large and idiosyncratic player, impacts on relative financial market prices. According to a first view, the NPC investment approach is nondistorting if it reflects the idiosyncratic economic characteristics of the central bank as an “investor.” Proponents of this view will argue that this allows putting the idiosyncratic privileges of central banks at the service of society also in the area of NPC asset allocation. The second view in contrast states that the NPC investment approach is nondistorting if the central bank broadly behaves like an average investor.

Within well-defined asset classes, the concept of “neutrality” seems much easier to define. For example, if a central bank has concluded to hold a government bond portfolio, then it seems “neutral” to reflect the maturity structure of outstanding bonds proportionally in the central bank portfolio. Such neutrality should be the starting point, and deviations from such neutrality may be considered if specific arguments suggest so. Similarly, in case a central bank runs a corporate bond portfolio, it seems uncontroversial that “neutrality” of issuer weights is defined with reference to a benchmark of outstanding eligible bonds.

Expertise Building Ensuring that the Central Bank Understands Financial Markets and Stability Issues

One further possible guiding principle in specifying NPC assets of central banks could be to ensure that the central bank builds up and maintains hands-on expertise in financial market segments that play an important role in monetary policy transmission and that can interfere with transmission in case of impairment. Hands-on capital markets expertise could be seen as precondition for “intervening” without delay in any of these markets, i.e., ensure the effectiveness of the central bank when a serious financial crisis breaks out. Indeed, central banks were easily able to launch monetary policy motivated asset purchase programs so quickly in 2009 because they were invested into most of these (or similar) asset classes beforehand.

No Interference of NPC Asset Management with Monetary Policy

Obviously the management of NPC assets should not interfere with monetary policy implementation. For example, large purchases or sales of NPC assets should not create autonomous factor shocks that impact on the overnight rate.

Should Outright Portfolios Aim at Impacting the Monetary Policy Stance?

Three possible reasons could argue in favor of the idea that outright portfolios with duration, credit and liquidity risk should permanently add monetary accommodation:

- Monetary income argument (linked to arguments stated earlier). Call DCL a composite measure of the duration, credit and liquidity risk in a central bank’s outright portfolio, and assume two alternative portfolio specifications with $DCL_1 > DCL_2$. Then, there should be two pairs of outright portfolio/short-term interest rate combinations, (DCL_1, i_1^*) and (DCL_2, i_2^*) , leading to the same monetary conditions, with $i_1^* > i_2^*$. Is there any point in preferring one to the other? One might argue in favor of DCL_1 as it seems to generate higher average income for the central bank and therefore eventually for the taxpayer, which appears as social welfare contribution of the central bank to society (the higher income results from both

the higher outright portfolio income and from the higher average level of short-term interest rates).

- Faster possible easing in case of a crisis. In a world of low growth, it may be good to provide more breathing space for the short-term interest rate to be lowered in case needed. It could be argued that injecting accommodation through a lowering of short-term interest rates is much easier and faster than doing so by building up a portfolio of not so liquid and possibly credit-risky bonds. Therefore it would be better to do first and permanently what is more time demanding, and have then more room for what can be done very quickly. However, this argument seems to be weakened by the fact that the announcement effect of large scale asset purchase programs tends to be powerful and allows for quasi-immediate effectiveness.
- Supports financial stability. Woodford (2016) argues that outright portfolios can provide monetary accommodation with less risk to financial stability than conventional (interest rate) policies. This is because outright portfolios with duration, credit and liquidity risk reduce risk premia, and thereby dampen incentives for financial intermediaries to excessively take such risks.

While all three points might be sufficient to provide further arguments in favor of having a part of central bank assets invested into securities with some duration, credit and liquidity risk, it is less obvious that they would also justify a permanent lengthening of the central bank balance sheet. This could be viewed as a return to the overambitious and oversophisticated monetary policy ambition of what was called in Section I the Baroque age of monetary policy implementation (the 1960s and 1970s). In addition, it seems clear that *variations* of outright portfolio size and composition should not be considered as tool for *varying* the stance of monetary policy over time. Adjusting short-term interest rates should be the only tool for that purpose in normal times.

VI. The Collateral Framework and the LOLR

The lender of last resort (LOLR) function of the central bank takes in particular three forms: first, and this is the main focus here, some

LOLR elements are built into the normal-times OF (e.g., elasticity of individual banks' recourse to central bank credit as determined by the collateral framework). Second, the LOLR can take the form of a decision of the central bank to expand, in crisis times, the LOLR content of the OF (e.g., temporarily broaden the collateral set). Ex ante, banks will have some beliefs on the readiness of the central bank to take such measures in a crisis. Third, the LOLR can take the form of idiosyncratic credit operations to single banks outside the applicable OF, called "emergency liquidity assistance" (ELA) by the Eurosystem and by some other central banks. Also with regard to this third element, banks will have beliefs on the attitude of the central bank that will materialize once a need for ELA occurs. The three components together will affect, together with regulation and supervision, the ex-ante decisions of banks on the extent of maturity and liquidity transformation they engage in. Section VI.iii will discuss further the respective roles of these three components of the LOLR.

The most important aspect (but not the only one) determining the LOLR content of the OF is the size of the eligible collateral set. For a given initial recourse of a bank to central bank credit, this set determines the banks' availability of unencumbered central bank eligible collateral, and thereby the extent to which banks can close emerging funding gaps through an increased recourse to standard central bank credit. This is the reason for treating collateral and the LOLR function in one section. In subsection VI.i, the collateral framework is discussed on a stand-alone basis, i.e., without seeing it particularly as a part of the LOLR framework. Subsection VI.ii turns to the LOLR question. Subsection VI.iii develops the idea of an "over-proportional borrowing framework" (OPBF).

VI.i. The Collateral Framework

While having been overlooked for a long time outside central banks, the importance of the central bank collateral framework for the financial system and for monetary policy has recently received more attention (e.g., Chapman et al. 2011; Bindseil 2013; Cassola and Koulicher 2015). Beyond the LOLR (treated in section VI.ii), three main objectives in the design of collateral frameworks may be distinguished.

1. Risk protection, which is the basis for allowing unconstrained counterparty access to central bank credit operations, including standing facilities (instead of imposing limits and foreseeing a credit approval process for each central bank credit).
2. Sufficiency of collateral for the majority of banks so that collateral scarcity does not interfere with the effectiveness of the framework in control of the operational target. For example, collateral scarcity should be sufficiently remote so as to allow a real symmetric corridor approach. If collateral is too scarce, then neutral liquidity would imply that interbank rates are clearly above the middle of the corridor since the true cost of accessing the credit facility would be significantly higher than just the interest rate charged.
3. Market neutrality, i.e., avoid that the collateral framework distorts relative asset prices. With this regard, once more two opposite philosophies can be observed among central banks: According to the first view, the central bank should get (at least in normal credit operations) a standard interbank market collateral set, otherwise it is a sign of undue “arbitraging” of the central bank (or “adverse selection,” or “Gresham’s law applied to central bank collateral use”). According to the second view, the central bank is special and in a world of scarce collateral, it should accept less liquid collateral since 1) it can impose haircuts (which are not an as effective tool to address risk concerns if the collateral receiver is also subject to default risk); 2) it is not liquidity constrained. The central bank best contributes to society if it reflects these comparative advantages in its collateral policies. The choice of the doctrine will have a market impact, but both views claim neutrality. E.g., Nyborg (2015) is a proponent of the first view.

On the basis of these three objectives, the following three questions relating to the design of the collateral framework emerge as key.

How Broad Should a Collateral Set Be?

If we order potential collateral from the most to the least suitable, where is the optimum cut off point between what should be eligible

and what should not? *Arguments in favor of a broad collateral set are:*

- 1) Sufficiency of collateral to minimise possible interference of collateral scarcity with monetary policy implementation.
- 2) Substantial LOLR elasticity built into normal framework supports *ex-post* financial stability and *ex ante* a high contribution to the ability of the financial system to contribute to maturity and liquidity transformation.
- 3) Potential for collateral diversification, i.e., such as to reduce central bank risk taking (benefiting from this advantage may require to *impose actual diversification* of collateral pools through e.g., limits).
- 4) Avoidance of privileged treatment of some issuers; minimize collateral eligibility premium and the potentially associated distortion of prices.

Arguments against a too broad collateral set are: 1) a broad set may be perceived by banks as invitation to rely excessively on easy central bank access, instead of devoting resources to maintaining a sound market access or a broad deposit base (it may create “moral hazard,” if one wants to use this term); 2) A narrow set reduces complexity, credit risk management issues and due diligence work for the central bank; 3) A broad set requires more diversification of haircuts and more monitoring; 4) If the set is narrow in good times, then there is more and easier broadening potential in crisis times, when needed for financial stability reason.

What Should Be the Level of Haircuts?

Haircuts should protect against 1) valuation mistakes; 2) the possible exogenous drop of value during the liquidation period; 3) possible negative effects on asset values of the central bank’s collateral liquidation in case of counterparty default on asset values. One straightforward approach to calibrating haircuts would be that for every eligible asset, one chooses a haircut that at a certain given confidence level (e.g., 99 percent) will not lead to losses when the central bank will optimally liquidate the asset after a counterparty default. This approach would ensure “ex-post risk equivalence” in the sense that after haircuts, all types of assets are, from the central bank perspective, equally risky (at least according to the measure chosen) when submitted by counterparties as collateral. Haircuts could also be higher for assets that are more costly for the central bank to assess and to handle, to discourage the use of such assets, or for assets with regard to which central banks fear

high use as collateral and therefore concentration risks. However, there would seem to be more precise tools to address this. The first issue could be addressed by imposing fees to make counterparties internalize costs arising to the central bank when accepting certain types of collateral. The second issue could be addressed by limits or concentration risk add-ons to haircuts (which would kick in if actual concentration risks arise).

How Segregated Should Collateral Sets Be?

Central banks take very different approaches in terms of segregating or not their collateral sets and assigning them to specific types of operations. The following three types of operations are segregated in terms of collateral pool by a part of the central bank community: 1) Short-term credit operations to control the operational target (overnight, up to one week); 2) Long-term credit operations (providing long-term funding to banks—called by the Bank of England “liquidity insurance”); 3) Liquidity providing standing facilities (“discount window” in the United States, “marginal lending facility” in the euro area). Central banks who do not segregate collateral sets would probably argue as follows: First, segregation means additional complexity and therefore needs strong justification. Second, haircut differentiation should ensure ex-post risk equivalence and thereby make central banks indifferent about what type of collateral is used by banks (see, e.g., ECB 2015). Third, if still banks overuse certain assets, this is not a problem per se as the central bank is special and it may be efficient that it ends up on average with, e.g., less liquid collateral. Finally, if central banks end with an unwarranted degree of concentration to some collateral category, then it is easier and as effective to set limits (e.g., to the share of one collateral class in the collateral portfolio submitted by a bank). Central banks insisting on the need to segregate collateral sets will argue that pooling collateral will in any case lead to overuse of illiquid collateral and that this would be a form of market distortion.

The Fed traditionally had a very narrow set of eligible collateral for standard open market credit operations. It never had in normal times a second broader set of collateral for, e.g., longer-term credit operations. However, it had a broad collateral set for discount

window borrowing, and discount window borrowing was perceived as relatively close to emergency liquidity assistance (ELA). The Bank of England introduced post crisis (at least) three collateral sets for regular operations. The collateral set for end of day overnight credit and the one for longer-term credit operations were set as identical (but theoretically could be distinct), and are broader than the one for the conduct of shorter-term credit operations serving the control of the overnight rate. The ECB and the Bank of Japan have only one set of collateral for all monetary policy credit operations, i.e., for credit operations aiming at the control of the operational target, for end of day recourse to overnight credit, and for longer-term refinancing operations. Finally, all central banks have nonexplicit collateral sets for discretionary ELA operations. Actually, in an ELA credit operation the central bank could potentially accept any bank asset as collateral, if there is sufficient legal certainty regarding the pledge to the central bank. Normally, in ELA operations the central bank would take an active approach and select the assets it would like to receive as collateral, or just take all the unencumbered assets for this purpose.

It may appear remarkable that no central bank seems to have opted for a portfolio approach to risk control, i.e., an approach with haircuts depending also on overall collateral portfolio characteristics, so as to reflect portfolio diversification or concentration effects. IT progress could suggest this to be reconsidered. Of course the rules of the portfolio approach would need to be transparent, such as to provide the necessary predictability to banks.³

VI.ii. The Lender of Last Resort (LOLR) within the OF

Bagehot's 1873 analysis of the LOLR is still considered valid today and it is rarely questioned that the LOLR function is a part of central banking and beneficial to society, and that its optimal specification reflects trade-offs between financial stability, central bank risk taking, moral hazard, preventing costs of defaults and contagion, etc. An extensive modern model-based literature has taken up these topics and has provided some more conceptual clarification. As mentioned above, the LOLR function of the central bank may take three forms, namely the built-in LOLR content in the normal-times OF, the readiness of the central bank to enhance the LOLR content of the OF in

crisis times, and the readiness of the central bank to provide ELA to individual banks. Consider the three forms one by one.

LOLR Built Into the Normal-Times OF

There are at least seven determinants of the LOLR content of the OF. *First*, as mentioned earlier, collateral availability provides a first natural limit to central bank credit at the individual bank level. The size of the collateral set should be viewed in relation to the liquidity deficit of the banking system to be covered by central bank credit operations. For example, in the case of the Eurosystem, the nominal value of eligible securities is around 13 trillion euros, of which around 5 trillion euros is held by banks, against a 0.5 trillion euro liquidity deficit of the euro area banking system to be covered by credit operations. This implies that a representative bank could extend recourse to central bank credit approximately 10 times relative to proportionality before hitting collateral constraints. *Second*, the size of the liquidity deficit to be covered by credit operations determines the potential *relative* central bank intermediation. Relative central bank intermediation occurs when liquidity constrained banks crowd out less constrained banks from central bank credit without the latter yet ending in a liquidity surplus toward the central bank. The spread between the interest rates charged on central bank liquidity providing operations and the remuneration of excess reserves does not provide counterincentives against relative central bank intermediation. *Third*, the spread between the central bank lending rate and the rate at which excess reserves are remunerated determines the cost of *absolute* central bank intermediation as it kicks in once the strong banks are crowded out completely from central bank credit operations. *Fourth*, the central bank may impose in theory limits on banks' recourse to central bank credit (beyond the collateral limit mentioned as first point). For example the Reichsbank in June 1931 imposed a freeze on central bank credit for banks, which, if anything, contributed to the subsequent run on the German banking system. *Fifth*, the central bank may consider an overproportional borrowing framework (see subsection VI.iv), variable rate tenders, or segregated collateral sets to provide additional counterincentives against overreliance on the central bank.

Sixth, active stigmatization or de-stigmatization through central bank communication will impact on the propensity of banks to rely on the LOLR. *Seventh*, it matters who is able to benefit from direct LOLR. The perimeter of institutions directly benefitting from the LOLR elements in the normal OF depends on the counterparty framework of the central bank. Blanchard et al. (2014, 14) notes: “The crisis has forced central banks to extend ... their liquidity support to non-deposit-taking institutions and intervened directly (with purchases) or indirectly (through acceptance of the assets as collateral) in a broad range of asset markets. The question is whether these policies should be kept in tranquil times,” which Blanchard et al. seem to answer affirmatively. For example, access to central bank credit will be of interest for nonbank central clearing counterparties (CCPs). Granting such access may, however, raise issues of equal treatment of nonbanks to central bank credit (i.e., implying the need to define objective criteria), and makes more complex the counterparty framework.

Readiness of Central Bank to add LOLR Content to the OF in Crisis Times

The impact of the LOLR on bank behavior will not be limited to the LOLR content of the OF in normal times. What matters as well (for a bank that is not completely myopic) is the bank’s liquidity in a scenario of financial market stress. Anticipating this case also includes building expectations on the readiness of the central bank to add LOLR content to the OF in crisis times, e.g., through a temporary broadening of the collateral framework (as indeed almost all central banks did in 2007-08). Expectations will be determined by historical experience and forward-looking central bank communication, which banks may find credible or not.

Readiness of Central Bank to Provide Emergency Liquidity Assistance (ELA) to Individual Banks

ELA can be defined as a LOLR activity for the benefit of individual banks with a funding problem that is not rule based, at least not in the sense that it is governed by the OF. Of course, ELA also needs to take place within some legal framework and within the mandate of the central bank. Limitations to ELA provision can result from: 1) ELA

collateral requirements (normally ELA collateral sets should be wider than standard credit operations' collateral set). 2) Pricing of ELA, i.e., what surcharge relative to monetary policy credit operations is imposed. 3) Limitations on the duration to provide ELA. 4) Limits on the total share of a bank's balance sheet that may be financed temporarily through ELA. 5) Possible requirement that ELA is only granted if the central bank is protected in addition by a government guarantee. Beyond additional risk protection, this may be considered useful as it requires an elected government to confirm its backing of ELA operations (but it should not delay very urgent and obvious ELA provision by the central bank). 6) ELA counterparty set: As by definition ELA is ex ante not subject to clear rules and constraints, also the question arises to what extent nonbanks may benefit from it. Those could be nonbanks that have access to central bank facilities in a rule-based manner (see above), but also entities that, according to the regular framework, do not have any central bank access. While by construction it seems wrong to ex ante define the perimeter of expansion of the ELA counterparty set, it seems useful for central banks to think through the conceptual, procedural and legal issues that would arise if during a crisis such ELA would be considered.

How Much Overall LOLR Should a Central Bank Provide?

Assume now for a moment that the relative contribution of the three LOLR forms is not the issue, as one would simply assume that the optimal mix is chosen, including on all the underlying details. Still one could ask what the total LOLR provision by the central bank should be. It is useful to think first about two extreme LOLR choices of the central bank. 1) *Maximum LOLR*: accept in the normal-times OF all assets of banks as collateral at fair values. This would allow solvent banks to finance all their assets with the central bank, if desired, and no solvent counterparty could ever default for liquidity reasons. Furthermore, the width of the standing facilities corridor is set to zero and there are no surcharges for over-proportional borrowing. The other two forms of LOLR (expanding the LOLR content of the OF in crisis times and ELA) would not really be needed as all these could add is already covered in the normal OF. This approach would maximize the ability of banks to provide maturity and liquidity

services to society and, in this sense, might be argued to be welfare maximizing. 2) *Minimum LOLR*: the central bank implements monetary policy only against risk free assets, which may either be defined as central government paper, or as highly liquid AAA-rated paper. It largely covers its asset side through outright holdings of the risk free asset. The central bank may conduct at the margin some repos against risk-free assets, but in a bilateral way in which it chooses its counterparties and always goes for the most secure ones. In this OF, banks have no discretionary access to the central bank at all to close possible funding gaps, i.e., the OF has zero LOLR content. Moreover, the central bank would fully pre-commit to never change the LOLR content of its OF nor to ever provide ELA. Proponents of such an approach may argue that a supportive LOLR will lead to as many financial crisis as a very tight one, but crisis will be more messy because when they occur the financial leverage will be much higher (“four wheel vehicles make you get stuck in areas which are more difficult to access when you need to be rescued”).

The large majority of central bankers believe that the optimal LOLR is in between these two extremes (and regulation will have to play an additional role to achieve an overall optimum for society). The LOLR strengthens the ability of the financial system to provide maturity and liquidity transformation as services to society. At the same time, putting some limits to the LOLR role is beneficial for society, to have some protection against information asymmetries and moral hazard, to avoid relying excessively on the abilities of supervisors and auditors, and generally to preserve stronger incentives to maintain funding market access and thereby market discipline.

Assume for a moment that we capture in a unit interval $[0,1]$ the supportiveness of the LOLR framework of a central bank and let the most restrictive framework described above be represented by 0 and the most forthcoming framework by 1 (again, it is of course a simplification to assume that designing the LOLR is a one-dimensional problem). One can imagine mapping the LOLR unit interval into at least five effects of interest which should not be expected to be identical, although often this seems to be implicitly assumed:

1. Social welfare is the ultimate measure of interest and can be equated, e.g., with the extent to which the LOLR framework contributes to financial conditions leading to maximum economic growth in the medium to long term, i.e., through the financial and economic cycle. For example Keister (2015) maps the LOLR supportiveness into social welfare, and Bindseil and Jablecki (2013) map it into growth. The latter show that while different shapes of the relationship between LOLR intensity and growth are possible, it is likely that the relationship is a concave function with interior maximum (i.e., an intermediate LOLR approach maximizes growth).
2. Central bank risk taking is normally expected to increase monotonously in the $[0,1]$ LOLR unit interval, whereby it will typically lift off from very close to zero only beyond a certain threshold. Bindseil and Jablecki (2013) also provide an example in which the relationship is a convex function with interior minimum, illustrating Bagehot's intuition that sometimes "only the brave plan is the safe plan" for the central bank, i.e., more forthcoming lending in a crisis reduces central bank risk taking relative to a restrictive approach.
3. Leverage of banks and their ability to provide liquidity and maturity transformation should increase monotonously across the LOLR unit interval. Obviously, regulation may limit leverage to lower levels.
4. Financial fragility will probably first decrease, and then increase across the LOLR unit interval, suggesting that a measured LOLR can stabilize the financial system while a too liberal one could eventually lead to particularly deep financial crises.
5. Market discipline and funding market functioning can be thought of as either falling monotonously, or as mirroring the financial fragility curve, i.e., it would benefit from some moderate LOLR, but is undermined if the LOLR is excessive. Bindseil (2013) shows that when asset liquidity deteriorates after some exogenous shock, then a supportive LOLR can preserve funding market access for solvent banks, but not for insolvent

banks, while a restrictive LOLR will imply a run also on solvent banks, implying that a more supportive LOLR can be conducive to a more effective market mechanism than a very restrictive one.

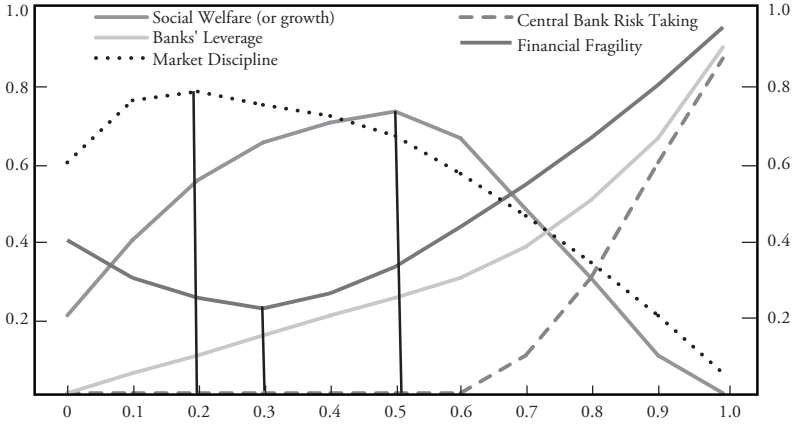
The exact shapes of all five curves will depend on the financial environment. Chart 7 provides an example of how the five curves may look (the shapes that could be considered most likely under conditions of developed financial markets). In this example, the x-value of the highest effectiveness of market discipline is strictly positive, but below the x-value of the minimum financial fragility, which itself is below the point of maximum social welfare (or maximum long-term growth).

What should be the Relative Contributions of the Three Forms of LOLR?

Assume that a certain optimal total LOLR provision has been chosen—what relative role should the three forms of LOLR play? Central bankers' consensus is that all three forms should play a role. Today, relative to the pre-2007 consensus, preference has moved somewhat toward more importance of clear rules *ex ante* (and certainly more importance is assigned to the complementary role of regulation).

What distinguishes the last two forms of LOLR from the first is the uncertainty attached to them, which in the past has sometimes been considered as advantageous “constructive ambiguity,” preventing that banks factor in such support *ex ante*. Indeed, many models come to the conclusion that ideally the LOLR appears harsh *ex ante* but is soft *ex post* (e.g., Acharya, V.V. and S. Wiswanathan 2011; or Keister 2016). The concept of constructive ambiguity may however suffer from the following three problems: First, ambiguity does not prevent banks from building expectations. Therefore, constructive ambiguity is not a universal solution to solve the tension between the *ex-ante* preference of central banks to not have banks rely excessively on the LOLR and the merits of a liberal LOLR *ex post*. Constructive ambiguity may instead only create additional randomness, but not be able to bias expectations systematically. Second, central banks are anyway bound to consistency in their ELA provision as a consequence of the requirement that the official sector needs to act in

Chart 7
Possible Relationships between LOLR Content of the OF
and Five Impacted Variables*



*Social welfare, central bank risk taking, leverage, financial fragility and market discipline.

accordance with equal treatment principles. Therefore, full discretion is anyway not possible, at least not in ELA. Third, one could argue that designing a rule based framework forces the central bank to really think through the problems that it wants to solve and how it wants to do so, while in contrast, emphasizing constructive ambiguity allows central banks to avoid such efforts.

Nevertheless, it would seem from a practical perspective wrong and overambitious to aim at a full ex-ante set of contingent rules on future liquidity provision in crisis situations, and to pre-commit against ex-post flexibility. While the mechanics of financial crisis have some common patterns, the details of each crisis tend to be different, and every stress situation in financial markets has idiosyncratic elements that cannot be anticipated. Ex post, it can be assessed to what extent LOLR of form 2 or 3 adds to central bank risk taking, whether it validates in some sense past moral hazard of banks, and to what extent overall it appears to be in the interest of society. If the financial stress originates from factors that neither banks, nor the central bank, nor banking supervisors could have anticipated, then one may come to the conclusion that there is less of a moral hazard issue, and it will be unlikely that the pre-crisis OF is necessarily adequate in terms of LOLR with regard to the nonanticipated crisis situation. Risk

endogeneity may also imply that additional ex-post LOLR may decrease, and not increase financial risks to the taxpayer. Such flexibility does not imply per se a too dovish approach, as still the central bank may set the hurdle for ex-post LOLR measures high, and communicate this to the financial system. Also, such flexibility does not preclude that the central bank aims at increasing the relative importance of rule based elements at the detriment of discretionary elements. Indeed, for the above mentioned reasons, a rule-based approach to LOLR incorporated into the OF has significant advantages, and it should be viewed as a permanent objective of central banks to learn from past crisis and to reflect on how a rule-based approach to LOLR may contribute to prevent future crisis.

The choice between forms 2 and 3 of LOLR, i.e., between an ex-post strengthening of LOLR elements in the OF versus ELA will be mainly determined by the scope of liquidity problem within the banking system. While in principle a rule-based approach benefitting everyone equally seems preferable, it can also be inefficient if the liquidity problem is limited to one or few banks. Moreover, the provision of ELA can be associated with specific conditions toward the benefitting bank, which may be considered important to address moral hazard. Therefore, both forms of ex-post LOLR should remain part of an overall approach.

The devil lies in the detail, and beyond these general questions on the overall LOLR provision and the contribution of the three different forms of LOLR, a multitude of more specific issues emerges in the LOLR field. Consider below a number of such issues.

Bagehot's 'Only the Brave Plan Is the Safe Plan' and Risk Endogeneity

Ever since Bagehot, it is acknowledged that the central bank cannot make its LOLR choices as if it was an atomistic investor not influencing the properties (e.g., default probabilities) of the system. Often, being more forthcoming as a LOLR after a negative financial stability shock (e.g., broaden the eligible collateral set to include less liquid assets) will decrease financial risk taking by the central bank, instead of increasing it. Risk endogeneity should lead to a more forthcoming LOLR, i.e., the welfare-maximizing LOLR framework will be more supportive than the one obtained if risk endogeneity is ignored.

LOLR and Monetary Policy

The LOLR becomes an important nonstandard monetary policy measure at the latest when the central bank has hit the zero lower bound. Indeed, the readiness of the central bank to act as LOLR affects intermediation spreads of banks, in particular in a liquidity crisis, and therefore, for a given level of the short-term, risk-free interest rate, the average funding costs of the real economy (e.g., Bindseil 2013).

LOLR Justifications if the ZLB Is not yet Binding

From a monetary policy centric perspective, one could ask whether the LOLR is at all needed when the central bank policy interest rate is not at the ZLB. In equilibrium, the ability of the banking system to provide liquidity and maturity transformation to society would be lower, but the effect on financial conditions could be compensated by the central bank setting lower monetary policy interest rates. Two counterarguments against this view can be formulated: first, the lower average central bank interest rate leads, everything else equal, to lower central bank income, which may be regarded as a measure of the social costs of such a policy (as central bank profits are eventually shared via the government with society). Second, the LOLR plays a role in the optimization toward the trade-off between zombification on one side, and the costs of default of viable companies on the other side, such as outlined in Bindseil and Jablecki (2013). In this sense, a too restrictive LOLR would lead to a lower economic growth rate as regularly too many resources get lost in liquidity induced defaults—and this holds independently of the appropriateness of monetary conditions from the perspective of price stability.

Is It Useful that the LOLR adds Monetary Accommodation in Normal Times such as to Allow a Higher Average Level of Short-Term, Risk-Free Interest Rates?

The relationship between the LOLR and interest rate policy in crisis times is discussed, for example, by Freixas et al. (2009). Should OFs aim at a sufficient LOLR content in normal times from the perspective of lifting the operational target interest rate further away from the ZLB, even if the ZLB is not an acute constraint (in analogy to a similar question raised in subsection V.ii on the central bank's

outright portfolio)? The LOLR function has an impact on the ability of banks to provide liquidity and maturity transformation, i.e., on bank intermediation spreads. Assume that L_1 and L_2 are two alternative intensities of the LOLR function within an OF, with L_1 having higher intensity than L_2 (i.e. L_1 facilitates more liquidity and maturity transformation by banks), and assume that (L_1, i_1^*) is considered to provide for an adequate stance of monetary policy (i.e., for adequate monetary conditions). Then, alternatively, there exists another level of the operational target rate, i_2^* , with $i_2^* < i_1^*$, which should allow to reach an identical, adequate stance of monetary policy by being combined with L_2 : (i_2^*, L_2) . Is there any point in preferring one combination to the other? Assume for a second that from a financial stability and central bank risk management perspective, L_1 and L_2 are identical. Then, one might argue—outside monetary policy considerations—in favor of L_1 as the higher average income it generates for the central bank and therefore eventually for the taxpayer is a measure of a social welfare contribution that the LOLR can provide to society (of course these results need to hold through the financial cycle). Beyond such monetary income arguments (which, again, actually capture a part of the LOLR contribution to social welfare), it seems difficult to identify arguments to use the LOLR content of the OF as a tool for structurally influencing, or for steering through time the stance of monetary policy.

Moral Hazard and Central Bank Losses

A popular theme in papers on the LOLR is moral hazard, but the concept often remains vague. One pragmatic view is that moral hazard only materializes in the context of the LOLR if the central bank faces actual losses from its credit operations. This interpretation also has the advantage that it would reduce the complexity of the LOLR design problem by one dimension and map something vague and complex (moral hazard) into something concrete and more measurable (central bank risk taking—even if somewhat complicated by endogeneity). If central banks are worried about moral hazard, they could tighten risk control measures (in normal times, to not be procyclical) so that the probability of central bank credit losses declines even further.

Excessive Stigmatization of the LOLR?

Sometimes central banks worry that banks attach excessive stigma to taking recourse to different forms of LOLR. For example, recourse to the Discount Window is considered to remain stigmatized in the United States although the Fed would want to change this since 2002. Also, in a number of credit open market operations of central banks during the financial crisis, aversion of banks to participate materialized such that the accommodation that the operations aimed at could not be fully achieved. Excessive stigmatization seems to go in the opposite direction of moral hazard. Central banks should therefore have tools in hand to adjust *in both directions* the willingness of banks to come to LOLR operations. Stigmatization through communication is difficult to control and to revert. Therefore, central banks should avoid the verbal stigmatization of LOLR operations and instead rely on monetary disincentives through, e.g., a framework such as the one described in the next subsection.

LOLR and Liquidity Regulation

Some have argued that the only solution to the central banker's angst from on one side being exploited by banks (moral hazard), and on the other side of excessive stigmatization of LOLR operations (preventing banks to use them), would be a liberal LOLR combined with tight liquidity regulation. A good combination of appropriate incentives to take recourse to the LOLR and well-designed regulation likely allows achieving the best outcome for society. As already noted in Section III, managing liquidity risk is a core activity of banking, and it seems unlikely that "centralizing" this subtle activity through liquidity regulation can be done without efficiency costs. Therefore liquidity regulation must not be overburdened, and central banks providing some well-designed and rule-based economic counterincentives to what they deem an excessive reliance on the LOLR is an important contribution to reduce the burden put on regulation. In fact, the combination of regulation (in all its details) and the LOLR (in all its details as well) will jointly determine 1) the ability of banks to provide liquidity and maturity transformation as services to society; 2) financial stability; 3) central bank risk taking and banks' possible moral hazard. A lot of work is ahead to better understand these

relationships and what conclusions to draw on the joint design of the LOLR and liquidity regulation.

VI.iv. Overproportional Borrowing Framework

Integrating a so-called “overproportional borrower framework” (OPBF) into the OF could be a worthwhile addition to provide for a strong and independent tool to control for perceived over-reliance of individual banks on central bank credit and the LOLR. Moreover, such an approach could be instrumental to assign a greater share of the LOLR to the OF, instead of to uncertain ex-post decisions. Possible reasons to dislike overreliance of single banks on central bank credit are multiple, and in particular: 1) Central bank financial risk taking from concentrated exposures to weaker banks, 2) contribution to zombification and weakening of market mechanism, 3) weakening of monetary policy transmission as a too high share of central bank credit may get absorbed by banks without much market interconnectedness. OPBFs have been applied in the past, as illustrated by the following three examples. First, the IMF foresees surcharges for large and long borrowing relative to a country’s quota. Second, e.g., Goldenweiser (1949) mentions that in 1919 some Federal Reserve Banks “adopted systems of rates graduated in proportion to the amount borrowed by an individual bank.” Third, the Bundesbank for decades applied a proportionality-based limit system (“Rediskontkontingente”) for the recourse of banks to a favorably priced credit facility. The logic of an OPBF can best be introduced through a simple system of financial accounts (Figure 2). Assume a financial system with two banks which may be different in size but also in terms of relative share of market (including deposits) versus central bank funding.

Let $L = L_1 + L_2$ be the total length of the banking system balance sheet. Let $P^* = B/L$ define “proportional” recourse to the central bank. Let $P_i = B_i/L_i$ be the actual value of the proportionality measure of bank i . Let $P\#$ be the threshold for P_i beyond which the central bank applies an extra fee. The central bank should provide some cost free leeway to borrow overproportionally, i.e., $P\# > P^*$. For P_i beyond $P\#$, surcharges would kick in. The surcharge function beyond $P\#$ could be any nondeclining positive function of overproportionality.

Figure 2
Financial Accounts to Illustrate Mechanics of OPBF

Bank 1			
Lending to corporates	$L_1 = D_1 + B_1$	Household deposits	D_1
		Credit from CB	B_1
Bank 2			
Lending to corporates	$L_2 = D_2 + B_2$	Household deposits	D_2
		Credit from CB	B_2
Central Bank			
Credit operations	$B = B_1 + B_2$	Banknotes	B

Consider the following example: $L_1 = L_2 = 100$ (total lending by banks to economy: 200); $D_1 = 95$; $D_2 = 85$ (total deposits = 180); $B_1 = 5$; $B_2 = 15$ (total bank notes $B=20$); Proportional borrowing $P^*=10$ percent of bank balance sheets; $P_1 = 5$ percent; $P_2 = 15\%$. Without an OPBF there would be in this example no financial incentives for the banks to equalize their central bank recourse, as *the corridor width does not help against "relative" central bank intermediation*. Assume however now that $P\# = 12$ percent and that beyond that an extra interest rate of 1 percent is charged. Now, the banking system has incentives to rebalance recourse to central bank credit. For example Bank 1 can give an interbank loan of 3 to bank 2. Alternatively, bank 2 could become more aggressive in attracting deposits, for example by increasing its branch network, or by paying higher interest rates on deposits. It would need to attract a total of 3 of extra deposits (which would be withdrawn by depositors from bank 1). A reduction of the recourse by bank 2 to central bank credit by 3 (and a corresponding increase by bank 1) would bring both banks to below the proportionality threshold set by the central bank.

The surcharge formula may be specified in relation to the *average* recourse to central bank credit over a certain period. That would reflect the intuition that short-term peaks in central bank reliance are less of a problem than permanent large-scale reliance.

Advantages of an OPBF

As mentioned above, central banks have good reasons to dislike concentration of their credit operations to few banks. Key

advantages of an OPBF relative to other tools to limit over-proportionality are the following ones. First, an OPBF is by definition focused on the problem itself, and adjusting it has less side effects (e.g., like in case one would adjust the collateral framework for the sake of reducing the leeway for overproportionality). Second, an OPBF is unconstrained in specifying a surcharge formula, including averaging over a chosen period. Surcharges can be billed conveniently to banks after any possible averaging period. Finally, an OPBF draws attention of banks and other stakeholders to the proportionality issue, and allows policy makers to reflect their views on this subject through a well-defined framework (essentially the surcharge function). The relative effectiveness of an OPBF as a tool to limit excessive reliance of single banks on central bank credit can further be illustrated by reviewing the weaknesses of *alternative instruments* in pursuing this objective.

Moral suasion/stigmatization: as already argued in subsection VI.iii, this is by definition an imprecise tool and is difficult to control and to adjust when needed.

Variable rate tenders are also a crude tool to control for overproportional borrowing. It may be partially effective, but it works via the creation of allotment uncertainty. It does not appear particularly efficient to use uncertainty to provide incentives.

The width of the standing facilities corridor is not an effective tool against *relative* central bank intermediation (i.e., the crowding out of other banks from central bank credit). Assume a banking system with 10 banks of equal size, and that initially each bank has 10 percent of the total central bank credit volume. If the funding dislocation is limited to one bank, then this bank can extend its central bank credit by a factor of 10 before the width of the corridor starts to matter. Clearly, an OPBF is a more effective tool to prevent overproportionality as it can kick in at any time earlier than that, as wished. Returning to the example, if the funding dislocation is more systemwide, and say five of the 10 banks suffer from liquidity outflows and the other five from inflows, then the corridor width will kick in earlier as an effective additional incentive. However, in this case typically central banks will prefer to be forthcoming and to reduce

stigmatization, and therefore may consider tightening the width of the standing facilities corridor.

Constructive ambiguity on ELA (in conjunction with a limited regular collateral set) may also be viewed as a technique to limit overreliance on central bank credit. Its drawbacks have been discussed above.

Possible Drawbacks and Challenges of an OPBF

A number of possible drawbacks and challenges may have deterred central banks from a more systematic reliance on OPBFs.

First, an OPBF constitutes an additional framework that needs to be maintained, and in this sense adds complexity. Additional complexity can be reduced if the central bank can rely on existing proportionality measures, such as a reserve base defined for a (previously existing) reserve requirement framework.

Second, central banks may consider that banks under liquidity stress tend to be potentially also subject to a weaker solvency situation. Therefore imposing high surcharges on them could seem counterproductive in terms of bringing them back to markets. However, surcharges should not rapidly make such a difference for the overall solvency situation of a bank. Also, if solvency is the issue, then solvency-related mechanisms should address it. Moreover, a surcharge system that is put in place in advance creates the necessary certainty allowing banks to factor it in in their liquidity risk management and pricing of liquidity risk. Therefore, consequences on profitability and solvency of overreliance on central bank credit should not come as a surprise to banks.

Third, central banks may actually find that stigma issues unduly deter banks from taking recourse to central bank credit, and they may feel that adding surcharges would make counterincentives even more excessive, through direct effects and through indirect effects via even more stigmatization. However, if this would be universally true, than the entire moral hazard debate relating to excessive recourse to the central bank during the financial crisis should not exist.

Fourth, an OPBF needs to find a solution for the case that some banks have no intention to come themselves to the central bank to

ask for central bank credit because, e.g., they do not have a full treasury desk with sufficient operational abilities. This may be the case for small savings and mutual banks which rely on a specialized bank hub to access central bank credit. Or, banking groups may have chosen one entity within the group to access the central bank for the sake of an efficient, centralized treasury. This issue can be addressed within an OPBF by allowing banks who indeed have a specific group structure to pool their surcharge-free central bank credit allowance. The entities who do not want to come to the central bank would need to declare their readiness to share their allowance with the related entity accessing central bank credit on their behalf. This has been practiced for example recently in the case of the Eurosystem's TLTROs, and has proved to be manageable (see ECB press release, July 3, 2014, annex, section 1). In addition, the difference between strict proportionality P^* and the threshold $P^\#$ at which surcharges kick in also helps.

Conclusions

Overall, an OPBF appears as potentially attractive tool to address overreliance of banks on central bank credit—an issue that got great attention during and after the crisis. An OPBF allows assigning the prevention of overproportionality to a focused and effective tool. Of course, a sort of OPBF could also be applied by the banking supervisor, i.e., the banking supervisor would start to ask questions or apply supervisory measures when central bank reliance exceeds $P^\#$. This raises again the question on the optimal overall combination of incentive setting by the OF and by banking regulation and supervision such as to achieve financial stability and an adequate extent of maturity and liquidity transformation by banks. Putting all the burden on regulation and supervision likely has efficiency costs in view of the decentralized nature of information in the economy.

VII. Conclusions: Designing and Evaluating Operational Frameworks

This paper aimed at reviewing the real-world design and evaluation of OFs. Its conclusions can be summarized as follows.

1. There is a set of *universal objectives* of OF design valid across environments. OFs should be effective, lean, automated; they should support financial stability, financial market functioning and financial efficiency; the OF should be in some sense neutral with regard to relative financial prices; the OF should be honest, and ideally universal, i.e., portable to different environments and across time.
2. The search for universal objectives of OF design still encounters some limits because of *divergent philosophical* views on a number of issues. In particular: 1) should central banks be seen primarily as part of the official sector or is their detachment from the government key and needs reflection in the avoidance of exposures to financial instruments issued by the government?; 2) should the central bank express in its collateral and asset allocation decision its idiosyncrasies or should it aim at behaving like an average investor? In addition, views on OF design (as maybe more generally views on monetary policy) will always depend on feelings toward ambitiousness, activism and acceptance of complexity. One type of central bankers and academics will tend to stress the limits of central banks' ability to design and operate complex and ambitious OFs and monetary policies, referring also to the general failures of the sophisticated approaches of the 1960s and 1970s. The other type will reject such scepticism as fatalism and will argue in favor of being ambitious and optimist on the human ability to design a more complex framework serving society.
3. *The universality of optimal OF design* finds some limits—even under the assumption of universal objectives—in the heterogeneity of environments under which the OFs have to operate. This does not put into question the observation that past heterogeneity of OFs among advanced large currency areas was mostly due to history and due to different views and doctrines, i.e., the explanations that heterogeneity across these currency areas (or across time) were necessary reflections of differences (or changes) in the environment tend to be unconvincing.

4. The key *operational target* of monetary policy should remain a short-term money market rate, without excluding that this could be some composite rate or a secured rate, or a rate encompassing the money market beyond the pure interbank market.
5. The best approach to steer in normal times the operational target still seems to be the symmetric *corridor approach*, even if money markets would be somewhat less efficient in the future due to financial regulation;
6. OFs should only rely on *automated tender procedures* for open market credit operations, i.e., tender procedures in which after the announcement of the conditions, the mapping from bids to tender results is automatic.
7. If the *demand for excess reserves remains unpredictable* in the new regulatory environment, fixed-rate, full-allotment operations may be the preferable automated tender procedure relative to variable-rate, fixed volume. The latter is however the appropriate tender procedures for credit operations maturing beyond the next meeting of the policy decision making body.
8. Doubts can be raised on the *efficiency of reserve requirements* with averaging because of their complexity and memory within the maintenance period. Other similarly effective tools appear simpler.
9. The control of the overnight interest rate can be improved by
1) narrowing the interest rate corridor set by standing facilities;
2) introducing (and increasing the quota of) a TARALAC facility;
3) increasing the frequency of open market operations;
4) conducting open market operations later in the day;
5) better autonomous factor forecasting. Preserving money market activity should be a key consideration in choosing among these tools.
10. Central banks should invest into autonomous factor forecasting to improve the control of the overnight rate for a given level of money market turnover. Actually if good autonomous factor forecasting and timing of open market operations

within the day ensures that banks perceive at the time they trade in interbank markets that liquidity conditions are balanced, then a full effectiveness of interest rate control can be achieved without harming money market turnover. This explains the remarkable overnight interest rate stability that a number of central banks could reach pre-2007 without reserve requirements and averaging.

11. A *TARALAC facility* system appears as potentially attractive tool, but superiority in terms of achieving better combinations of money market activity and overnight rate stability still has to be better established.
12. A lean CB balance sheet remains desirable, i.e., the length of the balance sheet of the central bank should be oriented to not exceed substantially the sum of the monetary base and the central bank's capital and reserves, unless policy needs provide very convincing arguments to do so.
13. There are several good justifications for central banks having in normal times an outright portfolio of securities with some duration and diversification across issuers, even if, as indicated in the previous point, the size of this portfolio should normally not lengthen the central bank balance sheet and leave enough breathing space for open market credit operations to steer money market conditions.
14. Collateral frameworks should avoid pro-cyclicality, i.e., they should be conservative in normal times, so that they can remain stable in stressed times when risk parameters (volatility, valuation uncertainty, etc.) deteriorate. Collateral frameworks should protect the central bank at a very high confidence level. This however does not imply that the central bank should only accept the most liquid assets, as the central bank can impose haircuts (accepted by its counterparties in view of the credit risk free nature of the central bank) and take whatever time is optimal for asset liquidation. It remains open whether it is worth adding the complexity of separated collateral pools,

which allow differentiation of central bank credit across collateral sets (e.g., in terms of price and/or duration).

15. The LOLR function of the central bank plays a role both in an ex-ante and an ex-post sense. Ex ante, the LOLR contributes to the ability of the financial system to provide maturity and liquidity transformation services to society; ex post, i.e., when asset and market funding liquidity deteriorated due to some exogenous shock, it can prevent economic damage that results from defaults and forced asset liquidation. From the perspective of OF design, it is important to note that the ex-ante effects of the LOLR will be based on three components: the OF's built-in elasticity of individual banks' recourse to the central bank to central bank credit; perceptions of banks regarding the propensity of the central bank to adjust the OF in a systemic crisis to strengthen its LOLR content (e.g., broaden the collateral set); perceptions of banks regarding the propensity of the central bank to provide emergency liquidity assistance (ELA) to single banks. The first two elements are at least as important as the last one, and therefore the LOLR should be considered a key dimension of OF design. As banks may also have a tendency to overleverage and to engage in excessive liquidity and maturity transformation (and actually this was the main interpretation of the 2007-08 liquidity crisis), the OF related elements of the LOLR should build in incentives that contribute to guide banks to the appropriate amount of liquidity risk taking. This should in any case include counterincentives against regular disproportional ex-ante reliance on the central bank. Obviously, also regulation should play a role, and in an ideal world the LOLR aspects of the OF and liquidity regulation would be designed in some consistent way.
16. If one simplifies the LOLR specification problem for a moment in a way that it would consist in choosing one-dimensionally the right LOLR intensity in an OF, and capture the choice between two extreme frameworks (with minimum and maximum LOLR content) in a unit interval $[0,1]$, then the

welfare maximizing LOLR intensity is likely to be an interior point, i.e., none of the extreme frameworks is optimal.

17. Better understanding the LOLR should allow strengthening its rule-based elements, which means building it to a larger extent into the OF, and reducing the contribution of the unpredictable additional LOLR elements. The constructiveness of ambiguity always had its limits, and even more in today's world of high demand toward the transparency of official sector decision making, the need for equal treatment across cases (also to prevent legal action against the central bank).
18. An overproportional borrowing framework (OPBF) is one focused way to control overreliance on the LOLR and prevent concentration in exposures from central bank credit operations in a focused and rule-based way.
19. In normal times, the stance of monetary policy should be steered through short-term interest rates, and not by variation of other central bank instruments that determine overall monetary conditions and financing costs of the real economy, such as the LOLR content of the OF, or the credit, liquidity and duration risk that the central bank holds in the form of outright portfolios.
20. Arguments from a monetary policy perspective for a structural level shift of the short-term interest rate through a constant dose of accommodation injected by these two other instruments are not obvious.
21. The ex-post assessment (individually, or in comparative terms for several central banks) of actual OFs can be supported by score cards, as outlined in Appendix A. At least, these score cards can direct quickly to the relevant questions for evaluating existing OFs and identifying opportunities for improvement.

Beyond these 21 conclusions, still within the search for universal qualities of OFs, one may also look for a radically more parsimonious overall OF design. Ideally, in a radically lean OF, each instrument would pursue clearly one objective and would not strongly interfere

with other instruments and objectives. Figure 3 tries to capture the current usual mapping of instruments to objectives (whereby only a subset of tools and objectives is covered).

In such an OF, the relations between instruments and objectives are not bijective in most cases: *Reserve requirements* in advanced economies now are one among several tools to ensure an effective control of overnight rates, while preserving some money market activity. The conduct of *credit operations through variable rate tenders* aims both at achieving the operational target short term interest rate, and be an incentive mechanism that invites banks to be competitive and not to overrely on the central bank. Also *standing facilities* face the multiple objectives of steering interest rates, while preserving incentives for trading first in markets. *Collateral policies* are not only considered a tool for financial risk protection of the central bank, but also as one to limit the ability of banks to rely overproportionally on central bank credit. A radically cleaned-up mapping of instruments to objective could be the following one in Figure 4.

Interest rate control would be achieved effectively by a zero width standing facilities corridor. Incentives to not rely disproportionately on the central bank would be based on an overproportional borrower framework which could also encompass penalties for banks who deposit too large amounts of excess reserves at the central bank. Collateral would aim only at central bank risk protection and sufficiency. The properties of such a bijective framework would need to be studied further. For the time being, the idea can serve as a benchmark for a more gradual streamlining of OFs.

Despite progress in our understanding of OFs, also some trial and error will probably remain necessary to find out what OF will work best for the central banks of large monetary areas after the eventual lift off from the zero lower bound and the normalization of balance sheets, i.e., in a few years from now. OF design will hopefully be approached even more consciously by central banks than in the past, reflecting well the importance of the OF in determining the starting point of monetary transmission and in shaping the financial system.

Figure 3
Traditional Mapping of Instruments into OF Objectives

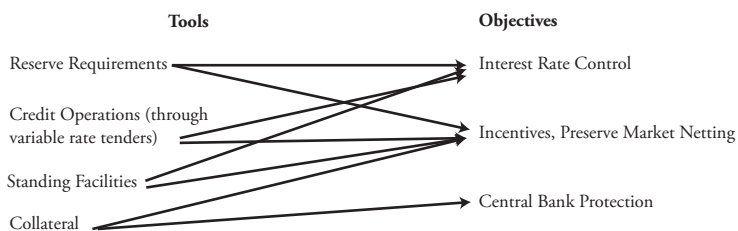
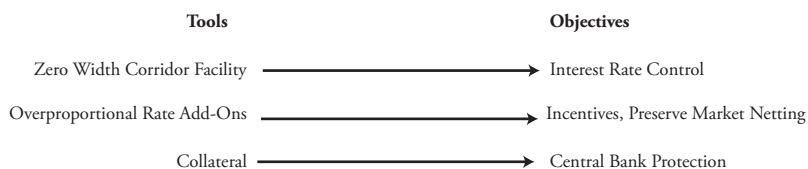


Figure 4
Reorganized Mapping of Instruments into OF Objectives



Author's note: Opinions expressed are those of the author and not necessarily those of the ECB. I wish to thank Jean-Pierre Danthine, Arturo Diez-Caballero, Troy Davig, John Groom, Paul Chilcott, Tobias Linzert, Antoine Martin, Arne Kloster, Yves Mersch, Ed Nelson, Simon Potter, Benjamin Sahel, Ylva Sovik, Miklos Vari and Olivier Vergote for helpful discussions and/or comments. All remaining errors are mine.

Appendix A

Score Cards

In this appendix, the conclusions from Sections IV, V and VI are translated into “score cards” which are constructed to be used for stand alone, or comparative assessments of existing OFs. This is an attempt to translate the conclusions drawn in these sections into something applicable in practice. The score cards consist of lists of statements, which, if fully affirmed, give a high score, and if fully rejected, a low one. The score cards actually contain four different types of statements:

Statements on a quantitative success measure. The measures could in principle be mapped in a predetermined way into a score. For example it could be predetermined that the statement “The control of the overnight interest rate is precise” gets a score of “5” if the daily volatility is below 3 basis points, of “4” if it is between 4 and 5 basis points, etc.

Qualitative statements on the efficiency and effectiveness of the OF design such as “Monetary policy implementation is automated in between monetary policy committee meetings.” One could develop guidance on how to decide on the scores for such statements.

Statements about whether the central bank has pursued well defined objectives and has applied sound analysis in designing and parametrizing its OF. For example, is it true that “The lender of last resort function built into the OF has been designed in a way to contribute to financial stability while preventing moral hazard and the design was based on state of the art analysis.” Answering this question could be either done on the basis of a review of publications of the central bank, or also on the basis of internal documentation, depending on access.

Statements on the soundness of the practical implementation of a framework, covering issues such as the quality of documentation, transparency, IT systems, understanding of decision makers, existence of contingency plans, operational risks, etc. Examples of such statements are: “The economic logic of the monetary policy

implementation framework is truthfully communicated and well understood by markets and the public”; “Internal processes relating to collateral assessment are well documented”; “IT systems are resilient and contingency procedures are in place”; “The central bank is well prepared in terms of resources and IT systems to launch nonstandard measures when needed.” These questions are actually rather general and independent of the specification of the OF, and therefore are kept at a minimum in the score cards.

The total number of score card questions was kept limited but can easily be expanded. Also, to not overdo it, no annotative guidance was added on how to map answers into scores. When completing a score card for a central bank, every score should ideally be explained, to give full content to such an exercise.

Score Card 1: Control of Operational Target (overnight rate) and Conduct of Tenders (Section IV)	Score (1-5)
1. The volatility of overnight interest rates (ONR) is low	
2. The volatility of ONRs (in the intermeeting period) is not transmitted along the yield curve	
3. Forward ONRs in the period until the next meeting of the policy decision-making body are very close to the level of the interest rate target	
4. In case of a symmetric corridor approach, recourse to standing facilities is usually one-sided ex post, but ex-ante symmetric.	
5. Stabilization of ONRs relies on instruments that are simple, transparent and automated	
6. Monetary policy implementation is normally automatic in between meetings of decision-making bodies	
7. ONR control is achieved without significant impairment of money market activity	
8. The approach to the choice, and the technique of control of the operational target is documented and explained to the public in a honest manner	
9. Neither tender announcements nor allotment decisions are used to signal the stance of monetary policy (reflecting the separation principle)	
10. When calibrating their bids in tender operations, banks do not need to think about bidding behavior of other banks	
11. After the tender announcement, the central bank does not need to take any further decision (except as formality), and bidding behavior is mapped automatically into allotment	
12. IT infrastructure and processes for tender procedures are efficient and reliable	
13. Credit operations with maturity beyond the next meeting of the policy decision-making body are conducted as variable rate tender with pre-announced volume	
14. Tender rates and relevant market rates are closely linked ex ante	
15. The announcement of tender results has normally no impact on short term market rates	
16. The number of outstanding tenders at any point in time is parsimonious	
17. The sharing of the total liquidity deficit amongst outstanding credit operations is well determined and controllable	
18. The counterparty set is broad enough to ensure 1) competitive intermediation between the central bank and the rest of the financial system and 2) that bids in variable rate tenders (if applicable) are not overly noisy.	
19. The counterparty set is not too broad in the sense of undermining the role of universal banks (with broad access to key financial markets including the money market and to borrowers) in managing and netting funding needs vis-à-vis the central bank.	
20. The central bank does not provide absolute intermediation of the banking system in normal times	
21. Access of nonbanks to depositing with the central bank does not create risks of bank disintermediation in case of a general negative perception of the banking system.	
Average	

Score Card 2: Balance Sheet Structure and Outright Portfolio (Section V)	Score (1-5)
1. The balance sheet is lean, i.e. it is not much longer than what is implied by the monetary base and central bank capital and reserves	
2. Outright portfolios do leave enough room to control short-term interest rates effectively at the margin through central bank credit operations	
3. The central bank has control of the average duration, credit, liquidity and duration risks in its balance sheet	
4. Non-policy constrained (NPC) assets are invested in a way to provide an efficient risk-return combination	
5. NPC assets are invested in a way to maintain relevant market expertise in the central bank	
6. The central bank is transparent on its NPC asset composition and explains it to the public	
7. The NPC asset composition does not distort financial market prices (i.e. is "neutral," according to the definition of neutrality chosen by the central bank). The central bank is conscious of its neutrality definition and makes it known to the public	
8. NPC assets do not interfere with monetary policy	
Average	

Score Card 3: Collateral Framework (Section VI.ii) Score	Score (1-5)
1. The collateral framework ensures at a very high confidence level that the central bank will not suffer losses in case of a counterparty default	
2. The collateral framework ensures that collateral scarcity does not interfere with the smooth implementation of monetary policy	
3. The collateral framework does not undermine the efficiency and activity in the money and capital market	
4. The collateral framework avoids unjustified discrimination across issuer types	
5. Haircut calibration is systematic and achieves post haircut risk equivalence	
6. The collateral framework does not lead to an excessive concentration in collateral use	
7. In case the use of some types of collateral is particularly costly for the central bank (in terms of assessment and handling), then these costs are internalised by charging fees to banks.	
8. The collateral framework is technically efficient, i.e. eligibility checks, use, monitoring, etc. are automated and well-organised.	
9. The collateral framework was tested for the more relevant eligible asset classes in the context of counterparty defaults and assets were successfully liquidated without losses	
10. The collateral framework is transparent and well explained toward the public	
11. The collateral framework is felt to lead to an adequate degree of elasticity of regular central bank credit to individual banks (adequate contribution to the CB's LOLR function)	
Average score	

Score Card 4: LOLR framework (Section VI.iii)	Score (1-5)
1. The overall extent of built-in LOLR elasticity within the normal OF provides adequate breathing space to bank funding in cases of temporary tensions in bank funding markets or temporary deposit outflows	
2. The overall extent of built-in LOLR elasticity within the normal OF does not lead to undue concentration of credit operations with few counterparties with weaker market access. Instead, mechanisms ensure that credit operations are spread amongst banks which have a wide range of market access and banking business	
3. There are adequate safeguards against moral hazard of banks with regard to their access to the LOLR function of the central bank	
4. Access conditions to CB credit within the regular OF is not pro-cyclical	
5. The central bank is well protected in LOLR against financial risks (through collateral policies and/or guarantees), so as to keep minimal the probability of central bank losses	
6. The LOLR framework is balanced towards the trade-off between zombification (survival of unproductive firms) and costs of undesirable defaults of viable firms	
7. The LOLR framework can be adjusted in a crisis to provide additional elasticity reflecting the higher exogenous liquidity uncertainty in such a context	
8. Recourse to the LOLR is not excessively stigmatised	
9. The central bank has consciously considered how to incorporate the LOLR into the OF; and to what extent to rely on other LOLR elements	
10. The ELA framework follows defined procedures and is documented in an internal manual	
11. ELA provision follows clear principles such as to ensure equal treatment of counterparties	
12. The degree of transparency on ELA policies and procedures is adequate to balance clarity and constructive ambiguity	
13. The roles of other stakeholders (e.g. the government, the deposit insurance scheme, the resolution mechanism, etc.) are well defined in the internal ELA manual and there is mutual understanding between these official sector entities on the respective roles and policies.	
Average	

Score Card 5: Focus and Structure of OF and Achievement of Fundamental Objectives	Score (1-5)
1. The OF is designed in a way that each instrument tends to be well-focused on few specific objectives	
2. The OF relies overall on few effective instruments to achieve its objectives	
3. The objectives of the different instruments are clear and how they interact toward achieving all main objectives of the OF is well analyzed and documented central bank internally.	
4. The objectives of different instruments and how they interact towards achieving all main objectives of the OF is well documented and explained to the outside world, and is generally well understood.	
5. The OF is presented in an honest way to the public	
6. The framework is universal, i.e. it appears portable to different environments (possibly with change in parameter values)	

Appendix B

Simulating the Control of Interest Rates While Preserving Money Market Activity

The simulation tool is based on a simple two-bank, one-day model. The two banks are subject to liquidity shocks before and after the trading session, whereby there are shocks of aggregate and of relative nature. Variants of the tool had been used in Bindseil and Würtz (2008) to simulate a TARALAC facility and in Bindseil and Jablecki (2013) to simulate the width of the corridor (see also Bindseil 2014, Section 6.2). The variant presented here allows for capture of the impact of a) the width of the standing facilities corridor, b) the existence and quota of a TARALAC facility, c) the frequency, and d) tender procedure of open market operations on: 1) overnight rate volatility, 2) interbank trading volume, and 3) central bank balance sheet length/average recourse to the facilities. The timeline of events every day is as follows:

1. **Central bank open market operation.** In the morning, the central bank adjusts its credit provision by means of an open market operation (“OMO”) in a way to match expected autonomous factors (“B” for bank notes), i.e. $OMO = B$. The actual autonomous factors at day end are defined as $B + d_1 + d_2$. B is the deterministic component and level of autonomous factors in the morning, while d_1 , d_2 are stochastic shocks hitting each bank in the course of the day, with $E(d_1) = E(d_2) = 0$ and with a symmetric density function. Since $OMO = B$ in the morning, the total bank reserves R will be equal to zero in the morning. There are no reserve requirements.
2. **Morning aggregate and relative liquidity shocks.** After the central bank operation, a first stochastic component of autonomous factors occurs and becomes publicly known: d_1 . At the same time, a deposit shift shock takes place, k , which is neutral in terms of aggregate liquidity, but reflects that, e.g., deposits of households and corporates move from one bank to the other. For the simulation, we assume that the two shocks are $N(0, \sigma_{d1})$, $N(0, \sigma_k)$, respectively.

3. **Interbank trading session.** At midday, a trading session takes place, in which the interbank rate is set in the middle of the valuations attributed by the two banks to central bank money under the assumption that no further interbank market trading could take place (i.e., the price is such that the rent from trading is shared equally between the two banks). These valuations under a no-trade assumption are for each bank weighted averages of the three standing facility rates, the weights being the perceived probabilities of the bank to be at the margin in recourse to the respective facility. The interbank trade y is the amount lent from bank 1 to bank 2 (i.e., a negative value of y indicates that bank 2 lends to bank 1). We assume that interbank trading is subject to transaction costs, implying that if the gains from trading are too small (because the pre-trade valuations of the two banks are too similar), then there is no trading. Moreover, banks only trade until the differences between their respective valuations of reserves reach the level of transaction costs.
4. **Afternoon aggregate liquidity shock.** In the afternoon, the eventual day's-end level of autonomous factors is revealed, as the second stochastic autonomous factor component d_2 occurs, which is assumed in the simulation to be $N(0, \sigma_{d2})$.
5. **Day's end and recourse to standing facilities.** To end the day with zero reserves, banks will take recourse first *to the TARALAC facility*, and if the imbalance exceeded the quota of $\Psi/2$ per bank, also *to the standing facilities at penalty level*. We will assume that the (penalty) deposit facility rate is zero. Therefore, the width of the corridor is equal to the rate of the credit facility.

The daily timeline is summarized in Figure B-1. The end-of-day financial accounts representation is shown in Table B-1. The interbank trading y is, as will be shown, a function of a) the width of the corridor; b) the size of a possible TARALAC facility; c) the standard deviation of the various liquidity shocks (as we assume for the sake of simplicity normally distributed shocks with expected value of zero, the unique parameter describing each of the liquidity shock stochastic variable is

Figure B-1
Daily Timeline of Central Bank Operations
and Interbank Trading

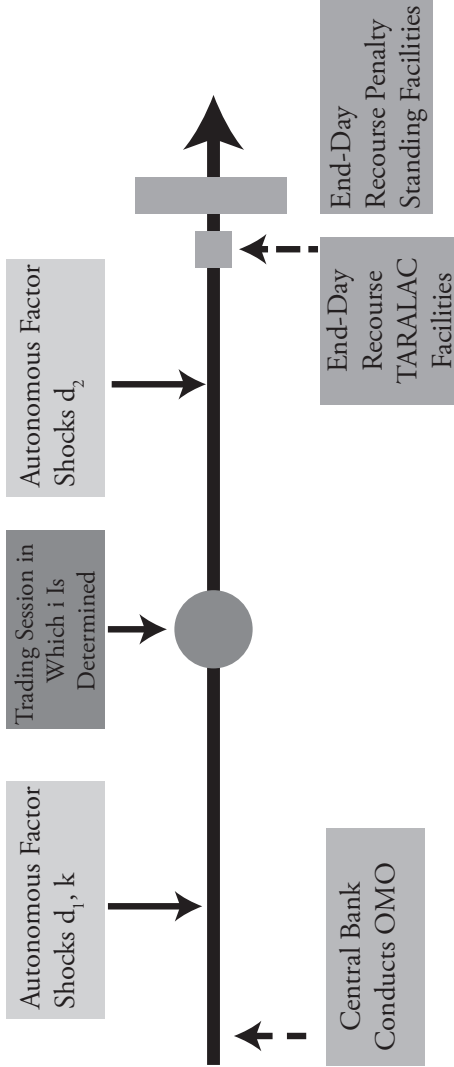


Table B-1
Financial Accounts at End of Day ($d = d_1 + d_2$)

Households/Investors		E
Real Assets	E-D-B	Household Equity
Deposits Bank 1	$D/2 - d/2 + k$	
Deposits Bank 2	$D/2 - d/2 - k$	
Banknotes	$B + d$	
Bank 1		
Lending to Corporates	$D/2 + B/2$	Household Deposits/Debt
Net Interbank Lending	y	
Recourse to TARALAC dep. Fac.	$\min(\Psi/2, \max(0, k-d/2-y))$	OMO Credit from Central Bank
Recourse to Penalty Dep. Fac.	$\max(0, k-d/2-y-\Psi/2)$	Recourse to TARALAC Cred. Fac.
		Recourse to Penalty Credit Facility
Bank 2		
Lending to Corporates $D/2+B/2$		Household Deposits / Debt
		Net Interbank Lending
		OMO Credit from Central Bank
Recourse to TARALAC dep. Fac.	$\min(\Psi/2, \max(0, -k-d/2+y))$	Recourse to TARALAC Cred. Fac.
Recourse to penalty dep. Fac.	$\max(0, -k-d/2+y-\Psi/2)$	Recourse to Penalty Cred. Fac.
Central Bank		
Open Market Operation	B	Banknotes
TARALAC credfac	$\min(\Psi/2, \max(0, (k-d/2-y)) + \min(\Psi/2, \max(0, -k-d/2+y)))$	TARALAC Dep. Fac.
Penalty Credit Facility	$\max(0, -(k-d/2-y)-\Psi/2) + \max(0, -(k-d/2+y)-\Psi/2)$	Penalty Dep. Fac.

its standard deviation), and d) the interbank market transaction costs. Note that for the simplicity of the presentation in the financial accounts, interbank lending is presented as a NET asset item of bank 1 and as a net liability item of bank 2. Obviously the relative liquidity shock could also induce the opposite case.

How will the different policy parameters affect the interbank market and average central bank balance sheet length? If there are no interbank transaction costs, then banks would always trade in the interbank market until the interbank shock is fully offset. With positive market transaction costs C_{MM} , trading volumes will be correspondingly lower. Call “AV_i” the “ante-money market value” of deposits of bank i and “PV_i” the “post-money market value” of deposits of bank i. Then, banks will trade if $|AV_1 - AV_2| \geq C_{MM}$ and in this case the trading volume will be such that $|PV_1 - PV_2| = C_{MM}$ as beyond this the additional transaction costs exceed the marginal rent from trading. The ex-ante and ex-post values of deposits for the two banks are as follows:

$$\begin{aligned}
 AV_1 &= P(k-d/2 < -\Psi/2)i_c + P(-\Psi/2 \leq k-d/2 \leq \Psi/2)i^* + P(k-d/2 > \Psi/2)i_d \\
 AV_2 &= P(-k-d/2 < -\Psi/2)i_c + P(-\Psi/2 \leq -k-d/2 \leq \Psi/2)i^* + P(-k-d/2 > \Psi/2)i_d \\
 PV_1 &= P(k-d/2-y < -\Psi/2)i_c + P(-\Psi/2 \leq k-d/2-y \leq \Psi/2)i^* + P(k-d/2-y > \Psi/2)i_d \\
 PV_2 &= P(-k-d/2+y < -\Psi/2)i_c + P(-\Psi/2 \leq -k-d/2+y \leq \Psi/2)i^* + P(-k-d/2+y > \Psi/2)i_d
 \end{aligned}$$

Endnotes

¹Of course the monetary policy stance is not, and should not be, neutral on relative asset prices.

²The German tradition seems to originate from the experience of monetary financing of two world wars and the subsequent almost total loss of purchasing power of money, once in 1923, and once in 1945/1948. The ECB's doctrine may be considered as a descendent from the German one. Independent of how the central bank perceives the risks of fiscal dominance, if it operates in an economy with insufficient amounts of economywide-risk-free assets (like the Eurosystem), the "consolidated official sector" approach does not work in practice because 1) there are insufficient assets which have the credit quality as the central bank and 2) any decision on how to invest among the government sector assets may create accusations of prompting government debt union through the back door. Hence, the best approach in practice for such a central bank is to have an asset portfolio (outright and collateral) which spans the full set of assets in the economy, possibly with a cut-off at a given risk level (e.g., investment grade).

³It may be noted that the ECB recently introduced an approach under which haircuts are applied whenever a counterparty submits an own covered bond. This is an example of haircut add-ons depending on counterparty-collateral issuer correlation.

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