Lender of last resort: A new role for an old instrument

CHAPTER 19

# LENDER OF LAST RESORT

*a new role for the old instrument*

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## 19.1 Introduction

The global financial crisis and the sovereign debt crisis in Europe have redefined the functions of the lender of last resort (LOLR) of the twenty-first century. First, they have placed the LOLR at the intersection of monetary policy, fiscal policy, supervision, and regulation of the banking industry. Second, they have given regulatory authorities the additional responsibility of monitoring the interbank market. Third, they have extended the LOLR role to cover the possible bailout of non-bank institutions, including sovereign countries. This chapter explores the link between the theoretical models of the banking industry and the mechanisms displayed in the aftermath of these crises and shows why acknowledging the existence of financial market imperfections constitutes a key to understanding the unprecedented LOLR policies during this period.

Since the creation of the first central banks (CBs) in the nineteenth century, the existence of an LOLR has been a key issue for the structure of the banking industry. The banking system has to provide mechanisms to manage banks' liquidity risk. In fact, one of the major functions of banks is to offer access to the payment system and facilitate property rights transfer. Furthermore, it is efficient to combine these functions with opaque long-term investments on the asset side (delegated monitoring) and with demand deposits on the liability side (Diamond and Dybvig, 1983; Diamond, 1984; Calomiris and Kahn, 1991; Diamond and Rajan, 2001). Although in any developed economy the principal mechanism to cope with both excesses and shortages of liquidity will be the interbank market, the well functioning of the banking system might still require an additional mechanism to avoid that both aggregate and bank specific liquidity risk mismanagement result in a bank defaulting on its contractual obligations. The terminology "of last resort" itself emphasizes that this institution is not intended to replace existing regular market mechanisms, but should make up for its possible failures. This justifies the existence of a discount window in the US and the marginal lending facility in the Eurozone.

The basic objectives of the LOLR were first formulated by Thornton (1802) and Bagehot (1873), who argued that it was necessary in order to support the whole financial system and to provide stable monetary growth (Humphrey, 1989). Since then, the role of the LOLR has become more controversial. The debate is inherent to the fact that, by providing insolvent banks with liquidity, we both allow them to escape market discipline and promote forbearance. There is a consensus among academics and central bankers that a mechanism should exist to allow solvent banks to obtain liquidity if the interbank market fails to operate correctly. Further, there is general agreement that insolvent banks should not access standard liquidity facilities and that, if necessary, we should deal with their insolvency on a case-by-case basis. Problems arise because liquidity shocks affecting banks might be indistinguishable from solvency shocks. Therefore, the debate about the role of the LOLR is connected with the efficient bank closure policy and, more generally, with the costs of bank failures and of the safety net, which is more the domain of fiscal policy.

This connection between the LOLR and bank bailout policy is not yet fully accepted. This may be because access to liquidity and the role of the LOLR have evolved through history. Those accepting Bagehot's view of the LOLR may argue that it relates to a world where solvent banks need protection against sudden deposit withdrawals without the recourse to a well-developed repo market and without the CB privilege of issuing fiat money. With the emergence of a well-functioning repo market, today's conception of the role of the LOLR is completely different. The LOLR may step in exceptionally to prevent a collapse of the payment system due to lack of liquidity, a task of the monetary policy under normal conditions. Hence, if the money markets are well functioning, the LOLR should manage aggregate liquidity only and leave the issue of solvency to the market that will eliminate the lame ducks.

The critical step in this argument is the assumption of perfect money markets. Once we consider imperfect money markets, we have to consider cases where it is impossible to establish whether a bank is solvent or insolvent. Hence, in solvency cases the LOLR is sometimes acting to channel liquidity and therefore is improving the efficiency of the monetary policy framework, while in the second case it is part of the safety net and directly related to the overall regulatory framework. Therefore, the design of an optimal LOLR mechanism has to take into account the monetary framework, the banking regulation context, and fiscal policy.

The panic of 2008 in the US vividly illustrates the new role of the LOLR. Years of accommodating monetary policy, regulatory arbitrage to save capital, and waves of financial innovations—which by definition tend to escape traditional prudential regulation—had created the conditions for slack credit standards without the rating agencies calling for adequate risk premia. The opacity of bank assets and the off-balance-sheet finance vehicles created to hold mortgages resulted at some point in a dramatic and sudden reappraisal of risk premia and the refusal to roll over the short-term debt issued to finance these assets. As with a thin market typical of the Akerlof lemons problem (Freixas and Jorge, 2008), financial intermediaries became reluctant to lend to each other if not for very short maturities. The fear that the interbank market might not work well and might fail to recycle the emergency liquidity provided by the CBs around the world induced

financial institutions to hoard some of the extra liquidity instead of recycling it by lending it to liquidity-deprived financial institutions. Thus, channeling emergency liquidity assistance through the interbank market did not work precisely because the interbank market did not function properly. To limit the systemic feedbacks of the sudden deleveraging of financial institutions in 2008, the Federal Reserve Bank (FED) took several unprecedented steps. It increased the list of collateral eligible for CB discount lending; it extended emergency liquidity assistance to investment banks, government-sponsored entities, money market mutual funds (MMMFs), a large insurance company; it entered into swap agreements with other CBs to provide dollar liquidity to banks outside the US; and it acquired bank capital. Preventing a complete meltdown of the financial system required that the CB guarantees (and accepts potential losses) that most, if not all claims, on financial institutions will be fulfilled, which is more the resort of the bank regulatory authority and fiscal policy than of the CB alone. As a consequence, the FED balance sheet grew from about $900 billion in September 2008 to more than $2 trillion in December 2008, to reach more than $4.5 trillion at the beginning of 2018. Discount window lending grew from a few hundred million dollars under normal circumstances to more than $500 billion at the height of the crisis.

Consequently, we argue that the 2008 panic has shown that it would be erroneous to adopt a narrow definition of the LOLR and to state that its role should be limited to funding illiquid but solvent depository institutions, while capital injections should be the Treasury's responsibility. This would lead to a very simplistic analysis of the LOLR functions, as the complex decisions would be either ignored, or handed over to the Treasury. In our view, such a narrow view of the LOLR would create an artificial separation between lending by the LOLR at no risk and the closure or bailout decision by the Treasury that could lead to incorrect policy assessments.

On the contrary, the view of the LOLR that we take here is a broad one, encompassing the closure or bailout decision defining the LOLR as *an agency that has the faculty to extend credit to a financial institution unable to secure funds through the regular circuit.* This definition omits any mention of the fact that the institution is illiquid or insolvent. Obviously, this does not preclude that a separation between LOLR and Treasury decisions might prove efficient. This broad definition has the additional benefit of encompassing the management of overall banking crises, which would be difficult to consider from the narrow perspective of pure liquidity provision. In the twenty-first century, and especially in the aftermath of the 2007 crisis, the links between the LOLR and the other functions are now widely accepted.

Once we agree that the LOLR policy is part of the overall banking safety net, the interdependence of its different components becomes clear. First, the existence and the extent of the coverage of a deposit insurance system, as documented in Santos (2006), limits the social cost of a bank's bankruptcy, and therefore, reduces the instances where an LOLR intervention will be required. Second, capital regulation reduces the probability of a bank in default being effectively insolvent, and so has a similar role in limiting the costly intervention of the LOLR. Third, the procedures to bail out or liquidate a bank,

determined by the legal and enforcement framework, will determine the cost–benefit analysis of an LOLR intervention.

The LOLR policy and its efficiency will depend upon the overall financial environment. When a liquid market for Certificates of Deposit, Treasury bills, and securitized loans, or even simply for the loans themselves exists, banks will only exceptionally encounter difficulties in coping with their liquidity shocks. Adopting a perspective of an all-embracing safety net does not mean that the safety net has to be the responsibility of a unique agent. Often several regulatory agencies interact, because different agencies are responsible for different functions related to the well functioning of the safety net. It is quite reasonable to separate monetary policy from banking regulation, and the separation of the Deposit Insurance Company (DIC) from the CB makes the cost of deposit insurance more transparent. Furthermore, the national jurisdiction of regulation makes cross-border banking a joint responsibility for the home and host regulatory agencies.

The rest of this chapter is structured as follows: in section 19.2 we examine the justification of LOLR lending in a simplified framework where only liquidity shocks arise. Section 19.3 is devoted to the case where liquidity shocks cannot be disentangled from solvency ones. Section 19.4 considers contagion in the interbank market and systemic risk. Section 19.5 discusses the issues raised by the implementation of the LOLR policy within the safety net. Section 19.6 concludes.

## 19.2 Pure Liquidity Shocks

As already mentioned, one of the major features of banks, and a justification of their existence, is that they combine assets with a long maturity with short-lived liabilities, as the investment and production schedules may not coincide with the consumption needs of the individuals. We will study here what types of liquidity shocks might affect banks and how emergency liquidity assistance (ELA) may help them cope with those shocks. However, setting a framework that explains why banks might face liquidity risk does not mean that an LOLR should exist. First, one could argue that monetary policy, jointly with peer monitoring, could solve the problem. Second, even if a specific institution is required, a private LOLR without any privileged access to CB liquidity could provide liquidity to the banks that need it.

### 19.2.1 Maturities Transformation Risk for a Single Institution

The classic models of Bryant (1980), and Diamond and Dybvig (1983) show that consumers who face independent risks about the timing of their consumption needs can pool resources to form a bank. The bank offers demand deposits, invests the proceeds in illiquid assets, and keeps an amount of liquidity equal to the expected value of the liquidity needs

of its depositors hence offering a valuable insurance function. The transformation of maturities exposes the bank to the threat of bank runs if a large number of depositors decide to withdraw their money for reasons other than liquidity.

In these models, there are two equilibria. In the efficient equilibrium, depositors withdraw only to satisfy their interim consumption needs, thus allowing the illiquid investment to mature. However, since the value of bank assets does not cover the contractual obligations of the bank with its depositors at the interim stage, there is also an inefficient equilibrium, where it is optimal for all depositors to withdraw early (a run), even for those that have no immediate consumption needs. This may cause the "fire sale" of long-term or illiquid assets, which, if generalized, may further depress asset values and cause a vicious circle. Deposit insurance and prudential regulation for many decades have essentially confined bank runs to textbook phenomena. This has changed with the crisis that began in 2007. Even in sophisticated banking systems, runs have reappeared in the retail markets, witness the run on the deposits of the mortgage lender Northern Rock in 2007—the first such thing in Britain since 1866—and in 2008 the runs on, among others, IndyMack, a Californian bank, and of Washington Mutual, the largest US thrift. Runs have appeared in the 2007–9 crisis on the repo market where large investors refused to roll over the short-term credit that financed asset-backed securities (ABS), and on the MMMFs from which institutional investors withdrew after the Lehman failure.

The traditional way to address equilibrium selection is to imagine that depositors behave in one way or another according to an exogenous event. Since in one equilibrium banks increase welfare and in the other one they decrease welfare, the impossibility to establish which equilibrium will prevail makes it impossible to determine whether it is ex ante desirable that banks arise as providers of intertemporal consumption insurance. In other words, it is not clear why consumers would find it optimal to deposit their money in a bank in the first place. Therefore, absent regulatory safeguards, policy recommendations rely on the assumption that a particular equilibrium will prevail, a problem that recent models that use global games do not face. Despite this shortcoming, the Bryant–Diamond–Dybvig approach has been the draught-horse for the study of financial instability and systemic risk.

In a modern economy, liquidity transformation takes on a different form from that envisioned in the classical Bryant–Diamond–Dybvig setup. Two major changes that have occurred are relevant here. First, banks have dramatically lowered the proportion of their liquid assets in their investment portfolio. Second, since long-term funding is more expensive than short-term funding, banks have funded an increasing proportion of long-term illiquid assets with short-term borrowing on the wholesale market. As a result, banks have replaced a relatively stable source of short-term funding (such as demand deposits) with short-term interest-sensitive wholesale funding and rolling over debt. Brunnermeier (2008) observes that in 2006 and 2007 the short-term overnight Repos were around 25 percent of the assets of brokers–dealers that, therefore, had to refinance their whole balance every four days. These related changes have put tremendous pressure on any financial institution in cases of funding problems.

One of the major features of the subprime crisis of 2007–8, the fact that with the widespread adoption of the so-called "originate-and-distribute" model of banking, maturity transformation takes place in part off-balance sheet, and therefore escapes banking regulation and the traditional regulatory mechanisms to prevent runs, is to be considered also from this perspective. A liquidity crisis in a conduit or special purpose vehicle, that is funded through a rollover of short-term debt, is akin (from the point of view of liquidity) to a holding bank company with an unregulated subsidiary where bank runs can occur.

### 19.2.2 Liquidity-Triggered Systemic Risk

Financially fragile intermediaries face the threat of systemic risk. Systemic risk can arise from the existence of a network of financial contracts from several types of operations: the payment system, the interbank market, and the market for derivatives. The tremendous growth experienced by these operations increases the degree of interconnections among operators and among countries and thus increases the potential for contagion.

A number of papers have modeled contagion among banks and the ways to prevent it. The discussion here will focus on the two we consider most relevant. Allen and Gale (2000) show that financial contagion can emerge in the banking system of a multi-region economy. The interbank deposit market offers insurance against regional liquidity shocks but also provides a channel through which the shocks to the agents' preferences in one region can spread over other regions. Allen and Gale (2000) consider a version of the Diamond–Dybvig model with several regions in which the number of early consumers (those demanding liquidity at an interim stage) and late consumers fluctuate. An interbank market in deposits allows insurance as regions with liquidity surpluses provide it to regions with shortages. This constitutes an efficient mechanism, provided there is enough aggregate liquidity. However, if there is a shortage of aggregate liquidity, due to a larger proportion of early consumers than expected at the contracting stage, the interbank deposit market can turn into the channel through which a crisis spreads. When facing a liquidity crisis, before liquidating long-term investments, banks liquidate their deposits in other banks, a strategy that just cancels out in aggregate. In cases of shortage of aggregate liquidity, the only way to increase the consumption good early is eventually to liquidate long-term investments. A financial crisis in one region can thus spread via contagion. Note that the nature of the crisis, and of the solution, is different with respect to the market for retail deposits as, for example, in the Diamond–Dybvig model. In the retail market, runs occur because banks liquidate when they have insufficient liquidity to meet the fixed payment of the deposit contracts. Hence, by making the contracts contingent or discretionary, one can eliminate the incentive to run. In the interbank markets, by contrast, the reciprocal nature of the deposit agreements makes these solutions impossible. Moreover, when each region is connected with all the others, the initial impact of the crisis can be attenuated and contagion avoided. On the other hand, when each

region is connected with few others, the impact of the initial crisis may be felt strongly on the neighboring regions.

In Freixas, Parigi, and Rochet (2000) a system of interbank credit lines arises because depositors face uncertainty about where they need to consume. Financial connections reduce the cost of holding liquidity but make the banking system prone to experience speculative gridlocks even if all banks are solvent. The mechanism of the gridlock is the following: if the depositors in one location, wishing to consume in another location, believe that there will be not enough resources for their consumption at the location of destination, their best response is to withdraw their deposits at their home location. This triggers the early liquidation of the investment in the home location, which, by backward induction, makes it optimal for the depositors in other locations to do the same. The CB can play the role of crisis manager: when all banks are solvent, the CB's role is simply to act as a coordinating device by guaranteeing the credit lines of all banks. Since the guarantees are not used in equilibrium, this action entails no cost. When, instead, one bank is insolvent because of poor returns on its investment, the CB's role is to close the bank in an orderly manner.

Both Allen and Gale (2000) and Freixas, Parigi, and Rochet (2000) emphasize the key role the interbank market plays in propagating a crisis through the intertwining of their balance sheets, the default of one bank generating an immediate loss to all its unsecured creditors. Yet from a policy point of view, the two models have a crucial difference. In Allen and Gale, any CB emergency liquidity injection allows solving the crisis no matter where the liquidity is injected, as it is profitable for one liquidity long institution to lend to a liquidity short one. In Freixas et al. since the crisis does not originate in an unpredicted liquidity shortage but in a rational alternative equilibrium strategy for depositors, injecting additional cash, in aggregate, will not help. Even in the case where every bank has access to sufficient liquidity, the inefficient gridlock equilibrium exists where banks' resources are used in an inefficient way. Solving the crisis in the Freixas et al. model falls more to the bank regulatory authority than to the CB, as it requires guaranteeing that all claims on banks are fulfilled. Therefore, despite apparent similarities, the LOLR plays the role of liquidity provider in the Allen and Gale model, while it plays the role of crisis manager in the Freixas et al. model.

The 2008 crisis offers a clear example of the distinction between systemic risk in Allen and Gale and Freixas et al. The resulting equilibrium closely resembles the gridlock described by Freixas et al. where the fear that a debtor bank will not honor its obligations induces the depositors of the creditor bank to withdraw deposits, thus triggering the liquidation of assets in a chain reaction style. This is the modern form of a "bank run" where financial intermediaries prefer to hoard funds rather than renew credit lines to other intermediaries, thus threatening the very survival of the system (see Heider, Hoerova, and Holthausen, 2015).

Modeling liabilities across banks, as in Allen and Gale, or Freixas et al. and Acemoglu, Ozdaglar, and Tahbaz-Salehi (2015), has the benefit to show that these networks of debts lead to better resilience to small liquidity shocks and full contagion for larger ones. The intuition is that, when the size of the shocks is large (tail risks) the excess liquidity

in the system may no longer be able to absorb them, and a less diversified interbank architecture allows to share the losses with the senior creditors of the distressed banks, protecting the rest of the system.

## 19.3 Distinguishing Between Insolvent and Illiquid Banks

The difficulty of distinguishing between an illiquid and an insolvent bank has been acknowledged at least since Bagehot's *Lombard Street*, when he argued (1873, II.64) "Every banker knows that if he has to prove that he is worthy of credit, however good may be his arguments, in fact his credit is gone." The scenarios are very different depending on whether we consider an individual bank in a perfect capital market or a potentially contagious banking crisis, possibly in an imperfect capital market, which implies a more complex cost–benefit analysis where the LOLR might have to make a risky loan.

The impossibility to distinguish insolvency from illiquidity may be due either to imperfect information of the LOLR or to the existence of multiple equilibria, one where banks are solvent and liquid and the other where banks are insolvent precisely because of the expectations that they are illiquid.

### 19.3.1 Unidentifiable Shocks

The simplest way to model shocks that could stem from illiquidity or solvency problems is to acknowledge the opacity of banks' balance sheets and the possibility of insolvent banks to hide their type by pooling with solvent illiquid ones, as modeled by Mitchell (2000) and Aghion, Bolton, and Fries (1999).

The impossibility of distinguishing illiquidity from insolvency is at the core of the Freixas, Parigi, and Rochet (2004) model. These authors consider that banks face shocks that may come from uncertain withdrawals by impatient consumers (liquidity shocks) or from losses on the long-term investments that they have financed (solvency shocks), and that the two types of shocks cannot be disentangled. When acting as an LOLR the CB faces the possibility that an insolvent bank may pose as an illiquid one and borrow either from the interbank market or from the CB itself. Then the bank may "gamble for resurrection," that is, it may invest the loan in the continuation of a project with a negative expected net present value. This assumption is in line with the criticism of the LOLR during the Savings and Loans crisis in the US during the 1980s and justifies why CBs are reluctant to be more liberal in their use of ELA. This setting allows to focus both on the incentive issues of ELA and under which macroeconomic conditions the CB should provide ELA, at the cost of abstracting from modeling contagion. In periods of crisis, borrowing in the interbank market may impose a high penalty because of the high

spread on loans. Freixas, Parigi, and Rochet (2004) show that ELA should entail a penalty rate in order to discourage insolvent banks from borrowing as if they were illiquid, but it should happen at a rate lower than the interbank market. The CB can lend at a better rate than the market since it can lend collateralized and thus override the priority of existing claims. By penalizing insolvent banks that demand ELA, the CB provides banks with the appropriate incentives to exert effort to limit the probability that a bank becomes insolvent in the first place. The implications of this approach appear clearly in the assessment of the 2007–9 crisis. The classic view, according to which the interbank market works perfectly, maintains that the spreads on interbank loans were understating risk, and that the observed turmoil was a correction in pricing on all assets and contracts that depended on the price of risk. By contrast, the Freixas, Parigi, and Rochet (2004) approach views the crisis as a joint one of liquidity and solvency, so that, absent CB intervention, the interbank market may exacerbate the adverse selection problems. Taking the argument to the extreme, as modeled, for instance, in Freixas and Holthausen (2005) or Freixas and Jorge (2008), may lead to thin-market equilibrium as in the market for lemons. The policy implications are important, since if the differential diagnostic is a correction back to the long-term price of risk, the optimal policy may be for the CB not to intervene except in so far as to reduce the cost of banks' failure. If, instead, adverse selection in the interbank market leads to a standstill, then the LOLR liquidity provision to individual institutions is capital.

The difficulty of sorting out liquidity and solvency shocks stems also from the unique position of banks in creating aggregate liquidity. Diamond and Rajan (2005) argue that, if a sufficiently large proportion of a bank's portfolio needs refinancing (a solvency problem) the bank will be unable to borrow against its future value. However, in that case there will be a shortage of liquidity in the economy for funding current consumption (a liquidity problem). A solvency problem or a liquidity problem alone can lead to a run on a bank if depositors anticipate losses. A run, in turn, destroys a bank's ability to extract money from borrowers and thus the ability to channel funds from surplus to deficit agents. Thus, after a run, aggregate liquidity is destroyed (an effect not present in bank runs of the type of Diamond–Dybvig), and liquidity is trapped in the wrong place, very similarly to what happened during the panic of 2008.

### 19.3.2 Adverse Selection-Driven Liquidity Dry-Ups

A common feature of Freixas, Parigi, and Rochet (2000), Rochet and Vives (2004) and Freixas and Jorge (2008) is the existence of hoarding, that is, liquidity that is not intended to be used in the market. A reason for hoarding is the potential of adverse selection in the secondary market for assets. Malherbe (2014) constructs a model in the tradition of the Diamond–Dybvig where, after investing, agents receive private information about the quality of their long-term project. They may want to sell part of their project either to consume early or to exploit their private information. However, because of adverse selection, the average seller's motive for trading determines the price at which they can

sell in the secondary market. This may depress the price and make it very costly to transform long-term assets into current consumption goods and provides a rationale for hoarding at the initial stage.

Crucially, the proportion of people selling in the secondary market because they have received negative information about their project's return increases when sellers exhibit hoarding behavior. In fact, the more sellers hoard liquidity, the less probable it is that a given seller trades because he must consume at the interim stage, and the more likely it is that he trades because he knows that his asset is a lemon. The investment decisions of the agent at the initial stage present strategic complementarities leading to multiple equilibria. When agents expect the secondary market to be illiquid, they rationally choose to hoard more. This reduces market participation, worsens the average quality of the asset for sale, and makes the market illiquid, validating the initial belief of the agents. Hence liquidity dry-ups can be self-fulfilling, which may explain why some markets, where the potential for adverse selection problems is serious, like, for example, those for asset-backed securities that were liquid before the financial crisis, dried up in the midst of the crisis and did not recover as cash became available again.

Malherbe (2014) argues that since the bad equilibrium happens because of coordination failure, a public insurance scheme that levies taxes to compensate for the losses that agents incurred for not storing enough, eliminates the incentive to hoard and the only remaining equilibrium is that with high liquidity.

Another way to overcome a market freeze due to adverse selection, for example, on the value of banks' pre-existing loans, is suggested by Tirole (2012). In Tirole's model, to finance new projects firms must sell legacy assets whose value is unknown to potential buyers. The ensuing adverse selection in the legacy assets market may prevent trade and funding for new projects. The government may buy legacy assets trading off the benefit of restarting trade versus the cost of distortionary taxation to buy legacy assets. This resembles the stated purpose of the $700 billion Troubled Assets Relief Program (TARP) in the US in October 2008. Gorton (2015) contrasts the market-making function of TARP with the widespread practice of suspending convertibility to avoid bank runs when, in the period before the FED's existence, there were no markets to sell bank loans.

## 19.4 Systemic Crises and Contagion

The mismatch between asset and liabilities maturity makes it imperative that a mechanism for the interbank transfer of liquidity is in place. A network of assets and liabilities links banks to one another. As a consequence, when assessing the cost–benefit of an LOLR operation, prevention of contagion and systemic risk will be the first factors to consider.

The global financial crisis has changed our views of how a systemic banking problem can emerge. Before the crisis, the conventional wisdom was that the main mechanism was the "domino effect." With this effect, the default of one bank generated both a change in depositors' and investors' confidence in the banking system as well as losses and illiquidity

for the banks that were the defaulting bank's creditors. The current crisis has shown that the decrease in the prices of banks' assets (ABS, collateralized debt obligations (CDO), but also mortgages) was the main driving force. Therefore, the injection of public liquidity to substitute the sudden lack of inside liquidity based on securities that were to become "toxic" was even more important than previously thought.

We will start by reviewing the literature on the "domino effect," then consider the literature on "fire-sale prices" and its impact on financial institutions' fragility, before analyzing some proposals to measure contagion. Indeed, since the prevention of systemic risk is one of the main rationales behind the LOLR, it is important to assess and quantify it.

### 19.4.1 The "Domino Effect" Approach

As the domino effect perspective on contagion relies on one bank's bankruptcy triggering other banks' bankruptcies, the analysis takes as given the failure of a bank and tracks its effects through the whole banking system. From a theoretical perspective, this approach is perfectly justified. Nevertheless, the majority of empirical studies show that the effect is quite limited. According to Furfine (2003), in the worst-case scenario the failure of the largest bank with a 40 percent loss, given default, would have affected between two and six banks or 0.8 percent of total bank assets. Interestingly, Furfine pointed out that liquidity presents a greater threat: if a large federal funds debtor becomes unable to borrow, illiquidity could spread to banks representing almost 9 percent of the US banking system by assets.

Three important criticisms should be formulated to the "domino effect" simulation exercise. They concern the indirect contagion that spreads through the behavior of depositors, the business cycle, and the price of bank assets during a crisis.

First, the empirical evidence is based on the network of banks' assets and liabilities, which may well affect the behavior of demand depositors. Their rational updating of the chances of another bank of similar characteristics may lead them to withdraw their deposits in a flight to quality. Many banking crises illustrate this phenomenon, as during the Great Depression, or in the ethnic bank crisis in the aftermath of the Bank of Credit and Commerce International in the UK. Iyer and Peydro (2011) studied the default of the Madhavpura Mercantile Cooperative Bank in India in 2001 to examine contagion through demand deposits. Similarly, Iyer and Puri (2012) examine the minute-by-minute depositors' withdrawals from a bank in India that experienced a run when a neighboring bank failed.

The second criticism is that the measure of contagion is different in good and in bad times. The impact of an individual bank when the banking system is healthy is the object of the above analysis. Yet from the policy analysis point of view, it is not clear that this is the best measure of contagion. An individual bank is more likely to go bankrupt when all banks are in trouble. This, of course, makes the analysis complex, because in such a case, contagion-induced and macroeconomic-induced systemic risk are simply indistinguishable. Hence, the new challenge in the measurement of contagion is to compute the

impact of a bank bankruptcy conditionally on the banking sector health, a topic that we discuss later in this section.

A third criticism is the impact of a number of bank failures or a large reduction of the size of their balance sheet on the value of assets. The main impact, first identified by Irving Fisher (1933), concerns the price of assets that serve as collateral. In a debt-deflation situation, the value of assets decreases, which lowers the amount of collateralized loans and therefore the amount of available credit, which, in turn, reduces output. This output decline will lead to a further reduction in asset prices until outside investors buy the assets (see also Kyotaki and Moore, 1997; and, more recently, Gorton and Huang, 2004; Acharya and Yorulmazer, 2008).

### 19.4.2 The Illiquidity View of Contagion

The simplest way to think about fire sales and illiquidity as triggering a systemic banking crisis is to assume that the aggregate amount of liquidity in the market is fixed. This "cash in the market" extremely simplifying assumption, initially proposed by Allen and Gale (1994), has the benefit of providing the bare bones of the argument. When banks face a liquidity shock, they will have to sell their assets independently of the market prices. With a given amount of cash in the market, any increase in sales begets a decrease in price. Consequently, if the number of selling banks is sufficiently large, some or all banks will be bankrupt. Acharya and Yorulmazer (2007) consider a more sophisticated version of this approach and show the necessity of an LOLR intervention.

Brunnermeier (2009), and Brunnermeier and Pedersen (2009) provide a more elaborated alternative to domino models of financial contagion. In their view, liquidity spirals may cause aggregate liquidity to dry up because of minor shocks. If leveraged, informed investors suffer even minor losses, in order to maintain the same leverage, they have to sell assets hence contributing to depress their prices even further if *market liquidity* for the asset is low. In addition to this loss spiral, Brunnermeier and Pedersen (2009) identify a margin spiral arising from the fact that, typically, financial assets are purchased on credit (*funding liquidity*) using the purchased assets as collateral (margin) for the loan, often a short-term one. The margin spiral reinforces the loss spiral as investors suffering losses have to sell assets to meet higher margin demands, that is, to lower the leverage ratio. Adrian and Shin (2008) confirm this spiral empirically for the five major US investment banks in the period 1997–2007. They identify a strong positive relationship for investment banks between the value-weighted change in leverage and the change in assets, hence showing that leverage is highly procyclical. This helps explain, according to Adrian and Shin (2008), how modest losses on US subprime mortgages triggered the most severe financial crisis since the Great Depression.

Finally, and more tentatively, if we restrict the analysis to solvency, we may end up underestimating the cross-bank links. In fact, a bank lending overnight to a peer financial institution that happens to be in default may not be fully satisfied with the knowledge that it will recover 95 percent of its claims in five years' time, after the liquidation of the

failing institution is complete. This may trigger the lending bank to liquidate some of its assets later at "fire sale," possibly increasing the impact on asset prices. The possibility of contagion from the asset side of interlinked balance sheets has received explicit attention in the literature. Schnabel and Shin (2004), and Cifuentes, Shin, and Ferrucci (2005) show that changes in asset prices may interact with solvency requirements or with internal risk control. This amplifies the initial shock in a vicious circle in which the reduction of the value of a bank's balance sheet may force the sale of assets or the disposal of a trading position, thereby further depressing asset prices, as illustrated above. This point appears particularly relevant in the 2007–9 crisis. While contagion was expected to occur through the interlinkages between the different banks assets and liabilities, it occurred through the financial institutions' lack of liquidity. The lack of liquidity led banks to sell some of their assets, which, in turn decreased the value of those assets; banks, therefore, faced losses and an increase in their risk, thus leading to reduced solvency. Thus it seems that, during the financial crisis, assets liquidity has been the channeling vehicle for the transmission of solvency shocks from one bank to another.

The awareness of this risk is linked to a number of steps taken by the regulators to soften liquidity requirements in the face of crises. Thus, for instance, the UK Financial Services Authority responded to the decline in stock prices in the summer of 2002 by diluting the solvency test for insurance companies and in 1998 the FED orchestrated the rescue of the hedge fund LTCM to prevent the negative impact of asset values that would have resulted from the unwinding of its positions.

### 19.4.3 Information Disclosure during Financial Crises

The financial history of the US before the creation of the Federal Reserve System in 1913 offers good examples of private arrangements to solve bank crises, namely the commercial bank clearinghouses (CBCs) (see Gorton, 1985; Gorton and Mullineaux, 1987 for a detailed analysis). Originally developed to facilitate check clearance, the CBCs became organizations that performed a variety of tasks. During bank panics, the CBC ceased to behave as an authority regulating competing banks and instead effectively combined the member banks into a single organization, with the group accepting corporate liability for the debts of each individual member. Among the most significant actions of the CBC during a bank panic were the suspension of the publication of individual banks' balance sheets and the publication instead of aggregate balance-sheet information for the clearinghouse as a whole; the suspension of convertibility of deposits into currency; and the issuance of loan certificates. Loan certificates were clearinghouse liabilities that member banks could use in the clearing process and circulate as currency. These loan certificates, issued up to a fraction of the market value of the assets of the member bank seeking them, were in effect the clearinghouse's fiat money.

Dang, Gorton, and Holmström (2012) use the example of the loan certificates issued by the CBCs to draw an important lesson about information disclosure during financial crises.

The question is whether in a crisis the CB should suppress bank-specific information. It is well known that the use of the discount window faces the problem of "stigma" as banks are reluctant to use this facility for fear that counterparties and investors will see this as an indication of weakness (see, for example, Geithner, 2014). The discount window stigma is sizable: Armantier et al. (2015) found that banks were willing to pay a premium larger than 44 basis points to avoid borrowing from the discount window, a premium that rose to 143 basis points after Lehman bankruptcy. To avoid this problem the FED created new anonymous lending programs (e.g., Term Auction Facility, Term Securities Lending Facility, and Primary Dealer Credit Facility) designed to use auctions to provide liquidity without disclosing the beneficiary bank.[1]

Dang et al. (2014) develop the economics behind suppressing bank-specific information in a crisis. The argument is that banks are optimally opaque so that their short-term debt is information insensitive and can be used in transactions and traded at par. Information insensitive means that no agent has incentives to acquire information about the payoff of the debt, which becomes free of adverse selection, and hence liquid.

An interesting example of government emergency assistance to distressed banks without revealing negative information is the Capital Purchase Program (CPP). The CPP, launched by the US authorities after the Lehman failure, forced all the major banks in the US to accept publicly funded equity injections. Since all banks had to participate in the program, the CPP did not reveal which banks were really in distress. Still, Calomiris and Khan (2015) caution against this interpretation, as the rationale behind forcing banks to accept capital injections could not be to mask weak banks as the market was well aware of them. Philippon and Schnabl (2013) offer a theoretical justification for the CCP type of programs. They show how forced participation in a publicly funded recapitalization program can overcome adverse selection and free riding when banks suffer from debt overhang.

If one accepts the argument for suppressing information to avoid adverse selection, then it may appear a contradiction to release information about banks after banks have undergone stress tests. In the spring of 2009, the US Treasury embarked on the new initiative of producing and revealing publicly information about the value of otherwise opaque banks' assets. The aim was to build confidence and resolve any residual uncertainty about remaining losses in banks' loans. These stress tests, widely seen as a success, received credit for contributing to ending the crisis. How can we then reconcile information suppression to avoid stigma and information release to separate healthy banks from unsound ones?

Faria-e-Castro, Martinez, and Philippon (2015) argue that what really matters is the fiscal capacity of the government behind the stress test. Providing information can reduce adverse selection, but negative disclosures can also trigger inefficient bank runs. Therefore, governments have to choose between runs and lemons. A government with a strong fiscal capacity can offer a credible deposit insurance guarantee that discourages runs and allows pursuing a high disclosure strategy. This helps explain the very different

[1] For a discussion of these facilities see Table 19.1.

outcomes of the US and European stress tests conducted in the same period. The European authorities chose not to disclose individual bank results; market participants widely disbelieved the tests, which in the end delivered few or none of the benefits of their US counterparts. Faria-e-Castro, Martinez, and Philippon (2015) argue that the difference is that, at the time, the EU, unlike the US, lacked a common resolution mechanism to mutualize the cost of guaranteeing the deposits of the weak banks in financially constrained countries. The EU chose not to reveal individual banks' information, like the CBCs before the foundation of the FED. Similarly Calomiris and Khan (2015) argue that CPP assistance provided a contingent source of government funding that assured that markets would not be rattled by the discovery of any capital deficiency following the stress tests in the US.

### 19.4.4 Measuring Links among Financial Institutions

Since the financial crisis, a new generation of studies has developed various measures of links among financial institutions and proposed systemic risk indexes that can be subject to empirical tests and are suitable for providing recommendations and early warning signals to regulators.

Billio et al. (2012) use principal components analysis to estimate the common factors driving the market returns of four groups of financial institutions: hedge funds, publicly traded banks, brokers/dealers, and insurance companies. They use pair-wise Granger-causality tests to identify the network of statistically significant relations among the four groups. Although banks may be of more concern than hedge funds from the perspective of connectedness, hedge funds, which experience losses first when financial crises hit, may offer early warning signals.

Important to note is the recognition that the impact of an individual bank's distress on the system is very different, depending on the health of the other banks. Adrian and Brunnermeier's (2016) CoVaR measures the Value at Risk (VaR) of financial institutions conditional on other institutions experiencing a financial distress. Leverage, size, maturity mismatch, and asset price booms significantly predict CoVaR. Out-of-sample forecasts of a countercyclical, forward-looking measure of systemic risk indicate that a pre-crisis value of this measure would have predicted more than one-third of the realized CoVaR during the financial crisis. This method, which estimates the value of the underlying assets through the market value of equity and the book value of debt, has the operational advantage of relying on the well-known regulatory tool of VaR. Allen, Bali, and Tang (2012) propose a system-wide index (CATFIN), which associates systemic risk to the VaR of the financial system as a whole, and complements bank-specific systemic risk measures to forecast macroeconomic downturns.

Acharya et al. (2017) measure the expected loss to each financial institution conditional on the entire set of institutions' poor performance. Each financial institution's contribution to systemic risk is measured as its systemic expected shortfall (SES), that is, the propensity of a bank to be undercapitalized in a future systemic event in which the

overall financial system is undercapitalized. Since SES is the expected contribution of each bank to a systemic crisis, a tax on each bank based on SES and its expected default losses can provide incentives to banks to take into account the externalities that their risk and default cause. Since SES is measurable, the authors demonstrate empirically the ability of components of SES to predict systemic risk during a financial crisis. The expected capital shortfall of a financial institution conditional on a prolonged market decline is also the basis for the measure of systemic risk called SRISK, introduced by Brownlees and Engle (2017). Besides delivering a ranking of systemically relevant institutions, SRISK provides early warning signals of distress indicators.

Giglio, Kelly, and Pruitt (2016) aggregate various systemic risk measures into a composite index of systemic risk. This index exhibits a significant power at predicting macroeconomic downturns, reinforcing the notion that systemic risk is a nonlinear and asymmetric phenomenon.

In sum, the new generation of studies portrays systemic risk in a different way from the first generation. Clearly, the magnitude of systemic risk is significant, its macroeconomic implications are fully recognized, and the need for regulatory action is therefore, warranted.

## 19.5 LOLR Policy

### 19.5.1 A New Background

The global financial crisis and the subsequent government bond crisis in the Eurozone have spurred an unprecedented level of LOLR activity. The systemic dimension of the crises implies that the distinction between the LOLR interventions supporting financial stability often uses the instruments of monetary policy.

Two phenomena have characterized the behavior of CBs: the injection of liquidity, to replace banks inside liquidity that was based on Repos, with liquidity using new procedures; and the drastic decrease of interest rates. With regards to liquidity injection, the Federal Reserve and the ECB balance-sheet increase was spectacular (see Figure 19.1). Such an increase in monetary injection, as well as the cooperation between CBs (Obstfeld, Shambaugh, and Taylor, 2009), contrasts with the policies followed during the Great Depression when, according to Friedman and Schwartz (1963), the money supply decreased by one-third between 1929 and 1933.

The magnitude of the interest rate cuts (the second phenomenon), as well as the frequency of interventions, was unprecedented (see Figure 19.2). Of course, one may argue that interest rate cuts reflect standard monetary easing, as the financial crisis was heralding a deep recession. Nevertheless, the departure from the classical Taylor rule response was clear in at least two dimensions. First, fighting financial fragility through the decrease of interest rates was the main objective, and the commitment to maintaining low interest rates for an extended period of time goes beyond the classical implementation

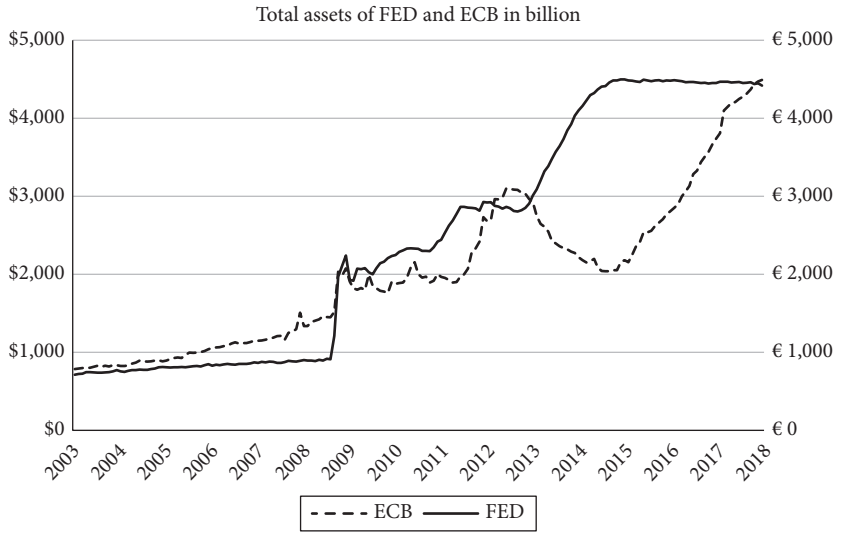


**FIGURE 19.1** Central Banks' Total Assets.

*Source*: https://fred.stlouisfed.org/.

of monetary policy. Second, the large-scale assets purchase programs that brought the balance sheets of both the FED and the ECB to their current size, were called for when it became clear that monetary accommodation alone could not further ease financial conditions, as the interest rate instrument was limited by the zero lower bound (Rogoff, 2017). These massive interventions have generated a new view of the role of LOLR, interacting both with monetary and macro prudential policy. In sum, the objective of both monetary policy and LOLR could be different when confronted with financial instability, in which case the LOLR may be concerned with restoring confidence and providing firms with access to credit to ease the credit crunch.

## 19.5.2 LOLR and Monetary Policy

To grasp these interactions, it is convenient to start by reviewing the events and the policies followed in the US during the financial crisis. The sudden change in defaults on subprime and Alt-A mortgages, later extended to prime mortgages, had two effects. First, it led the securities held by investment banks and some commercial banks (for example, ABS, CDO) from being AAA information insensitive to becoming sensitive to private information. Second, it caused huge losses for banks, either because they were holding the securities or because they had provided guarantees in special purpose vehicles that were holding the toxic assets. The same effect led to the collapse of both the repo market and the unsecured interbank market.

As a result, for banks to survive the liquidity shocks, the injection of liquidity was critical. This could be interpreted as the need to replace the vanished inside liquidity

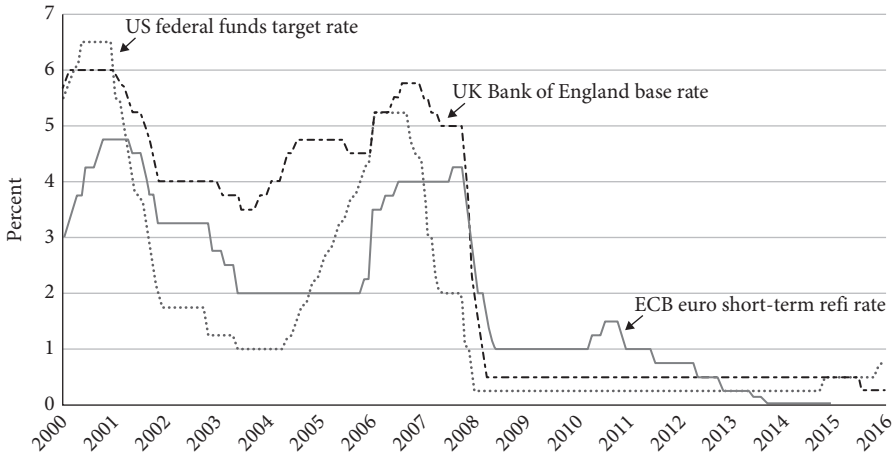


**FIGURE 19.2** Central Banks' Key Intervention Rates.

*Source*: Rogoff (2017).

provided by securities that were deemed safe, liquid and information insensitive in 2006, by outside liquidity provided by the CB. As a consequence the CB had to accept as collateral securities that could not be used in the repo market—as otherwise the banks themselves could have been using the securities to cope with their liquidity shocks.

The question of how to implement monetary policy and conduct LOLR operations is largely irrelevant in normal times when markets work smoothly. In contrast, when confronted with a crisis, some channels may close down and, new ones may have to be designed from scratch. First, implementing LOLR requires coordination between different institutions, which is often a neglected feature of the regulatory design. Second, the way the liquidity injection was implemented in the US and in the Eurozone has shown that it is possible to address the same issue in different ways, even if it is impossible to assess categorically which one is better.

The role of LOLR in liquidity creation is even more complex when not all assets can be used to purchase other assets. Gorton and Huang (2004) show that when there are such "liquidity-in-advance" constraints it is privately efficient for agents to hoard liquidity but it is not socially efficient, given the opportunity cost of foregone investment opportunities. When the amount of the assets to sell is so large that it would have been inefficient for private agents to hoard liquidity, the government can improve welfare by creating liquidity to bail out banks by taxing solvent projects. The drawback is that if the government tax capacity is too small, the government cannot bail out all banks, and forbearance arises. This is indeed the case for small countries and poses a serious risk for mid-sized countries with large banks. The link with monetary policy and the conflict of interest it implies is clear. Banking crises will materialize in a downturn, under tight monetary policy. This puts pressure on assets prices, thus setting the stage for a debt-deflation. If, simultaneously, the LOLR has to bail out banks in distress, there is a clear case for the coordination of policies and weighing the cost of a higher inflation versus the cost of banking crises.

The issue of how to inject liquidity shows a marked contrast between the US and the Eurozone. The US created a number of liquidity facilities to channel liquidity directly to some critical players of the financial market, thus bypassing the traditional banking system. It is possible to identify three types of facilities. The first corresponds to the classical role of the LOLR and emergency liquidity assistance. It consists of the term auction facility (TAF), the term securities lending facility (TSLF), the primary dealer credit facility (PDCF), and swap lines. The second set of policy tools aims to provide liquidity directly to borrowers and investors in key credit markets. It consists of the term asset-backed securities loan facility (TALF), the commercial paper funding facility (CPFF), the asset-backed commercial paper money market mutual fund liquidity facility (AMLF) and the money market investment fund facility (MMIFF). The third channel aims to support the functioning of credit markets and involves the purchase of longer-term securities for the FED's portfolio. To sum up, following Acharya and Richardson (2009) we can map these unconventional actions taken by the FED to expand liquidity in three dimensions: the expansion of the time duration of the CB loans; the expansion of the eligible collateral accepted by the CB in exchange of liquidity; and the expansion of the counterparties eligible for emergency liquidity assistance by the CB. These are described in Table 19.1.

In September 2017, ten years after the inception of the crisis, the Federal Open Market Committee announced that it would begin to reduce the size of the Federal Reserve's securities portfolio primarily by not reinvesting the maturing principal (Potter, 2017). This aims to make the unwinding process, which in itself is a primer as CBs have very little experience with such a large-scale reduction of holdings of domestic securities and reserves, as gradual and predictable as possible (Potter, 2017).

### 19.5.3 The LOLR in the Eurozone

In contrast to the US, in the Eurozone liquidity was injected through a single port of entry, the banks. Liquidity injection went directly to banks, which were then in charge of passing it through to the agents that required it.

It is useful to place the liquidity injection in the Eurozone in the context of the area's sovereign debt crisis in 2009–11. That crisis has put to the forefront the link between banking fragility and sovereign risk, a link that Brunnermeier et al. (2011) labeled the "diabolic loop." LOLR interventions under these conditions entail risks for the CB, because of credit risk, collateral risk, and market risk. A bank in distress may lose market access, and increase the use of CB credit. Since the eligible collateral that CBs accept from distressed banks tends to be both of lower quality and more illiquid (Acharya et al., 2009; Nyborg, 2015) as CB lending becomes more concentrated on weaker counterparties, the average quality of the risks in the CB's portfolio worsens (Bindseil and Jabłecki, 2013). More generally, Hall and Reis (2015) argue that the unconventional monetary policies have exposed CBs to increased interest rate and default risks.

**Table 19.1 LOLR Actions by the FED in the 2007–9 Crisis**

| Intervention | Objective | Period |
|---|---|---|
| Extension of Discount window (DW) duration | Extend the maximum term for depository institutions borrowing from DW to 30 days in August 2007, and 90 days in March 2008 | From August 2007 to March 2008 |
| Term Auction Facility (TAF) | Offer long-term liquidity to depository institutions given ineffectiveness of previous DW extension because of stigma | From December 12, 2007 to March 8, 2010 |
| Primary Dealer Credit Facility (PDCF) | Extend DW also to primary (i.e., systemically important) dealers after the collapse of Bear Stearns | From March 16, 2008 to February 1, 2010 |
| Term Securities Lending Facility (TSLF) | Provide medium-term liquidity to primary dealers' FED-loaned liquid Treasury securities to primary dealers for one month in exchange for less liquid collateral and a fee | From March 27, 2008 to February 1, 2010 |
| Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) | Extend loans to banking organizations to purchase asset-backed commercial paper from money markets mutual funds and help them meet investors' demand for redemptions. Introduced after the failure of Lehman Brothers. | From September 19, 2008 to February 1, 2010 |
| Money Market Investor Funding Facility (MMIFF) | Provide senior secured funding to special purpose vehicles to facilitate buying assets from money markets mutual funds and help them meet investors' demand for redemptions. No loans made under this facility | From October 21, 2008 to October 30, 2009 |
| Commercial Paper Funding Facility (CPFF) | Provide a liquidity backstop to US issuers of commercial paper. It funds purchases of highly rated unsecured and asset-backed commercial papers | From October 27, 2008 to February 1, 2010 |
| Term Asset-Backed Securities Loan Facility (TALF) | Help market participants meet the credit needs of households and small businesses, by supporting the issuance of ABS collateralized by student loans, auto loans, credit card loans, and loans guaranteed by the Small Business Administration in cooperation with the Treasury | From March, 2009 to June 30, 2010 |

This raises the question of the extent of LOLR operations. An excessively generous policy may imply losses that are either too large, as happened in Ireland in 2008, or pile up at the worst possible moment, when fiscal revenue is low, leading to the implementation of an austerity program in a downturn. This leads to additional difficulties because the solvency of the country itself and its rating are at stake. The price increase in sovereign bonds will affect especially domestic banks that, for home bias, behavioral, or cost reasons have invested a huge proportion of their portfolio in their countries' sovereign bonds.

In the extreme case, implementing the required LOLR policy increases a country's sovereign risk because it drains public finances seriously. This was the case in Iceland and in Cyprus, and in the first case, it even led to defaulting on the deposit insurance scheme, thus generating losses to other European countries as well (Acharya, Drechsler, and Schnabl, 2014). As a consequence, in the context of the European sovereign debt crisis, an even broader role and definition of the LOLR is emerging to address this vicious circle (see, for example, De Grauwe, 2011).

The implications of a twin crisis where both the banks and the country are in distress are also dramatic because it affects lending by the domestic institutions involved. Bofondi et al. (2013) show that after the Italian sovereign crisis, lending by Italian banks grew by about 3 percentage points less, relative to foreign banks and the interest rate they charged was between 15 and 20 basis points higher. The affected banks also drastically reduced their lending abroad, thus contributing to the credit crunch in the host countries, as shown by Correa, Sapriza, and Zlate (2012) in a study of the European banks' US branches' behavior during the European sovereign crisis.

The very implementation of any LOLR policy when a sovereign debt crisis is looming, and the CB, like the ECB, has a supranational dimension but lacks the backing of the Treasury, forces the monetary and fiscal authorities to look for bold new solutions. In October 2008, as a result of the tensions following the Lehman failure, the ECB switched from auctioning limited amounts of liquidity, to a policy that gave banks all the liquidity they asked for (full allotment) at the policy rate, provided they pledged sufficient collateral (Nyborg, 2015). This involved first the Main Refinancing Operations (MRO), and then the Long-Term Refinancing Operations (LTROs). One of the reasons behind the launch of LTROs was the run of US MMMFs on the banks of Greece, Ireland, Italy, Portugal, Spain (GIIPS) and non-GIIPS banks, after the MMMFs themselves in the summer of 2011 suffered a run in which they lost about 50 percent of their unsecured funding, or about $300 billion (Acharya, Pierret, and Steffen, 2016). The ECB conducted two LTROs (extending them from the three-month maturities before the crisis to three years) in December 2011 (EUR 489 billion to 523 banks) and February 2012 (EUR 530 billion to 800 banks) (Nyborg, 2015; Acharya, Pierret, and Steffen, 2016).

LTROs contributed to a substantial increase in home country bias and the financial fragmentation of the Eurozone. Acharya and Steffen (2015) document that Italian and Spanish banks increased their purchase of domestic sovereign bonds while banks from non-GIIPS European countries reduced their exposure to GIIPS sovereign bonds. As a result, LTROs did not stop the run of the US MMMFs on GIIPS and non-GIIPS banks.

The threat to the very survival of the euro remained real until the launch of the Outright Monetary Transactions (OMT) program in September 2012, which called for unlimited purchases of sovereign bonds. As Gorton (2015) argues, successful policy responses in a crisis are about managing expectations. In this respect, European Central Bank President, Mario Draghi's July 2012 speech introducing OMT, vowing to do "whatever it takes" to save the euro, and backing this promise with the announcement that the ECB would be a potential unlimited buyer of last resort (BOLR) of government bonds,

contributed to shifting the expectations of market participants, even if in the end OMT were never used.

Acharya, Pierret, and Steffen, (2016) compare the effectiveness of LTROs and OMT. Moral hazard is the clear risk of LOLR operations like LTROs where banks can use the liquidity to increase their holdings of domestic sovereign bonds (Crosignani, 2015) chiefly if they are accepted as collateral at the CB (Nyborg, 2015; Drechsler et al., 2016). Using an event study methodology, Acharya, Pierret, and Steffen, (2016) find that LTROs did not bring the reduction in sovereign yields that was expected, and instead the average GIIPS sovereign credit default swap (CDS) spreads increased after the second LTROs. As sovereign risk in the Eurozone became more concentrated in the banks of the GIIPS countries, the financial health of the banks of these countries also worsened. Instead, by committing to act as potential BOLR via OMT, the ECB effectively eliminated redenomination risk from the sovereign bonds of Italy and Spain. Banks of non-GIIPS countries started buying again sovereign bonds of GIIPS countries reducing the banks–sovereign loop.

Despite its success, OMT did not solve all the Eurozone's financial problems. In September 2014, the ECB announced a program to purchase asset-backed securities and covered bonds, and, in January 2015, launched a program to buy sovereign bonds outside OMT. Asset purchases bring to the forefront the terms of the exchanges of these securities and the issue of collateral framework: that is, what constitutes eligible collateral to obtain CB liquidity, and what haircut is required. Determining the collateral framework is at the discretion of the CB and it is seldom scrutinized ex post (Nyborg, 2015). During the crisis, the ECB extended the range of securities of the same credit risk that it accepted, and allowed securities of lower rating to be eligible collateral, hence taking on more risk. Furthermore, a large number of banks, mainly Italian ones, received government guarantees for their eligible collateral for a total value of around EUR 80 billion, thus strengthening the bank–sovereign nexus (Nyborg, 2015). In sum, whether the CB acted as buyer of last resort, or as lender of last resort, the crisis management capabilities of a supranational CB like the ECB were battle-tested for the first time on a large scale in the Eurozone sovereign debt crisis.

### 19.5.4 The Effects of Liquidity Injection

The emergence of new patterns of liquidity injection raises many different issues, which we describe below. Two theoretical contributions have challenged the traditional view of the separation of monetary policy and financial crises management by noting that during liquidity crises interbank markets cannot efficiently redistribute liquidity between banks with surplus liquidity and banks with a shortage of liquidity.

Allen, Carletti, and Gale (2009) consider an interbank market where banks can buy and sell long-term assets in the interim period to satisfy their liquidity shocks. However, to guarantee that banks have the incentive to hold both liquidity and long-term assets, the interbank market bids up the price of the long-term asset in the interim period when

aggregate liquidity demand is low. This induces asset price (and interest rate) volatility that hurts risk-averse consumers. The introduction of a CB that, via OMO, fixes the price of the long-term asset (or equivalently fixes the short-term interest rate) removes the inefficiency associated with the lack of hedging opportunities that aggregate liquidity uncertainty entails.

Freixas, Martin, and Skeie (2011) point out that during the current financial crisis, banks faced tremendous disparity in liquidity needs. Some banks were exposed to the risk to come up with billions of dollars on a same-day notice to honor the liquidity guarantees that they had offered to off-balance-sheet vehicles, while others were receiving large inflows of funds from investors fleeing other segments of the financial markets. To capture the variation in liquidity needs observed during the crisis, their model considers two different states of the world regarding the uncertainty of the distribution of banks' liquidity needs: low uncertainty in normal times and high uncertainty during the crisis. The interest rate affects the ex ante decision to hold liquidity versus the long-term assets, and ex post it affects the terms at which banks can borrow in the interbank market. Only state-contingent interbank rates allow achieving the optimal allocation: in fact, interest rates have to be low in crisis time to achieve the redistribution of liquidity, and higher than the return on the long-term asset under normal times, to give banks the incentive to hold liquidity ex ante. Freixas, Martin, and Skeie (2011) argue then that interest rates set independently of prudential considerations cannot be optimal and thus criticize the notion that monetary policy should not be used to manage financial crises.

On the other hand, these policies may be planting the seeds for the next crises if market participants anticipate them. One of the paradoxes of the policy interventions in the last financial crisis is that the banking sector has been saved in various ways by the monetary and fiscal authorities (Gorton, 2012). That is, ex post society as a whole preferred to engage in the costly bailout of some of the financial institutions whose behavior triggered or exacerbated the crisis as opposed to engaging in the liquidation of large chunks of the financial industry. This type of time-inconsistency has been recognized at least since Bagehot. Two recent models offer new insights of how banks behave ex ante, thus anticipating future policy responses.

The lack of commitment by CBs to bail out failing banks increases the likelihood of banking crises. Acharya and Yorulmazer (2007) start from this intuition and show that regulators find it ex post optimal to bail out banks when the crisis assumes systemic proportions, that is, when the number of failures is large. On the contrary, if only a few banks fail, their rescue can be arranged by having the surviving banks buy the failing ones. As the number of failing banks increases, the number of banks that can be the potential acquirers shrinks and the chances that the failing banks have to be liquidated at a loss increase. Anticipating this too-many-to-fail guarantee induces banks to herd ex ante, for example, lending to similar industries and/or betting on similar interest and mortgage rates risk. This problem focuses the attention on the choices of banks as a group rather than on individual choices, and as such, it suggests that also the category of small banks can be a source of systemic fragility.

Similarly, Fahri and Tirole (2012) argue that, since difficult economic conditions call for public policy to help financial institutions, strategic complementarities in banks' risk choices are generated. For example, the larger the number of banks exposed to the risk of a shock because of maturity mismatch, the more it is in the interests of an individual bank to do the same. This is so because when the number of banks involved increases, the fixed cost associated with the CB intervention declines, hence tilting the CB's incentives toward a lower interest rate policy.

## 19.6 Conclusions

To conclude, it is worthwhile comparing the classic view of the LOLR with the complexities of the above analysis and trying to summarize the recent advances in the contemporaneous approach of LOLR, as compared with the "wisdom of our ancestors." What is left today of the simple clear-cut guidelines suggested by Thornton and Bagehot that recommend to lend to solvent illiquid institutions against good collateral and at a penalty rate?

First, lending to the market through OMO is the standard way for a CB to prevent an aggregate liquidity shock. This is the contemporaneous version of "lending against good collateral," characteristic of developed financial markets. Yet, recent models of interbank lending teach us that market imperfections can lead to other inefficiencies that require LOLR support to extend beyond the pure CB responsibility of aggregate liquidity management and lend to individual banks, either unsecured or against collateral of lower quality, or guaranteeing their future liquidity.

The second classical recommendation was to lend at a penalty. This point is now clearly controversial. In the presence of ex ante moral hazard, as in Freixas, Parigi, and Rochet (2004), a penalty provides managers with the right incentives to be diligent in their lending. Yet in Rochet and Vives (2004), the recommendation is the opposite, to lend at a rate inferior of the market rate. When, in addition, we consider decentralization between several regulatory agencies, a penalty on interest rates decreases the expected cost of the LOLR loan and imposes a better discipline in banks' liquidity management. This will, therefore, make the LOLR more prone to forbearance, which, as mentioned, could either increase or decrease the efficiency of the LOLR. When the regulator is unbiased, this will be efficient, because in the case of success, the LOLR will obtain a share of the bank's profits.

The recent financial crises offer several lessons regarding the role of the LOLR in a systemic crisis. First, we have witnessed how repeated and coordinated aggregate liquidity injections are not sufficient to solve the crisis: the illiquidity of financial institutions around the world is linked not only to their solvency but also to asset prices. Second, it is important to notice that CBs around the world have been much more flexible in providing support to the banking industry than what was initially expected, or, in other words, that CBs cannot credibly commit to a well-targeted bailout or liquidation policy. Indeed,

the arguments in support of the bailout of banks only if their closure could have a systemic impact (too-big-to-fail), which were intended for an individual bank facing financial distress, were soon discarded in favor of a more realistic approach. The case of Northern Rock, certainly not a systemic bank, illustrates this point. Its liquidation in such a fragile banking environment would have triggered a domino effect with contagion from one institution to another. From that perspective, the lesson is that, when facing a systemic crisis, the LOLR has to take into account also the "too-many-to-fail," and consider how it will treat all banks that are in a similar position. A third point is that in a systemic crisis the perimeter of the safety net is extended to non-bank institutions. This may be the result of the waves of financial innovation. Yet, because AIG had been issuing CDSs, its bankruptcy would have affected the fragility of the banking industry by leading to losses and a lower capital. Fourth, the Eurozone government bond crisis has made it clear that the LOLR has to take into account the "dangerous liaisons" that arise when banks hold massive amounts of bonds of their sovereign.

In the end, the above discussion highlights the important notion that the LOLR of the twenty-first century lies at the intersection of the monetary policy, supervision, the regulation of the banking industry, and the financial imperfections of the interbank market—a long way from the Bagehot doctrine.

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