Liquidity: How Banks Create It and How It Should Be Regulated

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Liquidity creation is a core function of banks and an economic service of substantial importance to the economy. This chapter reviews and synthesizes the theoretical and empirical literature on bank liquidity creation. The focus is on the economics of bank liquidity creation, both in the traditional relationship banking context and in the shadow banking context. The related prudential regulation issues – pertaining mainly to capital requirements and liquidity requirements – are also discussed. A historical overview is provided, starting in the early 1800s and ending with Basel III and the Dodd-Frank Act. Open research questions are identified.

Keywords: Banking, Relationship Banking, Shadow Banking, Capital, Capital Requirements, Liquidity Creation, Liquidity, Liquidity Requirements, Regulation.

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INTRODUCTION

This chapter provides a review and synthesis of key issues related to "liquidity creation" by banks, including prudential regulation. The questions addressed are: How do banks create liquidity and how does this improve welfare? What risks does liquidity creation generate for the bank? How does the bank cope with these risks in the traditional originate-to-hold model and in the originate-to-distribute model that is closely linked to the shadow banking system? Does managing these risks call for regulation in the form of capital requirements and regulatory reserve / liquidity requirements?

"Liquidity creation" refers to the fact that banks provide illiquid loans to borrowers while giving depositors the ability to withdraw funds *at par value* at a moment's notice (e.g., Bryant, 1980; Diamond and Dybvig, 1983). Banks also provide borrowers liquidity off the balance sheet through loan commitments and similar claims to liquid funds (e.g., Boot, Greenbaum, and Thakor, 1993; Holmstrom and Tirole, 1998; Kashyap, Rajan, and Stein, 2002; Thakor, 2005). There is now a large theoretical literature on bank liquidity creation and an emerging literature on its empirical measurement (e.g., Berger and Bouwman, 2009).

Bank liquidity creation is important for the macroeconomy (e.g, Bernanke, 1983; Dell'Ariccia, Detragiache, and Rajan, 2009), and becomes even more prominent during financial crises (e.g., Acharya, Shin, and Yorulmazer, 2009). However, the creation of liquidity exposes the bank to a variety of risks, including liquidity risk. This risk can be mitigated to some extent by holding liquid assets like cash. Cash-asset reserves are not sufficient if depositors withdraw simply because they are afraid that the bank will shut down due to a run by others on its deposits. A regulatory safety net (including deposit insurance and the Federal Reserve discount window) can deal with such fears, but its existence reduces the bank's incentive to keep cash-asset reserves. Safety nets also give rise to moral hazard in that the bank has a perverse incentive to increase risk at the expense of the deposit insurer. This can increase the risk of future asset-value impairment, an event that would

trigger liquidity risk by causing depositors to run the bank; the empirical suggest that liquidity problems are often triggered by concerns that the bank is insolvent due to poor asset quality (e.g., Gorton, 1988). To improve the bank's asset portfolio choices and risk management, regulatory monitoring and capital requirements can be used.

This highlights that both liquidity requirements and capital requirements are useful as part of the regulation of banks' liquidity creation. The predominant focus, however, of the macro- and microprudential regulation leading up to the subprime lending crisis has been on capital requirements rather than liquidity requirements. The same holds for the theories. As a result, while I am able to discuss the past, present, and future of both capital and liquidity regulation and implementation issues in the US and Europe, the discussions on how they should be regulated will focus largely on capital.

To properly understand the roles of both capital requirements and liquidity requirements in influencing bank liquidity creation in the present-day economy, I also take a closer look at the economics of traditional banking (which focuses on relationship lending and the originate-to-hold model) and its evolution to modern-day banking, characterized by a mix of the originate-to-hold and the originate-to-distribute models, and a rapid growth of the shadow banking system. I describe this system and how it interacts with traditional banking in its liquidity creation role.

While one could argue that the absence of bank runs in U.S. commercial banking indicates the effectiveness of the regulatory safety net and the redundancy of liquidity requirements, the rapid drying up of liquidity in the shadow banking system during the recent subprime lending crisis suggests that regulators need to look beyond the traditional boundaries of deposit-based banking when thinking about capital and liquidity requirements. Basel III requires banks to operate with more and higher-quality capital, and introduces two liquidity ratios. I discuss these new standards, how they are adopted in the U.S. and Europe, and how they may affect liquidity creation. I also turn to the possible theoretical linkages between liquidity requirements and capital requirements, how one should think

about these requirements for both traditional deposit-funded banks and for shadow banks, and identify open research questions.

BANKS AS LIQUIDITY CREATORS

Theories

Standard textbooks on financial intermediation (e.g., Greenbaum and Thakor, 2007; Freixas and Rochet, 2008) explain that banks are institutions that make loans funded by a combination of deposits from the public and equity supplied by the banks' shareholders. More formally, banks engage in "liquidity creation," which is a form of "qualitative asset transformation."

To understand liquidity creation, picture a firm in need of long-term financing in a world without banks. In such a world, savers would directly finance the funding needs of the firm, and they would end up with an illiquid claim against the firm. In contrast, in a world with banks, it is the bank that provides the long-term loan to the firm, and the bank is able to offer savers demand deposits.[1] So it is the bank that holds the illiquid claim against the firm and savers end up with a liquid claim against the bank. Because of this difference in liquidity between what banks do with their money and the way they finance their activities, banks are said to create liquidity. Inherent in the liquidity creation in these models is maturity transformation; see Bhattacharya and Thakor (1993) and Hellwig (1994) for discussions on this topic. Formal models of banks as liquidity creators in this sense were developed by Bryant (1980) and Diamond and Dybvig (1983). In those models, depositors can suffer interim liquidity shocks, so being able to hold liquid (demand) deposit claims improves welfare.

[1] There are alternative theories as to why banks fund with so much short-term debt. Some argue that short-term debt has a disciplining role in that the threat of non-renewal of funding makes bank managers behave (Calomiris and Kahn, 1991; Dewatripoint and Tirole, 1994; and Diamond and Rajan, 2001). Others argue it may be the outcome of a maturity rat race (Brunnermeier and Oehmke, 2013) or debt overhang problem (Admati, DeMarzo, Hellwig, and Pfleiderer, 2012).

In Diamond and Dybvig (1983), this liquidity creation exposes banks to withdrawal risk.[2] Fear that other depositors may rush in to withdraw their deposits prematurely even though they may not have liquidity needs can cause all depositors to withdraw, precipitating a bank run as one of two possible equilibria.[3,4] It is impossible for the bank to "provision" for such an event, short of practicing 100% reserve banking, i.e., keeping all deposits as cash in vault. But such an institution would be merely a safe-deposit box, rather than a bank that creates liquidity. Diamond and Dybvig (1983) argue that federal deposit insurance can eliminate bank runs, thereby ridding banks of the prospect of the large-scale deposit withdrawals that characterize such runs.[5] But of course, the intent of deposit insurance is to help banks deal with panic runs, *not* substitute for the liquidity banks need to keep on hand to meet day-to-day routine deposit withdrawals. Thus, even with deposit insurance, banks need to worry about having enough liquidity on hand to meet the normal liquidity needs of depositors.

Because the level of even routine withdrawals on any given day is stochastic, the liquidity reserves a bank keeps may either be too high or too low in light of the realized level of withdrawals. Moreover, absent panic runs and financial crises, the daily withdrawal levels across banks will not be perfectly correlated, suggesting gains from diversification. To take advantage of these diversification gains, an interbank market in trading cash reserves emerged, called the federal funds market. The fed

[2] In practice, it also exposes banks to credit risk and interest rate risk (both are absent in Diamond and Dybvig, 1983) related to maturity transformation. Hellwig (1994) discusses the relation between both in a model of maturity transformation.

[3] In Diamond and Dybvig (1983), a bank run is a "sunspot" phenomenon, not attributable to any specific economic trigger. Chari and Jagannathan (1988) show that a bank run can arise as a unique equilibrium that is triggered by adverse fundamental information.

[4] Diamond and Dybvig (1983) take the sequential servicing constraint (SSC: first-come, first-served rule) as a given. Calomiris and Kahn (1991) provide an endogenous rationale. They show that demandable debt disciplines the manager because depositors can vote with their feet, and that the SSC gives depositors an incentive to monitor (avoids free-riding).

[5] Kane, Laeven, and Demirguc-Kunt (2008) examine deposit insurance in 170 countries from 1960 – 2003. They document that explicit deposit insurance schemes were not available in most countries before 1960. The number of countries with such schemes had grown to 45 by the beginning of 1995 and to 87 by year-end 2003. They argue that countries that do not have explicit schemes typically have some form of implicit deposit insurance.

funds rate is the rate at which banks borrow and lend on an overnight basis in this market in the U.S.[6] Banks with excess reserves are lenders and those with reserve deficiencies are borrowers.[7]

In addition to the fed funds market, banks can also avail of short-term borrowing at the discount window to meet their short-term liquidity needs. The Federal Reserve's willingness to provide banks with discount window access is an important potential source of liquidity for banks.

Banks face costs in accessing the federal funds market and in borrowing at the discount window. One of these costs is that eligible collateral must be posted. Accessing the discount window may in addition be associated with a stigma – such borrowing may be perceived as a sign of weakness, which may make banks reluctant to obtain funds.[8,9] Banks thus have an incentive to keep some cash on hand to deal with the liquidity risk that is an unavoidable companion to the bank's basic economic function of being a liquidity creator.

While the financing of banks through liquid demand deposits leads to withdrawal risk for banks, it also provides an opportunity for banks to provide liquidity to borrowers off the balance sheet. This was formalized by Kashyap, Rajan, and Stein (2002) who argue that banks face a demand for liquidity from their depositors as well as from customers who purchase loan commitments that can be exercised in the future, thereby obligating the bank to lend when customers exercise these

[6] In the U.K., the analogous rate is LIBOR, the London InterBank Offered Rate.

[7] Allen, Peristiani, and Saunders (1989) show that small banks tend to act as lenders while large banks tend to act as borrowers in this market. They argue this may be because small banks: prefer to use deposits to fund their activities; can attract deposits more cheaply due to local monopoly power; and face greater information asymmetries which makes fed funds more expensive for them than for large banks.

[8] In the words of the Chairman of the Federal Reserve, Bernanke (2008): "…the efficacy of the discount window has been limited by the reluctance of depository institutions to use the window as a source of funding. The 'stigma' associated with the discount window, which if anything intensifies during periods of crisis, arises primarily from banks' concerns that market participants will draw adverse inferences about their financial condition if their borrowing from the Federal Reserve were to become known." Ennis and Weinberg (forthcoming) provide a theoretical model on the origin and implications of stigma. Furfine (2005) provides some empirical evidence on stigma by examining data on a special Y2K Federal Reserve liquidity facility. In an attempt to quantify the costs associated with stigma using data from the recent subprime lending crisis, Armantier, Ghysels, Sarkar, and Shrader (2011) show that banks were on average willing to pay a 37-basis-point premium over a similar funding source (term auction facility) during the height of the crisis.

[9] Information on who obtains funds from the central bank is generally not available. However, data on access during the recent subprime lending crisis were recently made available. Berger, Black, Bouwman, and Dlugosz (2013) examine which kinds of banks obtained such funds from the Federal Reserve. Drechsler, Drechsel, Marques-Ibanez, and Schnabl (2013) instead focus on banks that used funds from the European Central Bank.

commitments. This means that a pool of liquid assets that the bank keeps on hand can serve two purposes – meeting the liquidity needs of borrowers as well as those of depositors. And there are diversification benefits associated with this costly holding of liquidity if the liquidity needs of borrowers and depositors are not perfectly correlated.[10]

The fact that banks make loan commitments is related to the seminal contributions of Diamond (1984) and Ramakrishnan and Thakor (1984) which provided the microfoundations of banks as specialists in screening credit information and monitoring borrowers.[11] Thus, banks as primary lenders make commitments to lend in the future. Such commitments create liquidity as they provide borrowers (partial) insurance against being rationed in the spot credit market (James, 1981; Blackwell and Santomero, 1982; Morgan, 1994; Thakor, 2005), so that a commitment can give a borrower access to future liquidity even when it is unavailable in the spot credit market.[12]

Boot, Greenbaum, and Thakor (1993) show that loan commitments improve *ex ante* welfare, even though they represent only "illusory promises" in that the bank may choose not to honor its commitment when the borrower attempts a takedown. They model the bank's choice as a tradeoff between reputational and financial capital – when the bank honors a loan commitment, it provides liquidity for the borrower but uses up its financial capital, and when it does *not* honor a commitment, it essentially "liquefies" its illiquid reputation capital and preserves its financial capital.

[10] As evidence, they report that loan commitments and transaction deposits are positively correlated across banks. Gatev, Schuermann, and Strahan (2009) test whether this leads to a diversification benefit and find it does: bank risk (stock return volatility) increases in unused commitments except for banks with high deposit levels. Building on this, Gatev and Strahan (2006) argue that transaction deposits and loan commitments may be negatively correlated during crises since banks enjoy deposit inflows and greater demand for loan commitments during such times. Such inflows occur because banks are viewed as a safe haven given explicit government guarantees, access to the discount window and other emergency liquidity facilities, and additional support for too-big-to-fail banks (e.g., O'Hara and Shaw, 1990).

[11] See also Leland and Pyle (1977), Millon and Thakor (1985), Allen (1990), and Coval and Thakor (2005).

[12] Other explanations for the existence of loan commitments include: they provide a mechanism for optimal risk sharing (Campbell, 1978; and Ho and Saunders, 1983), and they ameliorate informational frictions between the borrower and the bank (Berkovitch and Greenbaum, 1991; and Boot, Thakor, and Udell, 1991).

Empirical Evidence

Comprehensive empirical measures of liquidity creation were non-existent until recently. To measure the output of the banking sector, studies typically focused on total assets, total lending, or different types of lending. Taking a cue from the theories, Berger and Bouwman (2009) develop several measures of liquidity creation.[13] Using data on banks in the U.S., they show that large banks (assets over $1 billion) create over 80% of the banking sector's liquidity despite accounting for only a small percent of all banks. They also document that banks create almost half of their liquidity off the balance sheet through loan commitments and similar claims to liquid funds. Most of the empirical studies in this area examine the relationship between capital and liquidity creation (see "The Effect of Higher Capital Requirements on Bank Output" for a discussion of those papers). More recently, Bai, Krishnamurthy, and Weymuller (2013) develop a liquidity mismatch index (LMI), which is conceptually similar even though it measures the exact opposite: the LMI is a liquidity measure whereas the Berger and Bouwman (2009) measures capture illiquidity (creating liquidity for customers makes the bank illiquid). They calculate liquidity mismatch for the universe of bank holding companies (BHCs) in the U.S. and show that the banking sector's liquidity condition is largely determined by the top 50 BHCs.

Empirical studies on the use of loan commitments have generally focused on corporate customers and document that over 80% of commercial and industrial lending is in the form of drawdowns under commitments. Melnik and Plaut (1986), Shockley and Thakor (1997), and Sufi (2009) provide detailed descriptions of loan commitment contracts and their specific features. Berger and Udell (1992) and Morgan (1998) document that credit lines reduce the risk of credit rationing during downturns. Consistent with this, Ivashina and Scharfstein (2010) show that after Lehman

[13] Quarterly data on liquidity created by virtually every bank in the U.S. from 1984:Q1 until "now" are available for research purposes on my website (http://faculty.weatherhead.case.edu/bouwman/data.html) (updated regularly).

collapsed during the subprime lending crisis, there was a "run" by borrowers who drew down their loan commitments. There is also evidence, however, that banks renegotiated the terms for credit lines in their own favor during the crisis (Campello, Giambona, Graham, and Harvey, 2011).

THE NEED FOR REGULATION

Given the demand for liquidity by both its (on- and off-balance-sheet) borrowers and depositors, the bank will trade off the costs and benefits of keeping liquidity on hand in deciding how much cash and other liquid assets to hold. However, just as deposit insurance lessens the bank's need to worry about events that might induce depositors to run the bank, the discount window can cause banks to keep too low a level of liquidity to meet routine withdrawal risk. Why keep cash lying around earning nothing if you know you can borrow at the discount window at a cost lower than the return you would earn by investing the cash?[14]

Of course, the central bank can eliminate this moral hazard by removing the deposit insurance and discount window safety nets. But this entails social costs because it could result in disruptive banking panics. Moreover, it might even disrupt the bank's relationship loans if core deposits are withdrawn in large amounts, and this can add to the welfare losses (Song and Thakor, 2007). Rather than throwing out the baby with the bathwater, the central bank can deal with the moral hazard created by these back-stop liquidity safety nets by imposing a minimum cash-asset reserve.

Cash Reserve Requirements

Feinman (1993) documents that cash reserve requirements have been imposed in the US as early as 1820, when commercial banks were state-chartered and did not have large amounts of deposits.

[14] This assumes that the return earned exceeds the costs associated with posting eligible collateral and the possible stigma associated with borrowing from the discount window mentioned above.

However, they did issue bank notes which were often used as a medium of exchange. This initially only happened locally because it was challenging to gauge the solvency of far-away banks. To facilitate their usage over greater distances, banks voluntarily agreed to accept each other's notes, provided that the issuing bank kept enough liquid funds at the redeeming bank as backing. A few states subsequently mandated that banks hold reserves against their notes and deposits.

Reserve requirements were launched at the national level in 1863 with the passage of the National Bank Act. This Act enabled banks with a national charter to issue national bank notes and required them to hold a 25% reserve against such notes and deposits.[15] In 1864, this was reduced to 15% for banks located outside the largest cities. An Act of 1874 replaced reserve requirements on bank notes with a required redemption fund (banks were to deposit money equal to 5% of the notes with the Treasury) which counted toward fulfilling reserve requirements on deposits (Champ, 2007).[16] Reserve requirements did stay in place for deposits, which replaced bank notes as the preferred medium of exchange.

Various bank runs and panics in the late 19th and early 20th centuries demonstrated that reserve requirements could not safeguard the convertibility of deposits for the entire banking system (e.g., Calomiris and Gorton, 1991), in essence because a dollar of reserves could not concurrently meet a customer's demand for cash and also satisfy reserve requirements. To maintain stability of the financial system, the Federal Reserve System was created in 1913: in it, Reserve Banks could act as lenders of last resort by accommodating banks' temporary liquidity needs. While this seemingly eliminated the need for reserve requirements, they continued to be imposed on transaction and time

[15] They also had to deposit 111% of (the lesser of) the face or market value of these notes in US government bonds with the US Treasury. In 1900, this was reduced to 100%.

[16] Calomiris and Mason (2008) argue that this created economies of scope between note issuance and deposit taking because banks that issued notes had lower marginal costs of maintaining reserves associated with deposit taking.

deposits, albeit at lower levels than during the national banking era. Starting in 1917, banks could only satisfy these requirements by keeping non-interest-bearing balances at the Federal Reserve.

By 1931, reserves were not viewed only as a source of liquidity for deposits anymore, but also as a monetary policy tool used by the central bank to influence the expansion of bank lending (Federal Reserve, 1933). To reduce the burden on small banks, which tended to hold high cash balances, banks were able to count vault cash to meet reserve requirements from 1950 onward. In the late 1960s, new liabilities that were functionally equivalent to deposits also became subject to reserve requirements.

In the 1970s, rising interest rates increased the cost that banks incurred for satisfying reserve requirements, since the Federal Reserve paid no interest on reserves. This caused banks to leave the Federal Reserve System (Feinman, 1993). To stop this trend, Congress adopted the Depository Institutions Deregulation and Monetary Control Act (DIDMCA or MCA) of 1980 which mandated that all depository institutions – regardless of membership status – be subject to reserve requirements and be given access to the discount window. Regulation D of the Act specifies the reserve requirements. Initially, they were set at 3% on the first $25 million of transaction deposits and 12% on the rest, and 3% on non-transaction deposits. Over time, these percentages have declined, possibly to avoid disintermediation due to non-payment of interest on reserves. The Garn-St. Germain Act of 1982 introduced an exemption amount for transaction deposits, initially set at $2 million. The reserve requirement on non-transaction accounts was lowered to 0% in December 1990 and has been at that level ever since. In April 1992, the 12% rate was reduced to 10% and has stayed at that level. As of 2013, the exemption amount is $12.4 million, a 3% rate is imposed on transaction deposits between $12.4 million and $79.5 million, and amounts above that are subject to a 10% rate.

Figure 1 Panel A shows the dollar amounts of required reserves and vault cash for the U.S. banking sector from January 1960 through April 2013. While both required reserves and vault cash have increased over time, the banking system's cash balances exceeded the reserve requirements from

the late 1990s until the beginning of 2009, suggesting that depository institutions were able to satisfy their entire reserve requirement with vault cash during that period. Panel B contrasts the dollar amounts of required reserves with the total amount of reserves held by the U.S. banking sector. The picture is striking. Before the subprime lending crisis, total reserves of the banking sector showed a steady increase (from $18.8 billion in January 1960 to $49.9 billion in July 2007) and were on average a mere 2% higher than required reserves. During the initial phase of the crisis, total reserves increased somewhat, but they exploded after the collapse of Lehman Brothers in September 2008, reaching a level of $860 billion by January 2009 (almost 14 times the required level of $63.4 billion) and a record $1,885 billion by April 2013 (over 16 times the required level of $115.9 billion).

[Insert Figure 1 here]

The dramatic increase in reserves during the crisis coincided with the Federal Reserve's decision to pay interest on reserve balances for the first time in its history.[17] This has led many (e.g., Barrons, 2009; Edlin and Jaffee, 2009; Huffington Post, 2010) to conclude that banks are simply "parking" funds at the Federal Reserve – they do not want to lend anymore since earning a sure return by sitting on funds kept at the Federal Reserve is more lucrative.[18] In stark contrast, others (e.g., Keister and McAndrews, 2009) suggest that this perspective is incorrect, arguing that the increase in reserves merely mirrors the unprecedented scale of the Federal Reserve's liquidity facilities and other

[17] The Financial Services Regulatory Relief Act (FSRRA) of 2006 authorized the Federal Reserve to pay interest on balances held by or on behalf of depository institutions starting October 1, 2011. Section 128 of the Emergency Economic Stabilization Act (EESA) of 2008 moved the effective date forward to October 1, 2008. The Federal Reserve indicated (press release: http://www.federalreserve.gov/newsevents/press/monetary/20081006a.htm) that paying interest on reserves would give it "greater scope to use its lending programs to address conditions in credit markets while also maintaining the federal funds rate close to the target established by the Federal Open Market Committee". The Federal Reserve initially set the interest rate on required (excess) reserves at 10 (75) basis points below the average target fed funds rate over the reserve maintenance period. From December 18, 2008 onward it has paid a fixed rate of 25 basis points on both required and excess reserves.

[18] Some suggest that to curb this, excess reserves should be subject to a maximum (Dasgupta, 2009) or taxed (Sumner, 2009).

credit programs. That is, it is simply driven by an accounting identity: the Federal Reserve's liabilities need to equal its assets.

Capital Requirements Prior to the Subprime Lending Crisis

As discussed above, safety nets can facilitate liquidity creation. But these safety nets give rise to moral hazard in that the bank has a perverse incentive to increase risk at the expense of the deposit insurer – see Merton's (1977) analysis showing that deposit insurance gives the bank a put option on its assets, and that the value of this option is decreasing in the bank's capital. The observation that safety nets induce banks to lower their capital ratios is supported by the sharp drop in capital ratios after the adoption of federal deposit insurance in the U.S. in 1934 (see *Figure 2*).

[Insert Figure 2 here]

To increase bank capital and reduce the bank's risk-taking appetite, regulatory monitoring and capital requirements can be used (e.g., Campbell, Chan, and Marino, 1992; Chan, Greenbaum and Thakor, 1992; Merton and Bodie, 1992; Bhattacharya and Thakor, 1993; Thakor, 1996; Hellmann, Murdock, and Stiglitz, 2000).[19]

Formal capital requirements were introduced for the first time in the U.S. only in 1981. Prior to the 1980s, supervisors merely applied informal and subjective measures, including managerial capability and loan portfolio quality, because they could not agree on a framework (FDIC, 2003). Starting in 1981, banks were subject to a leverage ratio of primary capital (mainly equity and loan loss reserves) to average total assets. The minimum requirements were not uniform across the three regulators (Federal Reserve, the Office of the Comptroller of the Currency, and the Federal Deposit Insurance Corporation) but ranged from 5% to 6%. There were differences at the international level

[19] Higher capital requirements may increase portfolio risk in certain circumstances (Koehn and Santomero, 1980; Kim and Santomero, 1988; Genotte and Pyle, 1991; Besanko and Kanatas, 1996). Mailath and Mester (1994) examine the regulator's incentive to close banks and how that affects its ability to influence the riskiness of banks' asset portfolios.

as well. Over the next few years, regulators from the U.S. and around the world worked together to devise a uniform capital framework necessary to ensure that banks had adequate capital and were operating in a level playing field.

The Basel Capital Accord (commonly referred to as Basel I), adopted in 1988, became partially effective for all U.S. banks and thrifts at year-end 1990, and was fully implemented at year-end 1992. Basel I primarily focused on credit risk and forced banks to risk-weight their assets and off-balance-sheet items based on their perceived credit risk. While loans to private borrowers and stand-by letters of credit serving as financial guarantees for loans were risk-weighted at 100%, residential mortgages and long-term loan commitments were weighted at 50%, claims on or guarantees by qualifying banks were weighted at 20%, and very low-risk assets (including cash, government debt, and short-term loan commitments) were weighted at 0%. So banks had to hold more capital if they chose riskier assets. Banks were required to hold tier 1 capital of at least 4% of risk-weighted assets and total capital of at least 8% of risk-weighted assets.[20] Tier 1 capital is the purest form of capital, comprised of shareholders' equity and non-redeemable non-cumulative preferred stock. Total capital also includes capital/debt hybrids such as long-term subordinated debt (which counts as capital because it is at risk before deposits and other bonds). In 1991, U.S. bank regulators (OCC, FRB, FDIC, and OTS) also passed the Federal Deposit Insurance Corporation Improvement Act (FDICIA), which introduced an additional leverage requirement and specified that to operate without regulatory restrictions, a bank must be adequately or well-capitalized. To be adequately (well-) capitalized, it must have a tier 1 leverage ratio of at least 4% (5%), a tier 1 risk-based ratio of at least 4% (6%), and a total risk-based capital ratio of at least 8% (10%).

Soon after the introduction of Basel I, shortcomings became apparent. For example, capital requirements were the same on loans to highly-rated corporations and much riskier distressed firms.

[20] They had to meet interim minimum standards of 3.625% (tier 1 capital) and 7.25% (total capital) by year-end 1990.

Furthermore, capital requirements were typically higher for on-balance-sheet loans than for off-balance-sheet exposures to the same borrowers even when the risks to the bank were similar. These shortcomings gave banks incentives to engage in regulatory capital arbitrage, i.e., they tried to find ways to reduce their risk-weighted assets without truly lowering risk.

Basel II, initially published in June 2004, aimed to better align the minimum capital required with the underlying risks and focused on the denominator of the capital ratios. It introduced three pillars. Pillar 1 encompasses risk-based capital requirements for credit risk, market risk, and operational risk (risks arising from people, systems, or processes). Unlike Basel I, it does not prescribe one approach, but offers banks three approaches for credit risk (standardized approach, foundation internal ratings based approach (F-IRB), and advanced IRB approach (A-IRB))[21] and for operational risk (basic indicator approach, standardized approach, and advanced measurement approaches (AMA)). The A-IRB for credit risk and the AMA for operational risk together are called the "Advanced Approaches." Pillar 2 involves a supervisory review of banks' internal assessments of capital and risk, giving regulators discretion to impose higher capital requirements. Pillar 3 promotes market discipline by mandating banks to increase public disclosure of capital and risk.

The European Parliament approved Basel II for *all* banks in the E.U. in 2005 and formally adopted it in 2006 (European Parliament, 2011).[22] While most banks in Europe can choose any of the three approaches, many member states require the very largest banks to adopt at least the A-IRB. In contrast to the E.U., the U.S. never fully implemented Basel II. U.S. banking regulators adopted a final regulation only in late 2007 (Federal Reserve, 2007). It required the very largest banks (eleven

[21] The standardized approach groups exposures into several risk categories (as Basel I does), but the risk weights for loans to corporates, sovereigns, and banks depend on external credit ratings assigned to the borrower instead of being fixed. The F-IRB approach allows banks to use their own models to estimate probabilities of default (PD), while relying on the supervisor to provide estimates of loss given default (LGD), exposure at default (EAD), and maturity (M). The A-IRB approach allows banks with the most advanced risk management and modeling skills to provide all the estimates (PD, LGD, EAD, and M) needed to determine their capital requirement.

[22] Benink and Benston (2005) provide a more detailed discussion on changes in E.U. banking regulation.

or twelve "core banks" with consolidated total assets of at least $250 billion or with consolidated total on-balance-sheet foreign exposure of at least $10 billion) to apply the Advanced Approaches; other banks could obtain authorization to use those approaches ("opt-in banks") or had to stay on Basel I. The rule stipulated that banks would first be subject to a one-year parallel run of Basel I and Basel II, and would then start a three-year transition period. However, the subprime lending crisis happened, and the focus shifted to Basel III and the Dodd-Frank Act, which outlawed the use of credit ratings in regulations while Basel II heavily used such ratings (to be discussed in "Basel III" below). As of March 2013, all of the 27 Basel Committee member countries except for the U.S., Argentina, and Russia had fully implemented Basel II (BIS, 2013c).

FROM ORIGINATE-TO-HOLD (OTH) TO A MIX OF OTH AND ORIGINATE-TO-DISTRIBUTE (OTD) AND THE EMERGENCE OF THE SHADOW BANKING SYSTEM

As discussed above, cash-asset reserve requirements steadily declined in the U.S. until the subprime lending crisis for two main reasons. First, as a tool of prudential regulation, they simply became too costly since the Federal Reserve did not pay interest on reserves and market interest rates – the shadow price of holding reserves – spiked up dramatically in the 1970s. Second, as a tool of monetary policy, reserve requirements were hardly ever used because they represented a rather blunt instrument compared to other tools like the discount window and fed funds borrowing rates. Thus, reliance on reserve requirements has fallen over the years and we are now in a period in which banks are largely subject to capital requirements. Yet, as discussed below, there may be a role for both in moderating bank liquidity creation in an efficient way in the present-day economy. To properly understand these issues, we first need to step back and take a closer look at the economics of traditional banking and its evolution to modern-day banking.

Originate-To-Hold

The research on financial-intermediary existence implied that banks generate proprietary information about their borrowers.[23] This then suggested that banks could use their information to resolve informational frictions and increase the surplus generated by the bank-borrower relationship. This insight paved the way for the emergence of a literature on relationship banking which highlights the benefits of deep relationships between banks and their borrowers. The pioneering contributions in this area are Greenbaum, Kanatas, and Venezia (1989), Sharpe (1990), Rajan (1992), and Boot and Thakor (1994, 2000). Boot (2000) defines relationship banking as "the provision of financial services by a financial intermediary that: (i) invests in obtaining customer-specific information, often proprietary in nature; and (ii) evaluates the profitability of these investments through multiple interactions with the same customer over time and/or across products." The first part highlights that banks obtain information while providing screening and/or monitoring services. The second part emphasizes the fact that information can be used in multiple interactions with the same customer, which allows the bank to reuse information.

To address whether relationships benefit borrowers, empirical studies have typically included measures of duration, scope, and/or the number of bank relationships in regressions to explain the cost and availability of credit. While the international evidence is at times mixed, most U.S. studies tend to find clear benefits: stronger relationships result in lower cost, lower collateral requirements, and better access to credit (e.g., Petersen and Rajan, 1994; Berger and Udell, 1995; for a review, see Degryse, Kim, and Ongena, 2009, and the Chapter on Small Business Lending in this Handbook). Consistent with this, bank loan announcements are associated with significantly positive abnormal

[23] Using unique data on small-business borrowers, Mester, Nakamura, and Renault (2007) show that transaction accounts provide banks with ongoing information regarding borrowers' activities, thereby facilitating bank monitoring.

returns (e.g., James, 1987; Billett, Flannery, and Garfinkel, 1995).[24] Banks benefit as well – stronger lending relationships are associated with a higher probability of winning SEO underwriting business (Drucker and Puri, 2005)[25] and future lending and investment banking business (Bharath, Dahiya, Saunders, and Srinivasan, 2007). Small banks tend to form stronger relationships with customers than large banks, likely because they are better at processing soft information (Berger, Miller, Petersen, Rajan, and Stein, 2005).

Relationship banking involves the bank making the loan and holding it on its balance sheet. This is the so-called "originate-to-hold" model, in which banks fund relationship loans with core deposits. The loans are illiquid – banks keep them on their balance sheets until maturity. This reduces moral hazard on the side of the bank – the fact that the loans stay on the balance sheet gives the bank incentives to perform upfront screening and then monitor on an ongoing basis.

Relationships can lose a lot of value if they have to be liquidated prematurely due to a bank run; often, a bank's failure will result in the resolution authority arranging for the bank to be acquired by another institution, which results in a loss of the original relationship and its associated economic surplus, even if the loan is not liquidated.[26] To prevent such runs and protect the value of relationships, deposit insurance and lender-of-last-resort facilities were introduced.

[24] In contrast to the short-run effect, Billett, Flannery, and Garfinkel (2006) find significant long-run underperformance after firms have obtained bank loans.

[25] In contrast to evidence provided by Drucker and Puri (2005), Calomiris and Pornrojnangkool (2009) show that banks may charge higher prices when combining lending and underwriting.

[26] Song and Thakor (2007) show theoretically how this influences the bank's choice of funding mix between core deposits and purchased money. Berlin and Mester (1999) provide empirical evidence that banks with greater reliance on core deposits give their borrowers better insurance against negative shocks to their creditworthiness. Consistent with this, Ivashina and Scharfstein (2010) and Cornett, McNutt, Strahan, and Tehranian (2011) show that banks that relied more on (stable) deposits, cut their lending less during the subprime lending crisis.

Originate-To-Distribute

During the 1990s and 2000s, loan sales and securitization skyrocketed, in essence moving banks more and more away from the "originate-to-hold" (OTH) model toward a mix of OTH and the "originate-to distribute" (OTD) model. While loan sales are easy to grasp, it is helpful to show how securitization works and how it contrasts with traditional banking (see Figure 3). As shown in Panel B, the bank originates loans as it does in the traditional OTH model, but then transfers the loans to a trust called a Special Purpose Vehicle (SPV), which issues various tranches of debt claims called asset-backed securities (ABS) against this pool of loans. These ABS are sold to institutional investors and the money received by the SPV is transferred in part to the bank.[27] Thus, like loan sales, securitization provides banks with extra funding that can be used to originate new loans.

[Insert Figure 3 here]

Greenbaum and Thakor (1987) examine which assets banks will securitize, and show that with asymmetric information about borrowers' payoffs, they securitize higher-quality assets (see also Gorton and Pennacchi, 1995). Boot and Thakor (1993) show that banks may want to create tranches of claims against pooled assets, so as to diversify away idiosyncratic noise and then create information-sensitive claims that maximize issuer revenue. The push to split up securities in Gorton and Pennacchi (1990) is demand driven instead: uninformed investors can reduce their trading losses if they can trade relatively information-insensitive securities. While these papers focus on the bright side of securitization, recent papers point to a dark side:[28] it may negatively affect screening incentives since it allows lenders to pass onto others the loans they have originated (Aghion, Bolton, and Tirole,

[27] The bank may also purchase some of these ABS and use them as collateral to obtain repo funding from institutional investors like money-market mutual funds.

[28] Gorton and Haubrich (1990) argue that this is a natural way in which a market develops: initially, easy-to-value assets are sold; later on, increasingly complex and risky contracts are made. Loutskina (2011) points at another dark side – securitization makes banks more susceptible to funding shocks when the securitization market is disrupted.

2004; Stiglitz, 2007).[29] Evidence from the subprime lending crisis tends to support this view (e.g., Mian and Sufi, 2009; Demyanyk and Van Hemert, 2011, Purnanandam, 2011; Dell'Ariccia, Igan, and Laeven, 2012; Keys, Seru, and Vig, 2012; Dai, Zhang, and Zhao, 2013), although skin in the game seems to improve banks' screening incentives (Demiroglu and James, 2012). In Gennaiolo, Shleifer, and Vishny (2013), securitization leads to bank interconnected and raises their exposure to tail risks.

Banks may benefit from loan sales. Pennacchi (1988) shows that selling banks have an advantage in originating loans and a disadvantage in providing funding; the reverse holds for buying banks. James (1988) finds that loan sales can reduce underinvestment problems of banks with risky debt. Firms may also benefit from loan sales. It may enable them to borrow more (Drucker and Puri, 2009), and it can lower their cost of capital due to increased liquidity in the secondary loan market (Gupta, Singh, and Zebedee, 2008) or risk-sharing benefits between the originating bank and loan buyers (Parlour and Winton, 2013). There is also a dark side. Firms whose loans are sold by banks underperform their peers (Berndt and Gupta (2009)), maybe because banks sell loans of lower-quality borrowers and/or loan sales reduce bank monitoring since the bank-borrower relationship is broken.

Originate-To-Distribute and the Shadow Banking System

The OTD model fuelled the development of the so-called "shadow banking system."[30] While a consensus definition does not exist, Bernanke (2010) defines shadow banks as "financial entities other than regulated depository institutions (commercial banks, thrifts, and credit unions) that serve as intermediaries to channel savings into investment." Adrian and Ashcraft (2012) add that such channeling takes place "through a range of securitization and secured funding techniques,"

[29] These problems may be more severe when the economy is doing well: Thakor (2005) and Dell'Ariccia and Marquez (2006) show that lending standards decline during economic booms. Hellwig (1994) focuses on the incentive effects of securitization and argues that it should be structured such that the bank retains asset-specific return risks to ensure proper screening and monitoring of clients, i.e., the securitizing bank needs the right kind of "skin in the game."
[30] The term "shadow banking" is attributed to money manager Paul McCulley (2007).

highlighting the importance of securitization in shadow banking.[31] The shadow banking system includes institutions such as investment banks, brokerage houses, and finance companies; securitization structures such as asset-backed securities (ABS) and asset-backed commercial paper (ABCP); and key investors in securitized structures, such as money market mutual funds (MMMFs), which heavily rely on short-term funding like tri-party repurchase agreements (repos) and commercial paper (CP). *Appendix 1* briefly describes key shadow banking actors and discusses their roles during the subprime lending crisis. See Gorton and Metrick (2010), Adrian and Ashcraft (2012), Claessens, Pozsar, Ratnovski, and Singh (2012), and Martin, Skeie, and Von Thadden (2012) for more elaborate discussions.[32]

As in the case of the OTH model, banks create liquidity in the OTD model as well, since they continue to originate the loans that are subsequently sold or securitized. There are two key differences, however, from a liquidity creation perspective. The first is that with the OTH model, the risk associated with liquidity creation is borne by the bank, whereas with the OTD model this risk is borne largely by the investors who purchase the loans or securities created by securitization.[33] The second difference is that funding for loans in the OTH model tends to come from (core) deposits, while funding for securitized structures in the OTD model typically comes eventually from repos and CP, even though the pre-securitization origination of the loan may have involved deposit funding. Unlike core deposits, there is no deposit insurance backing repos and CP funding, so runs are possible. Various papers document that such runs indeed occurred during the subprime lending crisis – see Gorton and Metrick (2012) for evidence on a "run on repos"[34] and Covitz, Liang, and Suarez (2013)

[31] The Financial Stability Board (FSB, 2012) describes the shadow banking system more broadly as "credit intermediation involving entities and activities (fully or partially) outside the regular banking system" or non-bank credit intermediation.
[32] Calomiris, Himmelberg, and Wachtel (1995) discuss how growth of the CP market was driven by growth of finance companies, and how it fuelled disintermediation by providing high-quality firms a low-cost alternative to short-term debt.
[33] Banks typically continue to bear some risk - they often provide guarantees and keep (part of) the lowest-rated tranche.
[34] They focus on the bilateral (i.e., interdealer) repo market and interpret an increase in margin requirements ("haircuts") as a run. Copeland, Martin, and Walker (2012) find that no such run seemed to have taken place in the tri-party repo market, which may have accounted for 50-60 percent of all outstanding repo in the U.S. Krishnamurthy, Nagel, and Orlov

for evidence on "runs on ABCP.[35]" These differences aside, loan sales and securitization do not alter the fact that bank-intermediated liquidity creation occurs in the economy – it merely reflects a change in the *process* by which this liquidity creation is occurring.

Bord and Santos (2012) assess the impact of the OTD model on corporate lending. They document that while lead banks retained 21% of the term loans they originated in 1988, that share had dropped to a mere 3.4% by 2010. Banks' increasing use of the OTD model helped to fuel the syndicated loan market from $339 billion in 1988 to an all-time high of $2.2 trillion in 2007. The secondary loan market transformed from a market in which banks hardly participated to an active market with volumes that rose from $8 billion in 1991 to $176 billion in 2005.

Another indication of how much the OTD market has grown is to examine funding of the shadow banking system and bank deposit funding over time. *Figure 4* below shows that while they were roughly equal in 1988 ($2.7 trillion versus $2.4 trillion), shadow bank funding grew much more rapidly until the subprime lending crisis, peaking at $23.0 trillion in 2007 (versus bank deposit funding of $7.3 trillion in that year). While shadow bank funding dropped somewhat during the crisis, bank deposit funding increased, likely because of a flight to quality.

[Insert Figure 4 here]

REGULATION TO PRESERVE UNINTERRUPTED LIQUIDITY CREATION GOING FORWARD

Liquidity creation occupies an important seat at the table in both the OTH and OTD models. But for liquidity creation to not be ruptured, it is critical that banks operate with sufficiently high equity

(2013) find similar results and argue that Gorton and Metrick's (2012) "run on repo" is not the equivalent of a traditional bank run by depositors – to establish that, one should not analyze inter-dealer data but rather examine whether investors run on dealers. Martin, Skeie, and Von Thadden (2012) show that increasing margin requirements can be stabilizing: while it results in some loss of funding, it is better than losing all funding, as seemed to have happened with Lehman.

[35] Martin, Skeie, and Von Thadden (2013) show under what conditions short-term funding markets such as the repo market are immune to expectation-driven runs and discuss the scope of regulation to stabilize such markets.

capital and liquidity. That became apparent during the subprime lending crisis, which brought issues regarding both to the forefront of the discussions, and has prompted a call for revised capital regulation and new liquidity regulation. I now discuss some of the key regulatory issues and the progress made in the implementation of new regulations in the U.S. and Europe.

Capital Requirements for Traditional OTH Banking and for OTD Shadow Banking

Basel III

The subprime lending crisis revealed important weaknesses in Basel I and II. Both Accords seemed to provide inadequate incentives for banks to hold sufficient capital. Moreover, these accords failed to appropriately incorporate the risks posed by securitization, lacked liquidity standards, and failed to incorporate systemic risks associated with the buildup of leverage in the financial system. Inadequate levels of capital may have led to imprudent asset choices by banks, which then raised solvency concerns that contributed to the drying up of liquidity for banks during the recent crisis.

In response to these perceived shortcomings, various academics have written proposals which essentially argue that there are externalities due to the safety net provided to banks and thus social efficiency can be improved by requiring banks to operate with more capital, especially during financial crises (e.g., Kashyap, Rajan, and Stein, 2008; Admati, DeMarzo, Hellwig, and Pfleiderer, 2011; Calomiris and Herring, 2011; Hart and Zingales, 2011; Acharya, Mehran, and Thakor, 2013).

Consistent with the academic perspective, Basel III – released in December 2010 – proposes higher capital requirements and raises the quality of capital to address the seeming deficiencies of the prior Basel Accords (BIS, 2010, 2013b). Figure 5 compares Basel II and III capital requirements.

[Insert Figure 5 here]

First, it increases the minimum tier 1 risk-based capital ratio from 4% to 6%, and requires that the common equity component of tier 1 capital goes up from 2% to 4.5% to ensure that a bank holds

sufficient truly loss-absorbing capital (both requirements fully phased in by January 1, 2015). It leaves the minimum total risk-based capital ratio unchanged at 8%. Second, to reduce procyclicality and better withstand future periods of stress, it introduces a capital conservation buffer (additional common equity tier 1 of 2.5% of risk-weighted assets, fully phased in by January 1, 2019). Third, to reduce systemic risk that has built up as a result of excessive credit growth, a country's regulator may impose a countercyclical capital buffer (additional common equity tier 1 of 0% – 2.5% of risk-weighted assets). Fourth, to constrain leverage in the banking sector and to introduce extra safeguards against model risk and measurement error, it supplements the risk-based capital requirements with a minimum leverage ratio (based on tier 1 capital to on- and off-balance sheet assets) of 3% by 2018.[36] Fifth, it subjects globally systemically important banks (G-SIBs) to additional loss absorbency requirements (extra common equity tier 1 of 1% – 2.5% of risk-weighted assets depending on assessed systemic importance, fully phased in by January 1, 2019).[37]

All 27 member jurisdictions of the Basel Committee were supposed to translate the Basel III standards into their own national laws and regulations by January 1, 2013. As of April 2013, only 14 had done so (BIS, 2013c). The other 13 had published their draft regulations.

The E.U. intends to apply Basel III to all financial institutions. The U.S. proposes to apply it to all U.S. insured depository institutions, BHCs with at least $500 million in assets, and savings and loan holding companies. It plans to retain the distinction between the Advanced Approaches Banks

[36] As discussed above, U.S. banks had already been subject to a minimum leverage ratio since the early 1980s. However, the U.S. ratio is defined differently since it is based on tier 1 capital relative to on-balance sheet assets.

[37] G-SIBs are banks whose distress or disorderly failure would significantly disrupt the wider financial system and economic activity (BIS, 2011). G-SIBs are identified every year in November (starting in 2011) based on five equally-important characteristics: bank size, complexity, interconnectedness, lack of substitutability, and cross-jurisdictional activity. As of November 2012, there are twenty eight G-SIBs (see FSB, 2012b) of which four are subject to 2.5% extra capital (Citigroup, Deutsche Bank, HSBC, and JP Morgan Chase), two need to hold 2% extra capital (Barclays and BNP Paribas), eight are subjected to 1.5% extra capital (Bank of America, Bank of New York Mellon, Credit Suisse, Goldman Sachs, Mitsubishi UFJ FG, Morgan Stanley, Royal Bank of Scotland, and UBS), and the remaining fourteen have to keep 1% extra capital (Bank of China, BBVA, Groupe BPCE, Group Crédit Agricole, ING Bank, Mizuho FG, Nordea, Santander, Société Générale, Standard Chartered, State Street, Sumitomo Mitsui FG, Unicredit Group, and Wells Fargo).

and other banks for certain purposes (e.g., the counter-cyclical capital buffer would only apply to the Advanced Approaches Banks). Maybe surprisingly in light of the major role played by liquidity during the subprime lending crisis and as further discussed below, the U.S. proposals only see a role for Basel III's liquidity requirements for the very largest financial institutions.

Some argue that Basel III is not aggressive enough, that even higher capital requirements are needed and that they need to be imposed sooner (e.g., Financial Times, 2012; Haldane and Madouros 2012; Bloomberg, 2013).[38] In deciding on the appropriate level (and form) of future capital requirements, two key issues need to be considered: the effect on bank output, and the need for capital regulation in the shadow banking system.

Key Issue #1: Effect of Higher Capital Requirements on Bank Output

The first issue is the effect of higher capital requirements on bank output (alternatively measured as lending or liquidity creation).[39] Bankers are vocal in this respect – they claim that increases in capital would negatively affect their performance and lead to less lending. The academic literature suggests a more complex picture.

The theories produce opposite predictions. Some argue that the relationship between capital and bank liquidity creation or lending should be negative (e.g., Diamond and Rajan, 2001) because demandable deposits help to resolve a hold-up problem that cannot be resolved by bank capital. Others argue that capital will facilitate liquidity creation and other forms of bank output because it helps to absorb the risks associated with those activities (e.g., Bhattacharya and Thakor, 1993; Allen and Santomero, 1998; Allen and Gale, 2004; Repullo, 2004; Von Thadden, 2004; Coval and Thakor, 2005).

[38] The Systemic Risk Council, chaired by former FDIC Chairman Sheila Bair, proposes a minimum leverage ratio of 8% (2012). Admati and Hellwig (2013) propose it should be 20% to 30%.
[39] For an earlier discussion on this, see Berger, Herring, and Szego (1995).

The U.S. evidence is mixed. In the early 1990s, U.S. regulators imposed new leverage requirements, as well as the Basel I risk-based capital standards. Many studies conclude that the leverage requirements may have reduced lending (e.g., Berger and Udell 1994; Hancock, Laing, and Wilcox 1995; Peek and Rosengren 1995), while Thakor (1996) shows that the risk-based capital requirements may have had a similar effect, at least in the short run. However, the unusual combination of several major changes in capital regulation and a recession makes it challenging to separate the different effects and draw general conclusions.

European evidence suggests that the effect of higher capital requirements differs by bank type and the state of the business cycle. Using data from the U.K., Aiyar, Calomiris, and Wieladek (2012) find that increases in minimum capital requirements are associated with a decline in lending by some (U.K. banks and branches of foreign banks) and an increase in lending by others (subsidiaries of foreign banks). Using unique data from changes in capital regulation in Spain, Jiménez, Ongena, Peydró, and Saurina (2013) show that countercyclical capital buffers mitigate the effect of business cycles – while such buffers lead to less credit in good times, they result in more lending in bad times.

The studies discussed above focus on capital requirements, but many others focus on capital per se. Several studies find a significant reduction in lending following a decline in capital arising from loan losses in the 1920s – 1930s (e.g., Calomiris and Wilson, 2004) and late 1980s – early 1990s (e.g., Peek and Rosengren, 1995), consistent with a positive relationship between capital and lending during a period of distress. Using data on 165 large U.S. BHCs from 1992 – 2009, Berrospide and Edge (2010) also find that higher capital (the actual level or measured relative to an estimated target) is associated with higher loan growth, although the effect seems to be small. Francis and Osborne (2009) use data on banks in the U.K. from 1989 – 2007 to show that banks with greater surplus capital have higher growth in lending and off-balance sheet activities. They argue that higher capital requirements would reduce the amount of surplus capital and that a positive relationship between

surplus capital and lending should be viewed as evidence that higher capital requirements reduce lending. While this argument may be valid in the short run in which capital is hard to adjust, it does not seem appropriate in the long run. Some recent contributions in this area define bank output as liquidity creation instead of lending. Berger and Bouwman (2009) examine the relationship between bank capital and the amount of liquidity they create using data on banks in the U.S. from 1993 – 2003. For large banks, which create by far most of the liquidity, they find a positive relationship (driven largely by the effect on off-balance sheet activities), whereas for small banks, the relationship is negative. European evidence on this topic is starting to emerge (e.g., Distinguin, Roulet, and Tarazi, 2013; Horvath, Seidler, and Weill, forthcoming) and tends to suggest that capital and on-balance sheet liquidity creation are negatively related in Europe.

While the papers discussed above examine the effect of higher capital requirements and higher capital on bank output, it is useful to briefly address two related issues in closing. First, higher capital requirements may affect loan rates. Specifically, if higher capital requirements cause banks to operate with more capital, then two effects may be generated. First, the replacement of tax-advantaged debt with equity may increase the bank's weighted average cost of capital, putting upward pressure on loan rates. But second, higher capital will reduce the bank's debt funding cost (due to the cushioning effect of capital and also its incentive effects), and this reduction may be large enough to increase the bank's return on equity, so that higher capital in the bank may exert downward pressure on loan rates.[40] The overall effect of bank capital on loan rates may thus turn out to be small. Simulations by Hanson, Kashyap, and Stein (2010) support this notion – depending on the chosen scenario, a 10 percentage point increase in the capital ratio would cause loan rates to increase by a mere 25 to 45

[40] Cross-country studies on the relationship between capital (not: capital requirements) and loan rates tend to find evidence consistent with this (e.g., Demirgüç-Kunt and Huizinga, 1999; Saunders and Schumacher, 2000). Osborne, Fuertes, and Milne (2012) document that, for UK banks, the positive relationship between capital and loan rates exists only in non-crisis periods, and becomes negative during a crisis.

basis points. Second, it is important to remember that a key reason to impose higher capital requirements is to obtain a safer and less fragile banking sector.[41] Consistent with this objective, Mehran and Thakor (2011) show theoretically and find empirically that bank capital and bank value are positively related in the cross-section. Beltratti and Stulz (2012) provide evidence that banks which had higher tier 1 capital ratios before the recent subprime lending crisis showed better stock performance during the crisis. Berger and Bouwman (2013) show that capital helps small banks to survive at all times (during crises and normal times), and helps large banks primarily during banking crises. Baker and Wurgler (2013) document that in the past 40 years, banks with higher capital had lower betas risks but higher stock returns, leading them to conclude that higher capital requirements will increase the cost of capital in banking, although they will also make banks systematically safer.

In sum, it appears that the effects of higher *capital requirements* on bank output are mixed, but in the US, this is in part because the introduction of higher capital requirements in the early 1990s coincided with changes in the type of capital requirements and a recession which makes it harder to interpret the results. In contrast, it seems that higher *capital* generally benefits banks and their borrowers, reduces bank-specific and systemic risks (e.g., Acharya and Thakor, 2012; Farhi and Tirole, 2012), and reduces the need for taxpayer-funded bailouts (e.g., Farhi and Tirole, 2012).

Key Issue #2: Capital Requirements and the Shadow Banking System

A second issue is that imposing higher capital requirements might lead to widespread migration of financial intermediation towards the less regulated shadow banking system (Hanson, Kashyap, and Stein, 2011; FSB, 2012c). This is a concern since the subprime lending crisis showed that the absence of an explicit government safety net in this market can cause runs and that liquidity can dry up for

[41] Several recent papers examine how capital injections by the government affect bank lending in the U.S. (e.g., Duchin and Sosyura, 2012; Li, 2012; Black and Hazelwood, forthcoming) or liquidity creation in Germany (Berger, Bouwman, Kick, and Schaeck, 2012).

institutions in the shadow banking system, which can then threaten overall liquidity creation in the economy. Many of these institutions are considered "systemically important," so the government has an (ex post) incentive to rescue them, as we saw with non-deposit-insured institutions like Bear Stearns and American International Group (AIG) in the subprime lending crisis.

One way to address this issue is to impose capital requirements on shadow banks. Basel III includes steps in this direction (FSB, 2012c): it increases capital requirements for short-term liquidity facilities provided to securitization vehicles, and for exposures to unregulated financial institutions regardless of size. The Basel Committee decided against increasing capital requirements related to banks' short-term liquidity facilities to MMFs, fearing this could have unintended consequences and might be unnecessary in light of the introduction of the liquidity coverage ratio. The Dodd-Frank Act imposes capital requirements on shadow banks that are considered SIFIs. The Financial Stability Oversight Council proposed in early June 2013 to designate AIG, Prudential Financial, and GE Capital as such.

More steps are likely needed to prevent migration toward the shadow banking system. Gorton and Metrick (2010) discuss several additional proposals, including the conversion of MMFs that offer bank-like services (transaction accounts and the ability to withdraw funds on demand at par) into "narrow savings banks" with appropriate supervision, government insurance, and access to lender-of-last-resort facilities.

Liquidity Requirements – International and U.S. Developments

Although reserve requirements have taken a back-seat in U.S. regulation, there is now growing momentum for having explicit liquidity requirements for financial institutions, both in the U.S. and in other countries. Some of these developments are briefly reviewed here.

The Basel Committee is introducing liquidity regulation as part of Basel III. This is a departure from Basel I and II, which focused on strengthening capital regulation. The original December 2010 liquidity framework (BIS, 2010) specifies two minimum liquidity requirements with complementary objectives. The first is the liquidity coverage ratio (LCR) which promotes short-term resilience – to survive a specified stress scenario which lasts one month, banks have to operate with enough high-quality liquid assets. The second is the net stable funding ratio (NSFR) which promotes long-run resilience – to be able to survive an extended closure of wholesale funding markets, banks have to operate with a minimum acceptable amount of "stable funding" based on the liquidity characteristics of the bank's assets and activities over a one-year period. The Basel Committee initially focused on operationalizing the LCR and an amended proposal was endorsed by its oversight body in January 2013 (BIS, 2013a). It is currently working on operationalizing the NSFR. The discussion below reflects this two-step approach: it discusses the LCR in depth but only briefly describes the NSFR.

The LCR requires that a bank's stock of unencumbered high-quality liquid assets (HQLA) generally equals or exceeds its projected net cash outflows (NCOF) over a 30-day horizon under a stress scenario prescribed by the supervisors: $LCR = \frac{HQLA}{NCOF} \geq 100\%$. The numerator includes so-called Level 1 assets (cash, central bank reserves, and certain marketable securities backed by sovereigns and central banks), Level 2A assets (certain government securities, covered bonds and corporate debt securities), and Level 2B assets (lower-rated plain-vanilla senior corporate bonds and certain residential mortgage-backed securities). Level 2 (2B) assets may not account for more than 40% (15%) of the bank's total stock of HQLA. The denominator is defined as total expected cash outflows minus total expected cash inflows in the specified stress scenario for the next 30 days. Total expected cash outflows are calculated by multiplying the outstanding balances of different types of liabilities and off-balance sheet commitments by the rates at which they are expected to run off or be

drawn down in the prescribed stress scenario. For example, unsecured interbank loans are assumed to run off fully if they come due during the stress scenario, while deposits are assumed to run off by 5% or 10%, depending on the type of deposit. To ensure a minimum level of HQLA holdings at all times, total cash inflows are subject to a cap of 75% of total expected cash outflows. While banks are expected to keep their LCR above 100% at all times, the latest proposal suggests that banks' LCR may drop below the minimum requirement during times of stress (BIS, 2013b). The LCR will be introduced internationally on January 1, 2015, with a minimum requirement starting at 60%, increasing gradually in 10% annual increments to 100% on January 1, 2019.

The Federal Reserve intends to implement some form of the LCR, but the scope, timing and nature of such implementation is unclear. In its proposals to implement parts of the Dodd-Frank Act's systemic risk regulation framework, the Federal Reserve indicates that it intends to apply the LCR to: (a) all or a subset of the U.S. systemically important financial institutions or SIFIs (U.S. BHCs with consolidated assets of at least $50 billion and U.S. non-bank financial companies that the Financial Stability Oversight Council designates as systemically important) (Federal Reserve, 2012a); and (b) the U.S. operations of all or a subset of large foreign banking organizations (with combined U.S. assets of at least $50 billion) (Federal Reserve, 2012b).

If implemented, it is unclear how the LCR would interact with the liquidity risk management standards proposed in the Dodd-Frank enhanced prudential standards for large U.S. and foreign institutions. A few fundamental differences exist. First, while the LCR makes one-size-fits-all liquidity run-off assumptions which all banks have to use to determine the size of the liquidity buffer, the Federal Reserve's proposed internal stress testing would require each institution to conduct internal liquidity stress tests which are tailored to its capital structure, riskiness, complexity, size, and activities, and to use the results of these tests to calculate the size of its liquidity buffer. Second, the LCR requires banks to apply prescribed haircuts to specific asset classes when establishing its stock

of high-quality liquid assets, whereas the Federal Reserve's proposals merely ask an institution to discount the fair market value of assets included in its liquidity buffer to reflect any market volatility and credit risk. Third, the LCR relies on external ratings and requires a bank to calculate the amount of collateral it would have to post after a three-notch downgrade of the bank's rating, whereas Section 939A of the Dodd-Frank Act demands that regulations do not rely on external ratings and replace them with alternative standards of creditworthiness.

The NSFR requires that a bank's available stable funding (ASF) exceeds the required amount of stable funding (RSF) based on the liquidity characteristics of the bank's assets and activities over a one-year bank-specific stress scenario: $NSFR = \frac{ASF}{RSF} > 100\%$. Stable funding includes equity, preferred stock with a maturity of at least one year, liabilities with effective maturities of at least one year, and demand deposits / term deposits / wholesale funding with maturities of less than one year that are expected to stay with the bank in case of idiosyncratic stress. The numerator is determined by assigning weights to the amounts of stable funding the bank has. For example, tier 1 and tier 2 capital receive weights of 100% (fully stable), stable deposits are weighted at 80%, while less stable deposits obtain a weight of 50%. The denominator is calculated as the sum of the bank's assets and off-balance sheet activities multiplied by an RSF factor assigned to each asset and off-balance sheet activity type. Activities that are more liquid receive the lowest RSF factors (and require less stable funding) because they can act as a source of extended liquidity in case of stress. For example, cash receives a weight of 0%, conditionally revocable and irrevocable credit and liquidity facilities to any client are weighted at 5% of the undrawn portion, loans to non-financial corporates / sovereigns / central banks with a remaining maturity of less than one year are weighted at 50%, residential mortgages that qualify for a risk weight of up to 35% under Basel II's standardized approach obtain a weight of 65%, while loans to retail customers and small business customers with a remaining maturity of less than one year are weighted at 85%. (See BIS (2010) for more detail.)

Understanding Better How Liquidity Requirements Interact with Capital Requirements

Liquidity requirements and capital requirements are designed to address two different problems and they affect different sides of the bank's balance sheet – liquidity requirements deal with withdrawal risk on the liability side by stipulating that a fraction of the bank's assets be held as cash or deposits with the central bank, whereas capital requirements deal with asset-substitution risk by stipulating that a fraction of the bank's liabilities be in the form of equity. Nonetheless, liquidity requirements and capital requirements may interact. Little academic research has been done in this important area.

Two recent papers address this issue theoretically. Acharya, Mehran, and Thakor (2013) examine optimal capital regulation for banks that face two moral hazard problems: shirking by managers (i.e., underprovision of monitoring) and risk-shifting by shareholders. They show that a simple minimum capital requirement can rule out the second problem, but not the first problem, since it makes debt so safe that it eliminates market discipline related to loan monitoring. To deal with both moral hazards, they propose that regulators impose two kinds of capital requirements: a regular minimum capital requirement and a "special capital account." The regular capital can be used to invest in any type of assets. In contrast, the special capital has to be invested in relatively safe and liquid assets (which can be monitored and do not cause a downward price spiral in case of liquidation) such as Treasuries, and can thus be viewed as a liquidity requirement. The key innovation in the paper's proposal is that the special capital belongs to the bank's shareholders as long as the bank is solvent, but when the bank is insolvent, this capital goes to the regulator, not the bank's creditors. This means that this special capital is "invisible" to the bank's creditors and does not dilute their incentive to discipline the bank.

Calomiris, Heider, and Hoerova (2013) incorporate two unique aspects of cash relative to capital: the value of cash is observable at all times, and cash is riskless, making it impervious to risk

shifting. These two features mean that cash does not only mitigate liquidity risks associated with exogenous withdrawal shocks, but also mitigates endogenous asset risk. Specifically, the market recognizes that banks with higher cash holdings make more prudent risk-management decisions and thus will be more willing to provide funds, which implies that in bad states of the world, banks will avoid higher asset risk and increase their cash holdings to preserve market confidence. A key insight of the paper is that liquidity requirements should not be viewed as a mere insurance policy to deal with liquidity risk that may occur in a financial crisis, but also as a prudential regulatory tool that – like capital requirements – can limit default risk and encourage good risk management. That is, liquidity requirements and capital requirements act as (imperfect) substitutes.

The optimal design of both capital and liquidity requirements can only be addressed with a good understanding of the nature of government intervention in financial crises. It would be preferable to acknowledge up-front that such intervention is unavoidable and ask how capital and liquidity requirements should be designed ex ante, conditional on knowing that bailouts will occur ex post in circumstances that can be identified ex ante.

CONCLUSION

This chapter has covered the theory and empirical evidence related to bank liquidity creation to shed light on the underlying economics of this central aspect of the financial system. It has also covered regulatory issues and how these are affected by the evolution of banking from an Originate-To-Hold (OTH) model to one that has a mix of OTH and Originate-To-Distribute (OTD). These developments have profound implications for regulatory policy that is designed to ensure that liquidity creation continues without the costly breaches associated with financial crises.

As discussed, much work remains to be done. Foremost among these is the question of how capital requirements ought to be designed for both traditional OTH banking activities as well as for

the newly-emerged shadow banking system. A second question is the design of liquidity requirements. These two issues should not be addressed in isolation. It is critically important to develop a good understanding of how capital and liquidity requirements interact. Finally, Farhi and Tirole (2012) highlight the fact that inefficient bailouts of banks by regulators may occur because regulators cannot distinguish between insolvency and illiquidity even ex post, so research that informs regulators about how to distinguish between insolvency and illiquidity as a precursor to intervening in what looks like a crisis would be very useful.

Appendix 1: The shadow banking system

The types of activities and institutions that are part of the shadow banking system continues to evolve. Important players include the following (for a review, see Adrian and Ashcraft, 2012).

First, asset-backed securities (ABS): ABS are securities backed by claims on pools of assets such as loans and mortgages. The cash flows of the underlying assets are sliced and diced in different ways into several tranches, which are typically rated. The most senior tranche receives the highest rating (e.g., AAA) and the most junior tranche is the equity tranche, which may be retained by the issuer. Often a special purpose vehicle (SPV) is created to handle the securitization. The SPV is bankruptcy-remote, which allows the structure to receive off-balance sheet treatment. Collateralized debt obligations (CDOs) are a special form of ABS in which lower-rated tranches (e.g., the BBB tranches) of several securitizations may be pooled together and again split in various ways, creating yet again tranches with AAA, AA, etc., ratings. Some blame the financial woes of the subprime lending crisis on the complexity of CDOs and a failure of the models used by rating agencies to value them. The first CDO was created by Drexel Burnham Lambert Inc. in 1987. CDO issuance was at its highest in 2007 and fully collapsed during the crisis.

Second, asset-backed commercial paper (ABCP) conduits: an ABCP conduit is a bankruptcy-remote entity that issues CP to finance the purchase of a pool of financial assets (such as trade

receivables). To make the CP more appealing or to get a higher rating, a program sponsor typically arranges some form of credit enhancement (e.g., overcollateralization or excess cash) and/or a backup-borrowing facility. ABCP experienced a run in the Summer of 2007, when American Home, sponsor of a conduit, declared bankruptcy, and three of its mortgage programs extended the maturity of their paper. Not being able to value ABCP holdings, BNP Paribas stopped redemptions at two money market mutual funds on August 7, 2007. A run by investors on more than 100 programs (1/3 of the market) followed (see Covitz, Liang, and Suarez, 2013).

Third, tri-party repurchase agreements (repos): repos are collateralized deposits. A depositor puts funds in a bank for a short period (typically overnight) and the bank promises to pay the overnight repo rate. Since the funds tend to be too big to qualify for deposit insurance, the depositor demands collateral, which it can sell if the bank fails. Repos are overcollateralized – the difference between the collateral value and the sale price is the repo haircut. In a tri-party repo, a clearing bank holds the collateral, ensuring that both the lender and the borrower are protected against the other party's default. A 1984 law exempted repos on "safe" collateral from the automatic stay in bankruptcy, meaning that lenders would get quick access to their collateral in case of dealer default, fueling growth of the market. In 2005, mortgage-backed repos were given similar treatment. Their prevalence led to runs on repo during the subprime lending crisis.

Fourth, money market funds (MMFs): MMFs are open-ended mutual funds which invest in short-term securities like treasuries, CP, and repos. From 1971 onward, MMFs have acted as an alternative to bank deposits from the investors' perspective. In that year, Regulation Q restricted the interest rates that banks could pay on deposits. The MMF sector reached an all-time high at $3.5 trillion in 2008. The net asset value of MMFs is typically constant at $1. If it drops below $1, it is "breaking the buck." This can happen when its investment income does not cover its operating expenses, for example, because interest rates have dropped. The day after Lehman Brothers went

bankrupt in September 2008, the Reserve Primary Fund broke the buck, triggering a run on MMFs. In reaction to this, other fund managers sold assets or reallocated to treasuries, thus exacerbating the funding problems for other instruments such as repos and CP.

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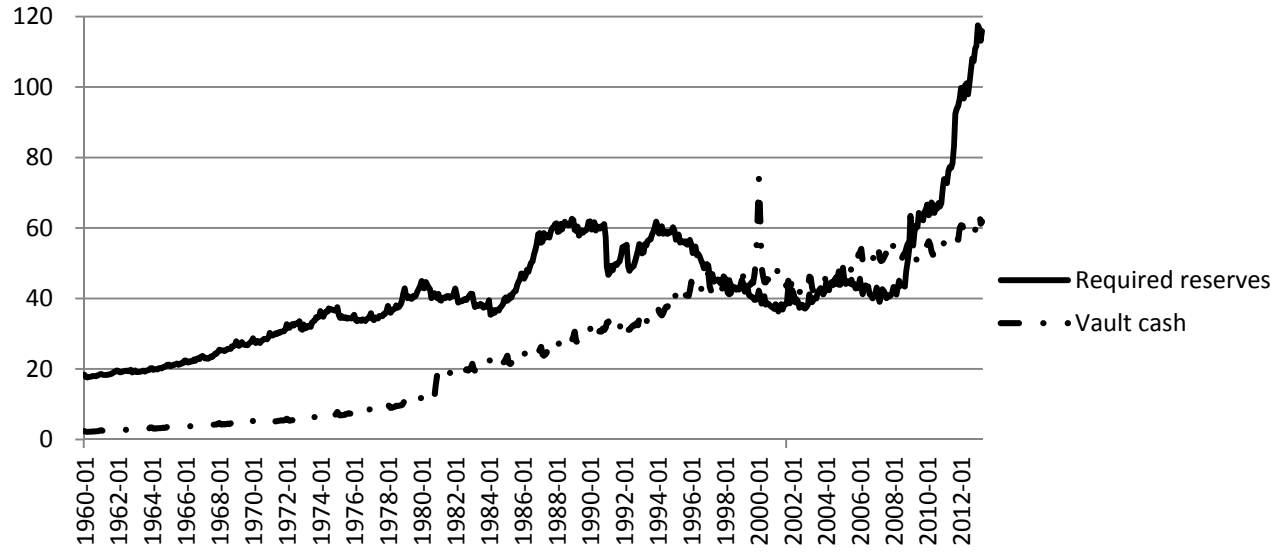
Figure 1: Total Reserve, Required Reserves, and Vault Cash over Time
This figure focuses on reserves of the U.S. banking sector from January 1960 – April 2013. Panel A shows both the dollar amounts of required reserves and vault cash, while Panel B contrasts the dollar amounts of required reserves with the total amount of reserves held.

Data Source: Aggregate Reserves of Depository Institutions and the Monetary Base, Not Seasonally Adjusted – H.3 Table 2

Panel A: Required Reserves and Vault Cash in $ Billion (January 1960 – April 2013)



Panel B: Total Reserves and Required Reserves in $ Billion (January 1960 – April 2013)

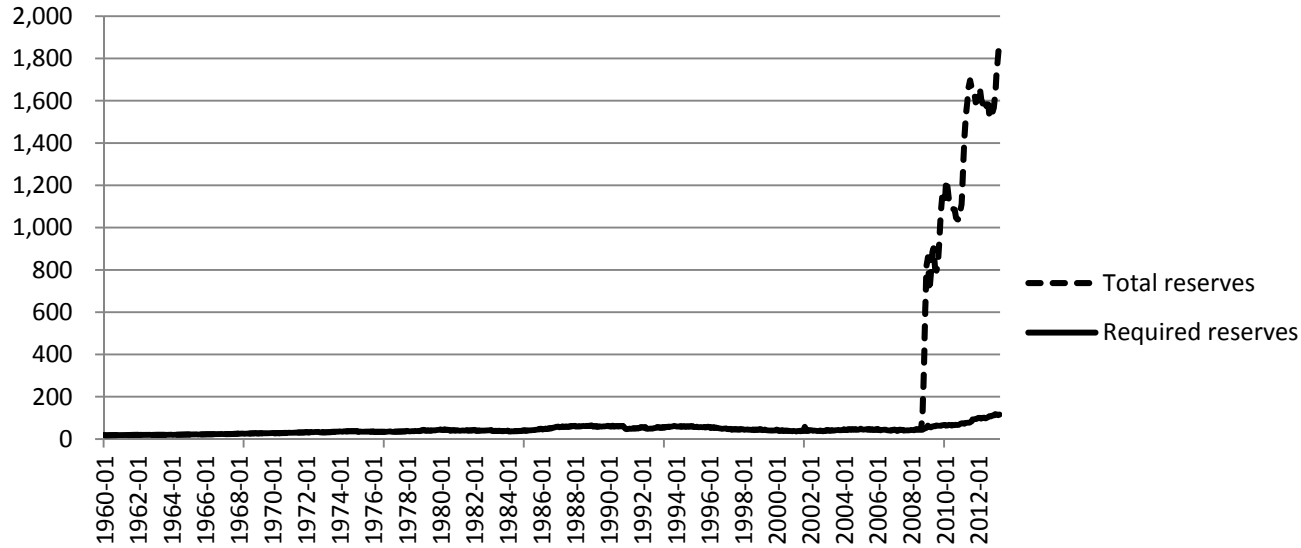


Figure 2: Capital Ratios over Time
This figure shows capital ratios of all insured commercial banks in the U.S. from 1934 – 2012. The capital ratios are measured as aggregate book equity normalized by aggregate book assets of the banking sector.

Data Source: Table CB14 of FDIC's Historical Statistics on Banking

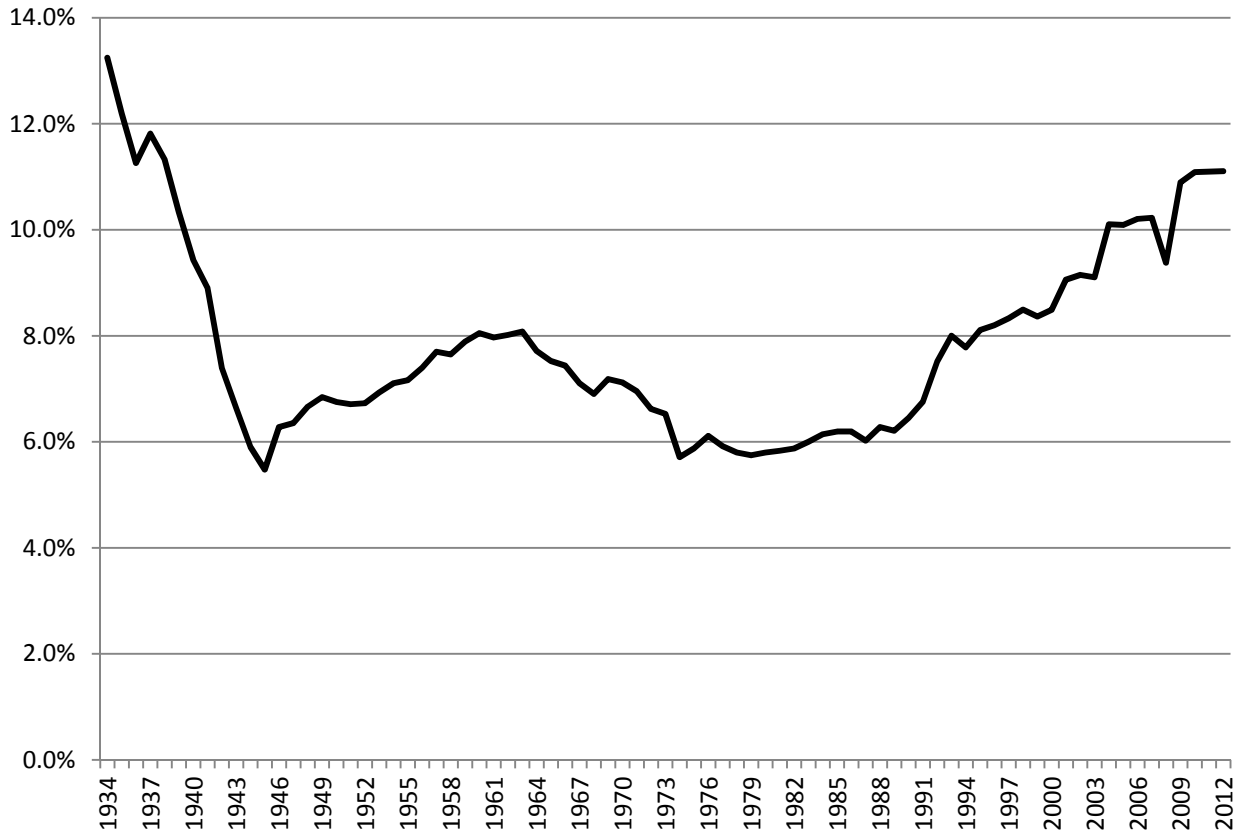
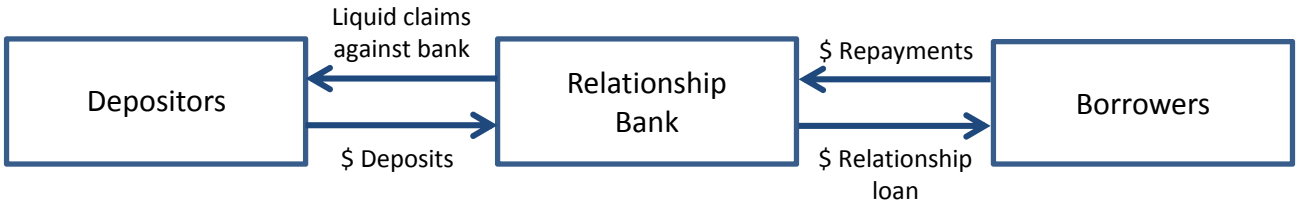


Figure 3: Traditional Banking versus Securitization in the Shadow Banking System
This figure compares the Originate-To-Hold (OTH) model of traditional banking with the Originate-To-Distribute (OTD) model of the shadow banking system.

Panel A: Traditional Banking (OTH)



Panel B: Securitization in the Shadow Banking System (OTD)

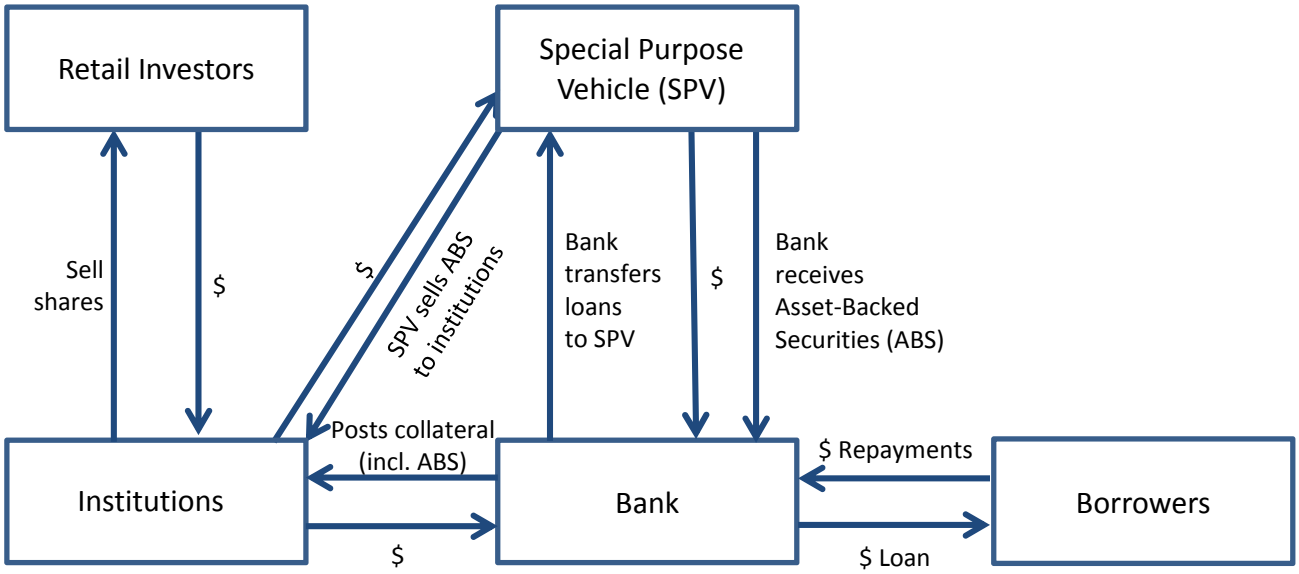


Figure 4: Shadow Bank Funding and Bank Deposit Funding over Time
This figure shows shadow bank funding and traditional bank deposit funding in USD trillions in the U.S. from 1988 – 2012. Shadow bank funding is defined as in Adrian and Ashcraft (2012) and is created using data from the Federal Reserve Flow of Funds Table L.107. It is the sum of money market mutual funds (line 31), repos (line 32), commercial paper (line 34), agency- and GSE-backed securities (line 35), and security broker-dealer payables plus credit (lines 41 and 42). Bank deposit funding is total deposits of insured banks as provided in Table CB14 of the FDIC's Historical Statistics on Banking.

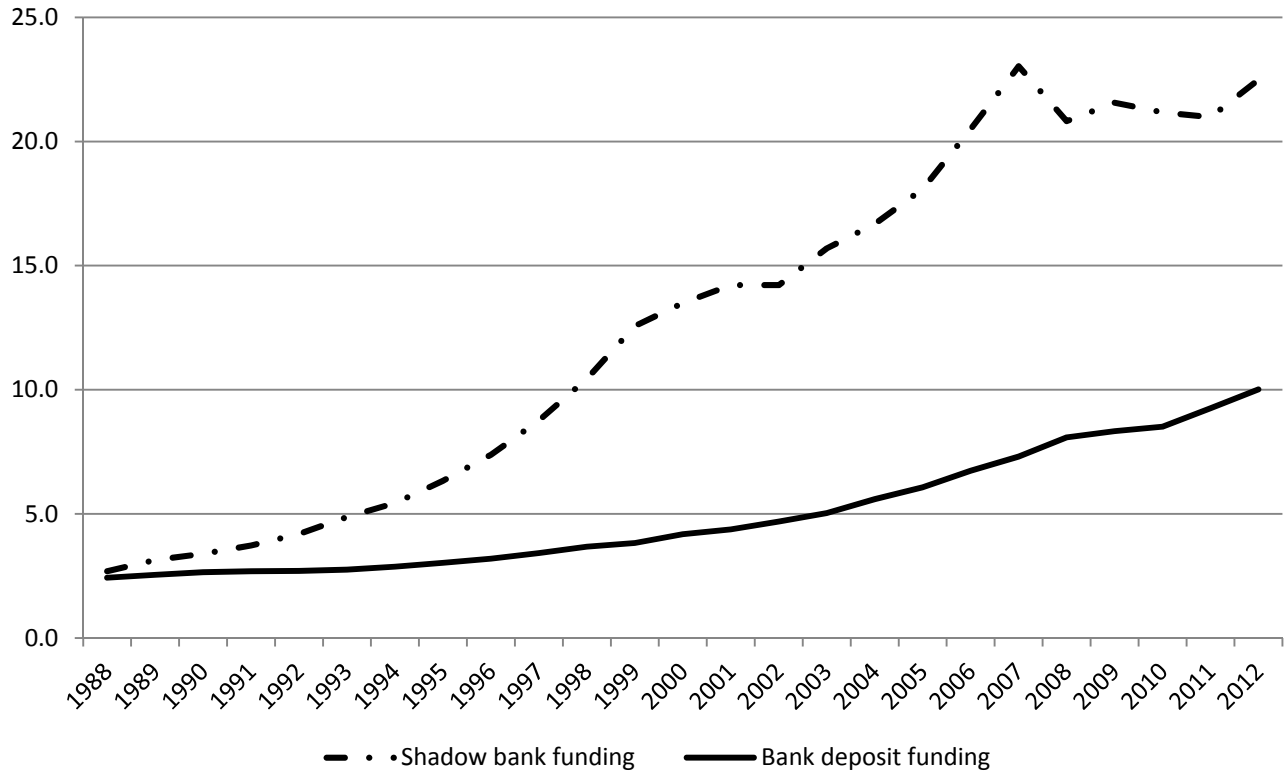


Figure 5: Comparison of Basel II and Basel III Capital Requirements
This figure shows the Basel II and Basel III risk-based capital requirements, and the Basel III tier 1 minimum leverage ratio. It also explains the U.S. plans to impose two leverage ratios.