Capital, Contagion, and Financial Crises: What Stops a Run from Spreading?

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After the 2008 financial crisis, policymakers focused on enacting improvements in two areas of financial regulation: capital and liquidity, affecting the composition of bank assets and the sources of bank funding. These improvements made both the emergence of a crisis less likely and the recovery from one more rapid. This article suggests, however, that post-crisis reforms did not address a distinct and critical third task: how to limit the damage—to other firms, and to the financial system—once a panic begins.

Using data on share prices and credit default swaps, we show that—at their low pre-crisis levels—the balance-sheet liquidity and regulatory capital of a banking institution did not predict the impact of the September 15, 2008 run on Lehman Brothers on that institution. On the contrary, in some markets, banks with greater balance-sheet liquidity and regulatory capital were *more* exposed—not less—to the resulting panic, and the higher their levels of regulatory capital, the more they relied on debt for funding. By contrast, we show that simple share-price correlation was a powerful predictor of run exposure, and that market valuations of large banks are more highly correlated today than they were in September 2008. This increase in correlation implies a convergence in the banks' business models, which could offer a ready conduit for an unexpected shock to metastasize into a contagious run.

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Table of Contents

I. INTRODUCTION

The early hours of September 15, 2008 were some of the most consequential and uncertain in American financial history. Lehman Brothers Holdings, Inc. ("Lehman") had filed for bankruptcy the night before, launching an insolvency process that would affect hundreds of billions of dollars in financial assets.[2] The previous Friday—the most recent time U.S. markets were open for trading—common wisdom held that another investment bank would purchase Lehman, perhaps with public assistance, as had been the case when JPMorgan Chase & Co. purchased Bear Stearns six months earlier. Instead, the day's trading began with news that Lehman had gone under, and that the accounts of Lehman's British and Japanese brokerage operations had been frozen.[3]

Investors were, quite understandably, unsure how to react.[4] However, their behavior was not indiscriminate. In the previous months, through the failure of Bear Stearns and the nationalization of Fannie Mae and Freddie Mac, the equity and debt markets had a fairly uniform view of large financial institutions; their credit default swap ("CDS") spreads, the price of insuring against a default on their debt, remained tightly clustered, and their share prices remained highly correlated. Lehman's bankruptcy shattered that uniformity. By the end of the day, the prices and spreads on large financial institutions had splintered, with some on a vastly more adverse trajectory than others. (*See* **Figures 1** and **2**.) Fears about Lehman had spread, but they had not spread evenly.

Figure 1: Share Prices Circa Lehman Bankruptcy

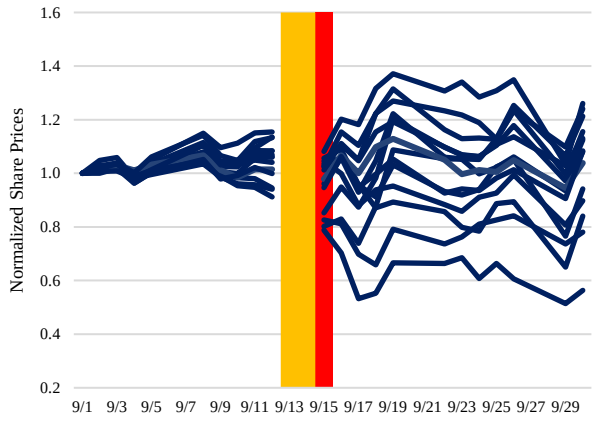
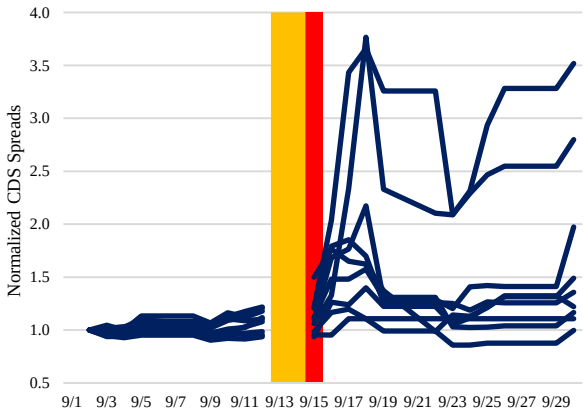


Figure 2: CDS Spreads Circa Lehman Bankruptcy



Each line represents one of the 14 largest U.S. banks in Sep. 2008. Yellow vertical bar indicates Sep. 13-14 (markets closed). Red vertical bar indicates Sep. 15 (date of Lehman filing). Data: Bloomberg LP.

[2] The voluntary insolvency petition for Lehman's U.S. holding company was filed at 1:45am on Monday, September 15. *See* Matt Egan, "Lehman Brothers: When the financial crisis spun out of control," *CNN Business* (Sep. 30, 2018), https://www.cnn.com/2018/09/30/investing/lehman-brothers-2008-crisis/index.html.

[3] Andrew Ross Sorkin, *Too Big To Fail: The Inside Story of How Wall Street and Washington Fought to Save the Financial System—and Themselves* (2010), at 536; *see also* Jennifer Hughes, "Winding Up Lehman Brothers," *Fin. Times* (Nov. 7, 2008), https://www.ft.com/content/e4223c20-aad1-11dd-897c-000077b07658;

[4] *See, e.g.*, Alexandra Twin, "Stocks get pummeled; Wall Street sees worst day in 7 years, with Dow down 504 points, as financials implode," *CNN Money* (Sep. 15, 2008), https://money.cnn.com/2008/09/15/markets/markets_newyork2/ ("You have to throw out the history books because there's really nothing to compare this to"; "We've never witnessed this before; there's no road map for this").

This paper examines why some financial institutions experienced greater stress than others in the immediate aftermath of the Lehman bankruptcy. In the process, it sheds light on a distinction among the goals that post-crisis reforms to financial regulation were intended to achieve. In the wake of the 2008 crisis, policymakers took steps to increase the required levels of capital and liquidity on the balance sheets of large financial institutions. A wide range of empirical literature has catalogued the effect of such reforms on preventing a financial crisis *ex ante* and hastening recovery from one *ex post*. However, vanishingly little empirical work has examined the effectiveness of capital and liquidity on a third goal: preventing an ongoing bank run (*i.e.*, the rapid withdrawal of funding from a single financial institution) from becoming contagious (*i.e.*, spreading to other institutions).[5] We understand much about the conditions that spark runs and heal the destruction they cause. We understand less about how the fire spreads, who burns, or how best to contain the damage.

Two related strands of post-crisis theory have addressed the causes of contagious runs: one that attributes them ultimately to inadequate capital, and the other to inadequate liquidity. Our empirical analysis uses the Lehman bankruptcy to engage each of these claims, with unexpected results.

- First, at levels then prevailing among large U.S. institutions, balance-sheet liquidity did not insulate an institution from the Lehman run. On the contrary, by several measures and in several markets, institutions with greater balance-sheet liquidity were more exposed to the run, not less.

- Second, most capital measures—including revised measures agreed internationally after the 2008 crisis—exhibited a similar relationship; in certain markets, the higher those measures were, the more run behavior an institution experienced. These problems appear to be tied closely to the Basel risk-weighting system, but they are not limited to it.

- Third, pre-crisis share-price correlation with Lehman Brothers was the most reliably and powerfully explanatory variable in our sample—even more than information available post-crisis about counterparties' actual exposure to the Lehman estate.

Our results have important implications for economic theory. They suggest that simpler measures may matter more in a financial crisis; that only certain capital measures are associated with the transmission of runs from one institution to another; and that the relationship between liquidity and run exposure is more complex than it might first appear. They imply that the efficiency of information about firms, and the transaction costs involved in obtaining such information, should figure prominently in our accounts of financial crises, when distinguishing fact from rumor is most difficult.

Our results also suggest that a central analogy for financial crises is incomplete at best. Discussions of financial "shocks" often treat contagious runs like a sudden storm, which hits an entire neighborhood and spares only the strongest houses from destruction. By contrast, our findings suggest

[5] A preliminary note on vocabulary: This definition of a run is limited to a single institution and not defined specifically by the behavior of creditors. For further discussion of the definition we adopt, *see infra* note 85. We use the terms "panic" and "crisis," for which there are no precise consensus definitions, to indicate a contagious run that extends to other financial institutions, drawing on empirical work that finds "panics are systematic." *See* Gary Gorton, "Banking Panics and Business Cycles," 40 *Oxford Econ. Papers* 751, 773 (Dec. 1988). For a broad-based discussion of runs, as well as runs in the financial crisis, *see* Ben S. Bernanke, "The Federal Reserve and the Financial Crisis," lecture at the George Washington University (Mar. 27, 2012), https://www.federalreserve.gov/files/chairman-bernanke-lecture3-20120327.pdf; *see also* Ben S. Bernanke, Timothy F. Geithner, and Henry M. Paulson, *Firefighting: The Financial Crisis and Its Lessons* (2019), at 15 ("A financial crisis is a bank run writ large, a crisis of confidence throughout the system").

that a contagious run is more like a fire, which starts inside a single home. Certain factors (*e.g.*, fire-proofing, sprinklers, smoke alarms) can keep the blaze from starting—but once it does, they are irrelevant to whether it consumes the neighborhood. Nearby homes may burn, or an updraft, flaming debris, or burning embers could carry the flames to houses clear across town. Fighting the fire requires an entirely different set of tools—from firehoses and firebreaks, to evacuation plans and zoning laws.

This distinction has important policy implications. Capital and liquidity on an institution's balance sheet play critical roles before and after an idiosyncratic shock; the existing literature is clear on both those points, and nothing in our results qualifies or contradicts it. However, our results suggest that investors treat capital and liquidity very differently during a crisis than in normal times, and that different tools are necessary to stop a bank run from spreading. Identifying, monitoring, and addressing the "correlation channels" that carry stress between institutions seems to be one such tool. Further research is necessary to identify others, and to gauge the effect of regulatory disclosures, trading automation, and risk-weighting reforms on our findings.

Finally, our results suggest that the decade since 2008 has seen a convergence among the largest financial institutions. Before the Lehman bankruptcy, the equity returns of several firms in our sample were highly correlated, and the higher the regulatory capital ratios of those firms, the more leveraged they were. Today, many of those returns are even more highly correlated, and the negative relationship between Basel III's highest-quality risk-based capital ratio (Common Equity Tier 1) and simple leverage (common equity/total assets) is even stronger. Other supervisory measures, such as resolution planning, may have altered the relationships that this article examines, making bank activities safer, business models more uniform, runs less likely, and recovery more orderly.[6] However, our findings suggest those measures may involve a trade-off—greater safety before a run occurs, but greater vulnerability once one begins.

Our paper proceeds as follows: Part II provides a brief overview of the fundamental concepts involved in our research; reviews the regulation of capital, liquidity, and short-term funding instruments before and after the fall of Lehman; and reviews the post-crisis literature on the causes of runs. Part III outlines our methods and research design and summarizes our empirical results; Part IV provides analysis of those results; and Part V offers policy recommendations and identifies areas for further study.

II. BACKGROUND

a. Capital, Liquidity, and Runs: How to Make (or Break) a Bank

Firms are investment vehicles that accept money from investors and use it to engage in activities that pay a return.[7] In exchange, investors typically gain the right to a specific measure of value from the firm. For example, an investor can purchase a right to the residual value of the firm's assets or allocations of the firm's profits.[8] Alternatively, an investor can purchase a right to the value of his or her initial

[6] The penultimate section of this paper contains a short discussion of the impact of resolution planning; however, we are not aware of any empirical research looking at the specific impact of resolution planning on run behavior, which limits our ability to offer substantive evaluation of its impact.
[7] *See* Ronald Coase, "The Nature of the Firm," 4 *Economica* 386 (Nov. 1937).
[8] *See* Financial Accounting Standards Board, Accounting Codification 505-10-05-3 ("Equity"), 505-20-05-3 ("Stock Dividends and Stock Splits").

investment, plus some kind of interest.[9] The first of these obligations usually is called equity; in the context of a bank, it and a variety of similar financial instruments are often called capital.[10] The latter is usually called debt.[11]

Equity generally comes with no guaranteed return; if a firm invests poorly, its equity might lose all or nearly all of its worth, and investors holding such equity (called "shareholders") typically cannot recover their investment from the firm in court.[12] Debt, by contrast, generally comes with a contractually obligated return; even if the firm invests poorly, it retains a duty to repay the investors who hold its debt (called "creditors").[13] In the event that a firm files for bankruptcy, creditors typically have "priority" over shareholders, and their debt is often secured by the firm's remaining assets, like equipment or real estate, and creditors are entitled to a share of proceeds from the sale of those assets.[14]

The equity and debt of a firm often trade in public markets, and when new information becomes available about the firm, the price of those financial instruments can change.[15] For example, when the expected value of a firm falls, the market price of its equity may also fall. When the probability that a firm will repay its debt falls, the market price of its debt may also fall. To protect against this latter risk, a firm's creditors (or, for that matter, anyone else) might enter into a CDS contract with a separate financial institution, which will pay the holder of the CDS if the firm defaults on its debt.[16] The price of a CDS is the "CDS spread"; the higher the probability that a "credit event" will occur, such as a default, the greater the spread typically becomes.[17]

In ordinary times, with respect to the funding at its disposal, a financial institution[18] is much like any other business. The main output of a bank is credit; it uses outside investment (*e.g.*, deposits, bonds,

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[9] *See* Financial Accounting Standards Board, Accounting Standards Update No. 2016-19 (Dec. 2016), https://asc.fasb.org/imageRoot/54/108316354.pdf ("A receivable or payable (collectively referred to as debt) represents a contractual right to receive money or a contractual obligation to pay money on demand or on fixed or determinable dates that is already included as an asset or liability in the creditor's or debtor's balance sheet at the time of the restructuring").

[10] Many sources either explicitly or implicitly conflate bank capital and equity. *See, e.g.*, William Alden, "What Is Bank Capital, Anyway?" *N.Y. Times* (Jul. 10, 2013), https://dealbook.nytimes.com/2013/07/10/what-is-bank-capital-anyway/; "Definition of bank capital," *Fin. Times* (accessed Dec. 11, 2018), http://lexicon.ft.com/Term?term=bank-capital. However, while the term "capital" almost always includes common equity, the two terms are not precisely coterminous; *see, e.g.*, "What is bank capital and what are the levels or tiers of capital?" Federal Reserve Bank of San Francisco (Mar. 2003), https://www.frbsf.org/education/publications/doctor-econ/2001/september/bank-capital/.

[11] For a comparison and exceptions relating to hybrid interests, see, *e.g.*, Financial Accounting Standards Board, Accounting Codification 480-10-05 ("Distinguishing Liabilities From Equity").

[12] *See* Financial Accounting Standards Board, *supra* note 8. This description excludes the possibility of recovery under other rights due to shareholders, such as a violation of fiduciary duty.

[13] *See* Financial Accounting Standards Board, *supra* note 9.

[14] This simplified description applies to common shareholders and secured creditors; *see* 11 U.S.C. § 507.

[15] *See* U.S. Securities and Exchange Commission, "Stocks" (accessed Dec. 11, 2018), https://www.investor.gov/introduction-investing/basics/investment-products/stocks; U.S. Securities and Exchange Commission, "Corporate Bonds" (accessed Dec. 11, 2018), https://www.investor.gov/introduction-investing/basics/investment-products/corporate-bonds.

[16] *See* Pacific Investment Management Company, "Credit Default Swaps" (Dec. 28, 2016), https://www.pimco.com/en-us/resources/education/understanding-credit-default-swaps/.

[17] *Id.*; *see also* Wang and Bahr, *infra* note 86. A credit event might also include other events, such as firm downgrades, by agreement of the parties to the CDS contract.

[18] In the remainder of this section, we use the term "bank" as shorthand for a financial institution. As discussed in the following section, and reflected in our sample and results, banks (i.e., deposit-taking institutions) are not the only financial institutions that can experience a run.

common stock) to fund the creation of financial assets (*e.g.*, loans).[19] Ideally, the bank makes more money off those assets than the bank's investors demand for funding them—the bank repays its creditors and earns a profit, and its shareholders' equity grows in value.

However, banks also have unique characteristics that expose them to unique risks. Banks typically use shorter-term sources of funding, like deposits, to invest in longer-term projects, like 30-year mortgages or 10-year business loans.[20] In a "fractional reserve" banking system, the amount of money a bank invests in these projects can exceed the money it receives in funding.[21] As long as the bank's investors do not withdraw shorter-term funding at once, the bank can operate normally. By contrast, if too many investors in a bank demand too much cash at once, the bank can face a "run." [22] To pay some creditors, it can sell its "liquid" assets for cash on short notice, at a price close to their economic worth.[23] As investor demands mount, however, the bank may have to sell other, less liquid assets at less—perhaps far less—than their actual worth. Doing so can satisfy some short-term creditor demands, but it results in losses that can further erode creditor confidence, leading to even more demands for cash. Repeated enough times, a firm that was solvent when the run began can become insolvent before it ends.[24]

Liquidity is tied closely to both the probability and severity of a run, since a less liquid bank must sell more of its assets at a loss to satisfy creditors. However, illiquidity and susceptibility to a run are not the same thing. The difference lies in the source and duration (or "fragility") of the bank's funding. For example, assume a bank gets all of its funding in overnight credit (which must be renewed on a daily basis) and keeps half that funding in reserve as cash. That bank is highly liquid, but also highly runnable, since its creditors could withdraw funding on less than a day's notice. By contrast, assume a bank gets all of its funding in 90-day loans, uses 95% of that funding to issue 60-day consumer loans, and holds 5% in reserve as cash. That bank is highly illiquid, but not highly runnable, since its creditors have no contractual right to withdraw funding before the bank's assets mature.[25]

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[19] Depositors, notably, are bank creditors, who provide principal (in the form of deposits) that the bank must repay, typically with a share of interest. *See* Gary B. Gorton, *Misunderstanding Financial Crises: Why We Don't See Them Coming* (2012), at 4-5; Jeanne Gobat, "Banks: At the Heart of the Matter," International Monetary Fund (accessed Dec. 12, 2018), https://www.imf.org/external/pubs/ft/fandd/basics/bank.htm.

[20] For a less condensed discussion of this activity (on maturity transformation, liquidity transformation, and other core functions of financial intermediation), see Laura E. Kodres, International Monetary Fund, "What is Shadow Banking?" 50 *Finance and Development* 42 (Jun. 2013), https://www.imf.org/external/pubs/ft/fandd/2013/06/pdf/basics.pdf.

[21] For detail on the mechanics of this mechanism, see Michael McLeay, Amar Radia, and Ryland Thomas, "Money creation in the modern economy," Bank of England, *Quarterly Bulletin* (Q1 2014), at 14, https://www.bankofengland.co.uk/-/media/boe/files/quarterly-bulletin/2014/money-creation-in-the-modern-economy; Morgan Ricks, *The Money Problem: Rethinking Financial Regulation* (2016).

[22] *See* discussion *supra* note 5 and *infra* note 85.

[23] *See*, *e.g.*, Stanley Fischer, "Is there a liquidity problem post-crisis?" remarks at the Brookings Institution, Washington, DC (Nov. 15, 2016), https://www.bis.org/review/r161118d.htm (citing 2015 International Monetary Fund Financial Stability Report definition of market liquidity as "the ability to rapidly execute sizable securities transactions at a low cost and with a limited price impact"); Bank of International Settlements, "Foreign exchange liquidity in the Americas," BIS Working Paper No. 90 (Mar. 2017), https://www.bis.org/publ/bppdf/bispap90.htm, at iii (defining a market as liquid if "an investor wishing to execute a transaction of a desired size can do so at or near the prevailing market price, relatively quickly, and with no material price impact").

[24] For a more detailed description of the dynamic in this paragraph, which incorporates an account of deposit insurance and includes working definitions of market and funding liquidity, *see* Gorton, *supra* note 19 at 45.

[25] This general description ignores other derivative rights available to shareholders, as well as other covenants that may create or limit creditor rights short of either maturity or default. *See also supra* note 12.

b. The Post-Lehman Reforms

Because the sources of bank funding are diverse, the channels that can give rise to a bank run are also diverse.[26] In the 2008 financial crisis, the run on large, diversified financial institutions occurred principally in the sale-and-repurchase (the repurchase agreement, or "repo") market. [27] To borrow in this market, an institution would typically offer investors a securitized bond, often backed by the stream of payments from mortgage loans, as collateral.[28] If the borrowing institution failed to repay its (usually short-term) loan by "repurchasing" the bond at a premium, the investor could keep the bond.[29] However, as the mortgage market began to deteriorate, doubts about the quality of those securitized bonds and the mortgage loans backing them increased, as did the cost of repo borrowing, until such borrowing ceased almost entirely.[30]

The story from here is familiar. Starting in late 2007, governments intervened.[31] Intervention fostered expectations of future intervention.[32] The September 15, 2008 bankruptcy of Lehman violated

[26] *See* Matt Pritsker, "The Channels for Financial Contagion," in Stijn Claessens and Kristin J. Forbes (eds.), *International Financial Contagion* (2001).
[27] *See* Gary B. Gorton and Andrew Metrick, "Securitized Banking and the Run on Repo," 104 J. Fin. Econ. 425 (2012). Note that, while the "run on repo" involved non-banking financial institutions, large multi-line financial institutions and investment banks were major participants in this market. *See* Darrell Duffie, "Prone to Fail: The Pre-Crisis Financial System," *J. Econ. Persp* (forthcoming, Jul. 19, 2018), https://www.darrellduffie.com/uploads/policy/Duffie-JEP-Prone-to-Fail-July7-2018.pdf, at 4
[28] *Id.*
[29] *Id.*
[30] *Id.*
[31] In the United States, pre-Lehman interventions included the Term Auction Facility (launched Dec. 7, 2007), the Single-Tranche Open Market Operations Facility (Mar. 7, 2008), the Term Securities Lending Facility (Mar. 11, 2008), and the Primary Dealer Credit Facility (Mar. 16, 2008). *See* Hal Scott, *Connectedness and Contagion: Protecting the Financial System from Panics* (2016), at 75. The U.S. government also provided multiple lines of support to the government-sponsored enterprises focused on the housing market (principally Fannie Mae and Freddie Mac), ultimately resulting in their conservatorship under the Federal Housing Finance Agency. *See* U.S. Federal Housing Finance Agency, "History of Fannie Mae and Freddie Mac Conservatorships" (accessed Dec. 11, 2018), https://www.fhfa.gov/Conservatorship/Pages/History-of-Fannie-Mae--Freddie-Conservatorships.aspx; "End of illusions," *The Economist* (Jul. 17, 2008), https://www.economist.com/finance-and-economics/2008/07/17/end-of-illusions. Other substantial interventions took place in the United Kingdom and Europe. *See* Martin Kellaway, "Public Sector Interventions in the Financial Crisis: Statistical Classification Decisions," Office for National Statistics, UK Parliament (2007), https://www.ons.gov.uk/ons/rel/psa/financial-crisis-and-statitical-classification/public-sector-interventions-in-the-financial-crisis/public-sector-interventions-in-the-financial-crisis-.pdf; "Commission adopts European Economic Recovery Plan," press release, European Commission (Jul. 6, 2009), http://ec.europa.eu/economy_finance/articles/eu_economic_situation/article13502_en.htm.
[32] Combatting this expectation was, at the time, among the stated intentions of the bankruptcy. *See* "Statement by Sec. Paulson on the Economy," C-SPAN (Sep. 15, 2008), https://www.c-span.org/video/?281125-2/statement-sec-paulson-economy ("Moral hazard is something I take very seriously").

those expectations.[33] Markets reacted poorly.[34] The result was further government intervention. Most crisis-era public programs offered financial institutions greater access to more liquid assets, such as cash or sovereign bonds, by pledging less liquid assets as collateral.[35] After Lehman, new programs also provided institutions with capital.[36] Still others directly supported markets in specific financial products.[37] Ultimately—and consequently—the financial system avoided collapse.[38]

Early debates about the causes of the crisis focused on the adequacy of bank capital.[39] Regulators have long required banks to fund a certain proportion of their assets with money derived from equity or

[33] We discuss the possible role of private information in our results below, but both financial market performance and the timeline of the "Lehman weekend" support this conclusion. On Friday, September 12, 2008, equity markets were stable, and the Dow Jones Industrial Average ultimately closed up 1.8%. *See* Steven Russolillo, "This Day in Crisis History: Sept. 12, 2008," *Wall St. J.* (Sep. 12, 2013), https://blogs.wsj.com/moneybeat/2013/09/12/this-day-in-crisis-history-sept-12-2008/. The CEOs of the largest U.S. banks spent the weekend attempting to negotiate an assistance package for the sale of Lehman to Barclays, which appeared to be near consummation until last-minute discussions with the UK Financial Services Authority about the prior need for a Barclays shareholder vote. *See* Andrew Ross Sorkin, "Lehman Files for Bankruptcy; Merrill is Sold," *N.Y. Times* (Sep. 14, 2008), https://www.nytimes.com/2008/09/15/business/15lehman.html; Thomas C. Baxter, "Too Big to Fail: Expectations and Impact of Extraordinary Government Intervention and the Role of Systemic Risk in the Financial Crisis," testimony before the Financial Crisis Inquiry Commission, Federal Reserve Bank of New York (Sep. 1, 2010), https://www.newyorkfed.org/newsevents/speeches/2010/bax100901. By market close on Tuesday, the Dow had fallen 4.4%, and the S&P 500 index had fallen 4.7%. Tom Lauricella, Serena Ng, and Neil Shah, "Dow, markets in Europe post big falls," *Wall St. J.* (Sep. 16, 2008), https://www.wsj.com/articles/SB122152873162140589.

[34] *Id.* Markets hit their crisis-era lows in March 2009, with the Dow Jones Industrial Index and S&P 500 at their lowest points since the late 1990s. Alexandra Twin, "For Dow, another 12-year low," *CNN Money* (Mar. 9, 2009), https://money.cnn.com/2009/03/09/markets/markets_newyork/.

[35] In addition to the programs described above, *supra* note 31, liquidity-focused programs included a secured revolving credit facility available to insurer AIG (launched Sep. 16, 2008), the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (Sep. 22, 2008), the Temporary Guarantee Program (Sep. 29, 2008), the Commercial Paper Funding Facility (Oct. 27, 2008), and the Term Asset-Backed Securities Loan Facility (Nov. 25, 2008). Scott, *supra* note 31 at 76-78. Federal Home Loan Bank advances also became an important source of liquidity. *See* Kathryn Judge, "Investor-Driven Financial Innovation," 7 *Harv. Bus. Law Rev.* (forthcoming), Columbia Law and Economics Working Paper No. 576 (2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3068991, at 15 (citing Jonathon Adams-Kane & Jakob Wilhelmus, "The Real Story Behind the Surge in FHLB Advances: Macroprudential Policy Changed How Banks Borrow," Milken Inst. Working Paper (Sep. 2017), https://www.milkeninstitute.org/publications/view/881).

[36] U.S. capital-based programs included the Troubled Asset Relief Program (passed as part of the Emergency Economic Stabilization Act, Pub. L. 110-343, enacted Oct. 3, 2008) and the broader Capital Purchase Program. *Id.*

[37] The Federal Reserve also instated unlimited swap lines with three foreign central banks, and the FDIC raised its deposit insurance limit. *Id.*

[38] The role of the government in staving off collapse is still subject to debate. For an accessible overview of this debate, and an argument for the paramount importance of public assistance programs, from an author with no official role in the crisis response, see Alan S. Blinder, *After the Music Stopped: The Financial Crisis, The Response, and The Work Ahead* (2013).

[39] Improved capital was the first commitment listed in the Leaders' Statement following the 2009 Pittsburgh G20 meeting; the focus of the first post-crisis supervisory stress tests; and the subject of countless statements from crisis-era policymakers. *See, e.g.*, Department of the U.S. Treasury, "Leaders' Statement: The Pittsburgh Summit, September 24-25, 2009" (Sept. 25, 2009), https://www.treasury.gov/resource-center/international/g7-g20/Documents/pittsburgh_summit_leaders_statement_250909.pdf; Ben S. Bernanke, "The Supervisory Capital Assessment Program" (May 11, 2009), https://www.federalreserve.gov/newsevents/speech/bernanke20090511a.htm; John Fell, "Stress Testing in a Crisis – The European Experience," presentation at the Federal Reserve Bank of Chicago Conference on Bank Structure and Competition (May 10, 2012), https://www.chicagofed.org/~/media/others/events/2012/bsc/fell-051012-pdf.pdf (detailing Tier 1 capital as the sole hurdle rate in the 2009-2010 CEBS-run stress tests).

equity-like instruments, which could "absorb" losses if those assets lost value.[40] These requirements are typically ratios, in the general form of:

$$\frac{capital}{assets}$$

Before the crisis, the prevailing international standards for capital regulation were the Basel II accords.[41] For the numerator, Basel II distinguished between three different categories of capital, including a Tier 1 category consisting of common equity and similar instruments.[42] For the denominator, Basel II required institutions to use "risk-weighted assets" ("RWA") instead of the total book value of all their financial assets. Risk-weighting applies a coefficient to the value of each asset; the higher the probability the asset will lose value, the greater the coefficient, and the greater the increase in the denominator of the capital ratio. Basel II allowed two methods for calculating risk-weighted assets: an "advanced approach," which allowed larger institutions to use their internal risk models to conduct the calculation, and a "standardized approach," which did not.[43] Under both approaches, when a bank's assets are riskier, it must fund those assets with more equity and equity-like instruments.[44]

The numerator and denominator of the capital ratios changed under the post-crisis Basel III accords.[45] (*See* **Appendix A** for selected definitions.) For the numerator, Basel III created a new Common Equity Tier 1 ("CET1") requirement, meant to hew more closely to equity capital, and introduced a new version of Tier 1 capital.[46] For the denominator, Basel III introduced a new version of the standardized approach and limited the discretion associated with the internal ratings-based approach.[47] Basel III also created a new leverage requirement, which used no risk-weighting, and which included both on-balance-

[40] For a primer, *see* "Regulation Guide: An Introduction," Moody's Analytics (Nov. 2011), https://www.moodysanalytics.com/-/media/whitepaper/2011/11-01-03-regulation-guide-introduction.pdf; Anat Admati and Martin Hellwig, *The Bankers' New Clothes: What's Wrong with Banking and What to Do about It* (2013), at 17.

[41] Since the 1980s, financial regulators have collaborated to produce standards for the oversight of internationally active banking institutions. These standards are called the "Basel accords," after the Swiss city where the first such agreement was negotiated (and where ongoing activity around these standards is based). *See* Basel Committee on Banking Supervision, "History of the Basel Committee" (Apr. 14, 2018), https://www.bis.org/bcbs/history.htm; Basel Committee on Banking Supervision, "Revised international capital framework" (2006), https://www.bis.org/publ/bcbsca.htm.

[42] The other two specific inclusions in Basel II Tier 1 capital are disclosed reserves and non-cumulative perpetual preferred stock *Id.*

[43] *Id.*

[44] Basel Committee on Banking Supervision, "Part 2: The First Pillar – Minimum Capital Requirements" (2004), https://www.bis.org/publ/bcbs128b.pdf.

[45] Basel Committee on Banking Supervision, "Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems" (2011), https://www.bis.org/publ/bcbs189.htm.

[46] *Id.*; *see also* Daniel K. Tarullo, "Financial Regulation Since the Crisis," remarks to the Federal Reserve Bank of Chicago and Office of Financial Research 2016 Financial Stability Conference, Washington, DC (Dec. 2, 2016), https://www.bis.org/review/r161205f.pdf ("In addition to increasing minimum capital ratios, post-crisis reforms also placed more emphasis on the quality of regulatory capital by introducing the common equity tier 1 capital ratio, which reflects the focus by bank investors and counterparties during the crisis on common equity").

[47] Basel Committee on Banking Supervision, *supra* note 45.

sheet assets and off-balance-sheet exposures.[48] Finally, the accords included several additional capital "buffers."[49]

Liquidity regulation also changed dramatically as a result of the crisis. Basel III created a new Liquidity Coverage Ratio ("LCR"), the first liquidity regulation in the Basel accords, meant to ensure that institutions had enough "high-quality liquid assets" to meet their demands for cash over a 30-day period.[50] To tackle run risk from an over-reliance on short-term funding, Basel III also created a measure to ensure banks had enough long-term funding to cover their long-term assets.[51] In November 2007, new U.S. disclosure requirements from the Financial Accounting Standards Board ("FASB") also took effect, requiring publicly traded companies to disclose their total "Level 1, 2, and 3" assets, roughly divided according to how liquid those assets are.[52]

The Basel accords are non-binding international agreements that apply to "internationally active" banks; national regulators implement and enforce Basel standards through domestic regulations.[53] In the United States, for instance, regulators imposed new capital and liquidity requirements through regulation and supervision, after the 2010 passage of the Dodd-Frank Wall Street Reform and Consumer Protection Act.[54] For the Federal Reserve Board, these included a host of "enhanced prudential standards," with capital and liquidity requirements roughly increasing with the size and complexity of a banking organization.[55] For the Office of the Comptroller of the Currency, they included a set of "heightened expectations" for large institutions.[56] For the Federal Deposit Insurance Corporation and Board, along with the other two federal prudential regulators, the new requirements also included recovery and

[48] These two measurements were seen as complementary. If risk-weighting was either too complex or too easily manipulated, the weights would fail to capture actual credit exposures—but without risk-weighting, a financial institution could seek higher returns by undertaking riskier loans for the same equity funding requirements. *Id.*; *see also infra* note 111.

[49] Basel Committee on Banking Supervision, *supra* note 45.

[50] Basel Committee on Banking Supervision, "Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools" (Jan. 2013), https://www.bis.org/publ/bcbs238.pdf.

[51] *See* Basel Committee on Banking Supervision, "Basel III: The Net Stable Funding Ratio" (Oct. 31, 2014), https://www.bis.org/bcbs/publ/d295.htm.

[52] Financial Accounting Standards Board, "Statement of Financial Accounting Standards No. 157: Fair Value Measurements" (2010), https://www.fasb.org/pdf/aop_FAS157.pdf; *see also* PricewaterhouseCoopers, "Guide to Fair Value Measurements" (2007), https://www.pwc.com/bm/en/publication/assets/fvguide2007.pdf.

[53] *See* Bank of International Settlements, "The Basel Process - Overview" (accessed Dec. 12, 2018), https://www.bis.org/about/basel_process.htm.

[54] Pub. L. No. 111–203, § 929–Z, 124 Stat. 1376 (2010) (codified as 12 U.S.C. § 53o).

[55] *Id.* at § 165; *see also* Daniel K. Tarullo, "A Tiered Approach to Regulation and Supervision," remarks at the Community Bankers Symposium in Chicago, IL (Nov. 7, 2014), https://www.federalreserve.gov/newsevents/speech/tarullo20141107a.pdf. Note, in particular, that the federal banking agencies imposed a required "enhanced Supplementary Leverage Ratio" for large financial institutions; *see* Board of Governors of the Federal Reserve System, Federal Deposit Insurance Corporation, and Office of the Comptroller of the Currency, "Agencies adopt enhanced supplementary leverage ratio final rule and issue supplementary leverage ratio notice of proposed rulemaking," press release (Apr. 8, 2014), https://www.federalreserve.gov/newsevents/pressreleases/bcreg20140408a.htm.

[56] Office of the Comptroller of the Currency, "OCC Finalizes Its Heightened Standards for Large Financial Institutions," press release (Sep. 2, 2014), https://www.occ.treas.gov/news-issuances/news-releases/2014/nr-occ-2014-117.html.

resolution plans, intended to avoid or facilitate the liquidation of a large, complex financial institution, without interrupting critical operations or requiring public financial support.[57]

Many Basel member jurisdictions, including the United States, also crafted new "stress-testing" regimes, formalizing a tool first deployed in the throes of the crisis.[58] Typically, a regulatory stress test involves a set of macro-level "stress scenarios"—*e.g.*, a fall of X% in GDP, a rise of Y% in unemployment, or some combination of factors—that regulators and banks use to model separate estimates of resulting changes to the bank's balance sheet.[59] In the U.S., regulators launched a stress-testing program focused on capital at large financial institutions, and required those institutions to separately run their own periodic stress tests simulating liquidity shocks.[60] Smaller institutions faced a separate new requirement to conduct their own capital stress tests and report results to regulators.[61]

c. Prior Literature

These new measures had a dominant stated motivation at the time they were created: "No more taxpayer-funded bailouts, period."[62] On these grounds alone, regulators had good reason to focus on capital. Before and after the crisis, an extensive empirical literature has explored the benefits of higher

[57] *See, e.g.*, Board of Governors of the Federal Reserve System, "Living Wills (or Resolution Plans)" (Dec. 20, 2018), https://www.federalreserve.gov/supervisionreg/resolution-plans.htm; Federal Deposit Insurance Corporation, "Resolution Plans" (Dec. 20, 2018), https://www.fdic.gov/resauthority/resplans.html; Office of the Comptroller of the Currency, U.S. Department of the Treasury, "Recovery Planning," press release, OCC Bulletin 2018-9 (Apr. 26, 2018), https://www.occ.treas.gov/news-issuances/bulletins/2018/bulletin-2018-9.html.

[58] *See, e.g.*, 12 U.S.C. § 5365 (United States); Kieran Dent, Ben Westwood, and Miguel Segoviano, "Stress testing of banks: an introduction," Bank of England Quarterly Bulletin (Q3 2016), https://www.bankofengland.co.uk/quarterly-bulletin/2016/q3/stress-testing-of-banks-an-introduction (United Kingdom); European Central Bank, "ECB to stress test 37 euro area banks as part of the 2018 EU-wide EBA stress test," press release (Jan. 31, 2018), https://www.bankingsupervision.europa.eu/press/pr/date/2018/html/ssm.pr180131.en.html (European Union); *cf.* "Japan's financial regulator to scrutinize banks' stress tests," *Bloomberg*/*Japan Times* (May 10, 2016), https://www.japantimes.co.jp/news/2016/05/10/business/japans-financial-regulator-scrutinize-banks-stress-tests/ (Japan).

[59] *See, e.g.*, Board of Governors of the Federal Reserve System, "Federal Reserve Board releases scenarios for 2018 Comprehensive Capital Analysis and Review (CCAR) and Dodd-Frank Act stress test exercises and issues instructions to firms participating in CCAR," press release (Feb. 1, 2018), https://www.federalreserve.gov/newsevents/pressreleases/bcreg20180201a.htm.

[60] For an overview of this system as enacted shortly after the crisis, see Daniel K. Tarullo, "Developing Tools for Dynamic Capital Supervision," remarks at the Federal Reserve Bank of Chicago Annual Risk Conference, Chicago, IL (Apr. 10, 2012), https://www.federalreserve.gov/newsevents/speech/tarullo20120410a.htm.

[61] *See, e.g.*, Federal Deposit Insurance Corporation, "Dodd-Frank Act Stress Test (DFAST)" (May 3, 2018), https://www.fdic.gov/regulations/reform/dfast/index.html.

[62] *See* Helene Cooper, "Obama Signs Overhaul of Financial System," *N.Y. Times* (Jul. 21, 2010), https://www.nytimes.com/2010/07/22/business/22regulate.html. The closely related mantle of "too big to fail" took hold in public discourse very early. *See, e.g.*, Jonathan Macey, "Brave New Fed," *Wall St. J.* (Mar. 31, 2008), https://www.wsj.com/articles/SB120692412871875675 (linking the Bear Stearns sale to prior "Too-Big-To-Fail" policies); Neil Irwin, "Paulson To Urge New Fed Powers," *Wash. Post* (Jun. 19, 2008), http://www.washingtonpost.com/wp-dyn/content/article/2008/06/18/AR2008061803225.html ("We must limit the perception that some institutions are either too big to fail or too interconnected to fail. If we are to do that credibly, we must address the reality that some are"); "Text of Obama's Speech on Financial Reform," *N.Y. Times* (Sep. 14, 2009), https://www.nytimes.com/2010/07/22/business/22regulate.html ("Those on Wall Street cannot resume taking risks without regard for consequences, and expect that next time, American taxpayers will be there to break their fall").

capital ratios, from minimizing the moral hazard associated with deposit insurance,[63] to reducing the probability of insolvency,[64] to improving lending volumes in the wake of a shock.[65]

A separate, largely theoretical literature also argues that higher capital levels can help prevent runs by limiting doubts about an institution's ability to pay its short-term debts.[66] These claims about *ex ante* vulnerability to a run also entail a theory about investor behavior *during* a run—that the "deeper reason" for investors' actions is insolvency. Before the financial crisis, in this theory,

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[63] *See* João A.C. Santos, "Bank capital regulation in contemporary banking theory: A review of the literature," 10 *Fin. Markets, Inst. & Instr.* 41 (2001), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=248314.

[64] *See, e.g.*, Laura Chiaramonte and Barbara Casu, "Capital and liquidity ratios and financial distress: Evidence from the European banking industry," 49 *British Accounting Rev.* 138 (Mar. 2017), https://www.sciencedirect.com/science/article/abs/pii/S089083891630004X (describing the association between higher capital and lower probability of "failure and distress" at large EU banks).

[65] The overwhelming majority of the empirical literature on capital has focused on the relationship between capital and lending. That literature is outside the scope of this paper, but much of it suggests that capital has a smoothing effect, dampening lending during high points in the business and credit cycles and preserving lending during low points. However, as Berrospide and Edge (2010) note, the time frame and geographic scope of these studies seem to play a role in their results. *See, e.g.*, Ben S. Bernanke, "Non-Monetary Effects of the Financial Crisis in the Propagation of the Great Depression," 73 *Am. Econ. Rev.* 257 (1983); J. Peek and Eric Rosengren, "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States," 90 *Am. Econ. Rev.* 30 (2000); Patricia Jackson, "Capital Requirements and Bank Behaviour: The Impact of the Basle [sic] Accord," Basle Committee on Banking Supervision Working Paper No. 1 (Apr. 1999); Joseph Noss and Priscilla Toffano, "Estimating the impact of changes in aggregate bank capital requirements on lending and growth during an upswing," 62 *J. of Banking & Finance* 15 (Jan. 2016) (documenting association between higher capital requirements and lending in UK banks); Mark Carlson, Hui Shan, and Missaka Warusawitharana, "Capital ratios and bank lending: A matched bank approach," 22 *J. of Fin. Intermediation* 663 (Oct. 2013) (finding strong post-crisis relationship between higher capital ratios and increased lending); Marko Košak, Shaofang Li, Igor Ločarski, and Matej Marinč, "Quality of bank capital and bank lending behavior during the global financial crisis," 37 *Int'l. Rev. of Fin. Anal.* 168 (Jan. 2015) (finding greater continuity in lending for banks with higher Tier 1 capital and retail deposit levels, but not Tier 2 capital or interbank deposit levels); Leonardo Gambacorta and Paolo Emilio Mistrulli, "Does bank capital affect lending behavior?" 13 *J. of Fin. Intermediation* 436 (Oct. 2004) (finding lower leverage dampens lending shocks in Italian bank sample); Sudipto Karmakar and Junghwan Mok, "Bank capital and lending: An analysis of commercial banks in the United States," 128 *Econ. Letters* 21 (Mar. 2015) (finding "a moderate relationship between capital ratios and business lending" through multiple business cycles); *cf.* Matthew Osborne, Ana-Maria Fuentes, and Alistair Milne, "In good times and in bad: Bank capital ratios and lending rates," 51 *Int'l Rev. of Fin. Anal.* 102 (May 2017) (finding that better-capitalized banks are more likely to engage in secured household lending during upturns than downturns); Ruby P. Kishan and Timothy P. Opiela, "Bank Size, Bank Capital, and the Bank Lending Channel," 32 *J. of Money, Credit and Banking* 121 (Feb. 2000) (finding variable effects according to asset size and baseline capitalization); Jonathan Bridges, David Gregory, Mette Nielsen, Silvia Pezzini, Amar Radia, and Marco Spaltro, "The Impact of Capital Requirements on Bank Lending," Bank of England Working Paper No. 486 (Jan. 31, 2014) (finding an initial decrease in lending after an increase in capital requirements, followed by recovery within three years); Jose M. Berrospide and Rochelle M. Edge, "The Effects of Bank Capital on Lending: What Do We Know, and What Does it Mean?" FEDS Working Paper 2010-44 (2010) (finding relatively weak relationship between capital levels and lending capacity); Shekhar Aiya, Charles W. Calomiris, John Hooley, Yevgeniya Korniyenko, and Tomasz Wieladek, "The international transmission of bank capital requirements: Evidence from the UK," 113 J. of Fin. Econ. 368 (Sep. 2014) (finding decreased interbank lending to "non-core" countries as a result of higher UK capital requirements).

[66] *See, e.g.*, V. V. Chari and Ravi Jagannathan, "Banking Panics, Information, and Rational Expectations Equilibrium," 43 *J. of Fin.* 749 (1988); *cf.* Gorton, *supra* note 5 at 778-79 (determining, from analysis of pre- and post-Federal Reserve Act banking crises, that "depositors panic when the liabilities signal is strong enough," and rejecting a "sun spot" hypothesis of depositor behavior).

> banks were highly indebted. When banks suffered losses, investors, including other financial institutions, lost confidence and cut off funding, fearing that the banks might become unable to repay their debts. The Lehman Brothers bankruptcy itself heightened investors' concerns by showing that even a large financial institution might not be bailed out, and therefore that default of such an institution was a real possibility.[67]

The most prominent (and voluble) counter-argument to this view claims that, while higher capital might prevent runs, it also comes with substantial private and social costs.[68] However, another counter-argument based in "contagion theory" also exists, claiming that the capital-focused account of runs is based on a faulty premise. [69]

Contagion theory agrees that a run can begin with doubts about the quality of a bank's assets. It argues, however, that a run can begin for virtually any reason, from concerns about asymmetric information, to a change in the elasticity of investment, to simple herd behavior or randomness.[70] Instead, what both causes and distinguishes a run is a lack of liquidity—that is, a mismatch between the cash that bank creditors demand, and the cash that a bank owns or can get. If too few of a bank's assets are liquid, even a few creditor redemptions can exhaust them, leading to the sale of illiquid assets at a loss, leading to further demands for cash. This positive-feedback loop continues until the bank is insolvent—but with enough liquidity, it never occurs at all. In this view, "crises are about cash and not capital," and regulators

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[67] *See, e.g.*, Admati and Hellwig, *supra* note 40 at 12; *see also* Daniel K. Tarullo, "The evolution of capital regulation," remarks at the Clearing House Business Meeting and Conference, New York, NY (Nov. 9, 2011), https://www.bis.org/review/r111110c.pdf ("In the fall of 2008, there was widespread doubt in markets that the common equity of some of our largest institutions was sufficient to withstand the losses that those firms appeared to be facing. This doubt made investors and counterparties increasingly reluctant to deal with those firms, contributing to the severe liquidity strains that characterized financial markets at the time").

[68] *See, e.g.*, Douglas Elliott and Andre O. Santos, "Assessing the Cost of Financial Regulation," IMF Working Paper No. 12/233 (Sep. 26, 2012), https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Assessing-the-Cost-of-Financial-Regulation-40021; *cf.* Anat Admati, Peter M. DeMarzo, Martin Hellwig, and Paul Pfleiderer, "Fallacies, Irrelevant Facts, and Myths in Capital Regulation: Why Bank Equity is Not Socially Expensive," Stanford University Graduate School of Business Research Paper No. 13-7 (Nov. 4, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2349739. Note: We largely elide a third counter-argument, on the relationship between leverage and agency rents, where empirical research remains scant. *See, e.g.*, Luc Laeven and Ross Levine, "Bank governance, regulation and risk taking," 93 *J. of Fin. Econ.* 259 (2009) (observing an inverse relationship, with multiple confounding factors); Thierno Amadou Barry, Laetitia Lepetit, and Amine Tarazi, "Ownership structure and risk in publicly held and privately owned banks," 35 J. of Banking and Fin. 1327 (May 2011) (observing a direct relationship in sample of European banks); *cf.* Anat R. Admati and Martin F. Hellwig, "Does Debt Discipline Bankers? An Academic Myth about Bank Indebtedness" (working paper) (Feb. 18, 2013), https://admati.people.stanford.edu/sites/g/files/sbiybj1846/f/publications/3031_1.pdf (advocating for lower leverage); Thomas F. Hellman, Kevin C. Murdock, and Joseph E. Stiglitz, "Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?" 90 *Amer. Econ. Rev.* 147 (Mar. 2000), https://www.aeaweb.org/articles?id=10.1257/aer.90.1.147 (advocating for higher leverage).

[69] *See* Scott, *supra* note 31 at xv (defining contagion as "an indiscriminate run by short-term creditors of financial institutions that can render otherwise solvent institutions insolvent due to the fire sale of assets that are necessary to fund withdrawals and the resulting decline in asset prices").

[70] *See id.* at 13 (citing Gary Gorton and Guillermo Ordoñez, "Collateral Crises," 104(2) *Amer. Econ. Rev.* 343 (2014)). Douglas W. Diamond and Philip H. Dybvig's seminal argument posits that demand deposit contracts have multiple equilibria, one of which is a bank run, and that "almost anything" can cause a "shift in expectations" and a movement to the run equilibrium. "Bank Runs, Deposit Insurance, and Liquidity," 91 *J. of Polit. Econ.* 401 (Jun. 1983).

who seek to prevent contagious runs should focus on making liquidity freely available, rather than increasing the *ex ante* proportion of funding a bank gets from equity.[71]

Much of the contagion literature is theoretical, but some suggestive evidence is contingent with the contagion hypothesis. First, banking crises were prevalent in the United States even in the 19th century, when bank capital ratios hovered above 50 percent.[72] Second, although balance-sheet measures of regulatory capital have increased substantially since the 2008 crisis, some market-based measures of volatility and risk remain the same or higher than they were a decade ago.[73] Third, other non-liquidity explanations for Lehman seem to fall short; for example, other major financial institutions had relatively low asset and liability exposure to Lehman, suggesting that the run was not purely a function of direct counterparty risk.[74]

The claims of the capital and contagion literature fall into a gap in the academic literature. They focus not on reducing the probability of a run, nor on mitigating its damage, but on what can stop a run already underway from spreading. They concern investor decision-making, especially decisions to

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[71] Gorton, *supra* note 19 at 153; *see also* Scott, *id.* at 10 (describing contagion as "a liquidity-driven phenomenon" that is "not conditioned on insolvency"); "Managing the Next Financial Crisis: An Assessment of Emergency Arrangements in the Major Economies," Group of Thirty (Sep. 2018), http://group30.org/images/uploads/publications/Managing_the_Next_Financial_Crisis.pdf, at 14 (arguing for an expansion of the Federal Reserve's emergency lending powers); Timothy Geithner and Andrew Metrick, "Ten Years After the Financial Crisis: A Conversation with Timothy Geithner," Yale Program on Financial Stability Working Paper No. 2018-01 (Sep. 5, 2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3246017. These sources are ultimately rooted in Walter Bagehot's dictum in *Lombard Street: A Description of the Money Market* (1873) to "lend freely, at a high rate of interest, on good banking securities." Group of Thirty, citing Charles Goodhart, "Myths About the Lender of Last Resort," 2 *Int'l. Fin.* 339 (1999). Importantly, however, Scott grants an important role for capital in protecting specifically against "a correlated negative shock [that] causes the failure of many large financial institutions at the same time," since in such an event banks would lack "adequate collateral" that would be eligible for credit from a lender of last resort, such as a central bank. Scott, *supra* note 31 at 181.

[72] *Id.* at 161.

[73] Natasha Sarin and Lawrence H. Summers, "Understanding Bank Risk through Market Measures," Brookings Papers on Economic Activity (2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3230766. Sarin and Summers "suspect that without increases in capital requirements, levels of volatility would have increased even more than [they] observe," but note that their results could be due to gaps between the definitions of regulatory and true economic capital. Consistent with the former explanation, several papers have argued that socially optimal levels of Tier 1 regulatory capital are substantially higher than the current state. *See, e.g.*, Simon Firestone, Amy Lorenc, and Benjamin Ranish, "An Empirical Assessment of the Costs and Benefits of Bank Capital in the US," Federal Reserve Finance and Economics Discussion Series (2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2946814 (13 to 26 percent); Martin Brooke et al., "Measuring the macroeconomic costs and benefits of higher UK bank capital requirements," Bank of England Financial Stability Paper No. 35 (Dec. 2015), https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-paper/2015/measuring-the-macroeconomic-costs-and-benefits-of (10 to 14 percent); David Miles, Jing Yang, and Gilberto Marcheggiano, "Optimal Bank Capital," 123 *Econ. J.* 1 (Mar. 2013), https://onlinelibrary.wiley.com/doi/full/10.1111/j.1468-0297.2012.02521.x (16 to 47 percent); Basel Committee on Banking Supervision, "An assessment of the long-term economic impact of stronger capital and liquidity requirements" (Aug. 2010), https://www.bis.org/publ/bcbs173.pdf (9 to 16 percent); Jihad Dagher et al., "Benefits and Costs of Bank Capital," IMF Staff Discussion Note SDN/16/04 (Mar. 2016), https://www.imf.org/external/pubs/ft/sdn/2016/sdn1604.pdf (15 to 23 percent); Wayne Passmore and Alex von Hafften, "Are Basel's Capital Surcharges for Global Systemically Important Banks Too Small?" FEDS Working Paper (Mar. 1, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925705 (15 to 23 percent); Federal Reserve Bank of Minneapolis, "The Minneapolis Plan to End Too Big to Fail" (2016), https://www.minneapolisfed.org/publications/special-studies/endingtbtf/final-proposal.

[74] Scott, *supra* note 31 at 52-53, 288.

withdraw funding on extremely short notice. By contrast, most empirical work on capital has focused on its role before and after a crisis (*i.e.*, in preventing one or hastening recovery from one).[75] Most articles on the contagion view have been theoretical, rather than empirical.[76]

The Lehman bankruptcy is foundational to both the capital and contagion narratives, not only because of its magnitude and historical significance, but also because the company's decision to file was so unexpected, and thus was plausibly exogenous to subsequent investor behavior. We are aware of only one study that examines how capital and liquidity levels affected the responses of investors in financial institutions to the Lehman failure.[77] This study found that large banks with lower leverage and higher reliance on deposit funding had higher post-Lehman stock returns—and, by contrast, that pre-Lehman regulatory capital ratios and liquidity measures did little to explain those returns.[78]

However, several attributes of this study limit its specific relevance to runs. First, its market and balance-sheet data are both included on a quarterly or even annual basis, which is too infrequent to capture run behavior in funding markets.[79] Second, its outcome variable only captures the behavior of

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[75] *See supra* note 65.

[76] *But see, e.g.*, Philippe Jorion and Gaiyan Zhang, "Credit Contagion from Counterparty Risk," 64 *J. of Fin.* 2053 (Sep. 28, 2009) (finding substantial variance in CDS spreads not explained by counterparty exposure in sample of 250 public bankruptcies); Darrell Duffie et al., "Frailty Correlated Default," 64 *J. of Fin.* 2089 (Sep. 29, 2009) (finding, per U.S. non-financial firms from 1979 to 2004, that probability of extreme default losses is "an order of magnitude" higher than a model based "only on exposure to observable risk factors" would suggest). Other notable articles study discrete concepts that they place under the mantle of "contagion," such as direct interconnectedness between institutions and economies or correlation between asset valuations. *See, e.g.*, Philippe Jorion and Gaiyan Zhang, "Good and bad credit contagion: Evidence from credit default swaps," 84 *J. of Fin. Econ.* 860 (2007) (distinguishing between positive CDS-spread correlation, as a sign of market-wide events, and negative correlation, as a sign of firm-specific events); Laura Ballester, Barbara Casu, and Ana Gonzalez-Urteaga, "Bank fragility and contagion: Evidence from the bank CDS market," 38 *J. of Empirical Fin.* 394 (Sep. 2016) (making a similar distinction "between systematic and idiosyncratic contagion"); Adrian Alter and Andreas Beyer, "The dynamics of spillover effects during the European sovereign debt turmoil," 42 *J. of Banking and Fin.* 134 (2014) (defining contagion as "extreme amplification of spillover effects"); Shahriar Azizpour, Kay Giesecke, and Gustavo Schwenkler, "Exploring the sources of default clustering," 129 *J. of Fin. Econ.* 154 (Jul. 2018) (defining contagion as the channel "by which the default by one firm has a direct impact on the health of other firms"); Efraim Benmelech and Nittai K. Bergman, "Bankruptcy and the Collateral Channel," 66 *J. of Fin.* 337 (Mar. 21, 2011) (neglecting to define contagion, but speaking of "contagion through liquidity enhancers," "credit enhancers," and indirect counterparty exposure through third-party equities); Sheri M. Markose et al., "Too Interconnected to Fail: Financial Contagion and Systemic Risk in Network Model of CDS and Other Credit Enhancement Obligations of US Banks," Univ. of Essex Discussion Paper No. 683 (Feb. 2010) (measuring counterparty network exposures during "the 2007 financial contagion"). This article follows the definition used in Scott, *supra* note 31, which distinguishes contagion from both counterparty and correlation risk.

[77] Asli Demirguc-Kunt, Enrica Detragiache, and Ouarda Merrouche, "Bank Capital: Lessons from the Financial Crisis," IMF Working Paper WP/10/286 (2010), https://www.imf.org/external/pubs/ft/wp/2010/wp10286.pdf. Using CDS spread data, Nicolas Dumontaux and Adrian Pop also found that the negative effect of the Lehman bankruptcy on both share value and CDS spreads was "correlated with the financial condition of the surviving institutions." However, their measures of financial condition were focused specifically on institutions' loan books, specifically "the ratio of loan loss reserves to total loans" and "the ratio of non-performing assets as a fraction of total assets." These balance-sheet measures, as well as their regression specifications have the same limitations as those of Demirguc-Kunt et al. "Contagion Effects in the Aftermath of Lehman's Collapse: Evidence from the US Financial Services Industry," Banque de France Working Paper No. 427 (Mar. 25, 2013), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2239006, at 19.

[78] *See* Demirguc-Kunt, *supra* note 77 at 7 (detailing liquidity controls of "liquid assets/assets," "deposits/total assets," "loans [sic] loss provisions/total assets," "net loans/assets," and "log of total assets").

[79] *Id.* at 7-8.

shareholders in equity markets. Equity market capitalization is an easily observable component of enterprise value, and since it is highly liquid, it can reflect concerns from a wide range of investors.[80] However, debt markets are, by definition, where a run occurs, and as discussed, institutions are funded by both equity and debt; the interests of creditors and shareholders are not necessarily aligned, and their reaction to a shock also might be different.[81] Third, the study uses Basel II measures of capital, and thus sheds little light on whether Basel III and other reforms might have changed the relevance of regulatory capital ratios to investors during a run.[82]

III. EMPIRICAL ANALYSIS

a. Methodology and Research Design

This article attempts to fill this empirical gap, using Lehman's *unexpected* bankruptcy to examine the impact of capital and liquidity on large financial institutions' susceptibility to a run.[83] Recall that the Friday prior to the Lehman's bankruptcy—the most recent time U.S. markets were open for trading—investors could reasonably expect that another bank would purchase Lehman, perhaps with public assistance, as had been the case when JPMorgan Chase & Co. purchased Bear Stearns six months earlier. That did not occur. Instead, Monday's trading began with news that Lehman had gone under, and that the accounts of Lehman's British and Japanese brokerage operations had been frozen. We set up the econometric specification as follows.

First, our outcome variables—share prices and CDS spreads—draw on information from both debt and equity markets.[84] These variables are proxies for run behavior, rather than direct measures. As

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[80] *See* Sarin and Summers, *supra* note 73 (discussing relationship of bank equity and debt market measures to bank exposures and asset quality).

[81] *See, e.g.*, Antonio S. Mello and John E. Parsons, "Measuring the Agency Cost of Debt," 47 *J. of Fin.* 1887 (Dec. 1992).

[82] Demirguc-Kunt et al. also contains a methodological flaw: Its outcome variable measures raw change in a sample bank's stock price, controlling for the stock's beta, or covariance between the stock's return and the return of the host country's stock market. *Supra* note 77 at 7. This approach has several shortcomings. First, failing to normalize raw price changes to ticker price or market capitalization can make meaningful comparison impossible. (For example, Bank A with 100 shares trading at $10 has the same market capitalization as Bank B with 1000 shares trading at $1. If the prices of both banks' shares fall $0.10, Bank A loses 1% in value, while Bank B loses 10%.) Second, this approach fails to isolate capitalization from earnings data. Bank A may have had a higher return on equity ("ROE") than Bank B before the Lehman bankruptcy, and its return on equity may be higher afterwards. However, the same high leverage that improved Bank A's pre-Lehman ROE could have set it on a worse trajectory afterwards—precisely as basic corporate finance suggests it would. *See, e.g.*, Troy Adkins, "The Optimal Use of Financial Leverage in a Corporate Capital Structure," *Investopedia.com* (Dec. 14, 2018), https://www.investopedia.com/articles/investing/111813/optimal-use-financial-leverage-corporate-capital-structure.asp.

[83] We cannot reject fully the absence of private *ex ante* information about Lehman's planned filing, and thus completely eliminate concerns about endogeneity. However, as discussed above, Lehman counterparties and government officials worked to negotiate a transaction that would have avoided the filing until late on Sunday, September 14; markets were closed over the entire "Lehman weekend"; and the Lehman filing itself came shortly before the Monday, September 15, market opening. The likelihood that the market already reflected Lehman's failure before that Monday is low, as the subsequent splintering of equity prices and CDS spreads of large institutions suggests. *See infra* notes 2, 3, 4.

[84] Several studies have used similar techniques to examine other aspects of investor behavior during the 2008 crisis; *see, e.g.*, Jian Yang and Yinggang Zhou, "Credit Risk Spillovers among Financial Institutions around the Global Credit Crisis: Firm-Level Evidence," *Management Science* (forthcoming, 2012),

discussed above, the definition of a bank run is typically limited to withdrawal of debt financing—in an ideal-type case, the withdrawal of deposits, by depositors.[85] Direct measures of such withdrawals are unavailable publicly, either today or in 2008, at the level of granularity required to isolate the effect of the Lehman failure. However, we would expect CDS spreads to reflect the overall availability of funding to an institution, since they capture the market price of insuring against a credit event, including default.[86] Equity prices complement CDS measures, since equities trade in thicker, more complete markets; CDS spreads can reflect incomplete information when the probability of a credit event is remote.[87] (As discussed later, the results using either outcome variable are very similar.)

Second, we use a panel fixed-effects regression approach for our baseline model, with standard errors clustered by institution, to capture changes in the trajectory of share prices and CDS spreads in response to the Lehman failure.[88] This dynamic model utilizes daily market data to estimate the impact of

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https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1691111; Barry Eichengreen, Ashoka Mody, Milan Nedeljkovic, and Lucio Sarno, "How the Subprime Crisis went global: Evidence from bank credit default swap spreads," 31 *J. of In'tl. Money and Fin.* 1299 (Sep. 2012). We also explored the possibility of measuring "run behavior" through an institution's use of public liquidity programs on September 15, 2008. However, of those programs available to U.S. financial institutions, only one was (a) operating and accessible on that date and (b) has data publicly available on its use by individual institutions: the Primary Dealer Credit Facility. This program offered liquidity to primary dealers (six, specifically, on that day), who in turn provided liquidity to non-primary dealers through the repo market; as such, the direct exposures of those primary dealers provides little meaningful information on their own proximate liquidity needs. Detailed transaction information on discount window lending, meanwhile, is unavailable publicly prior to 2010. *See* Board of Governors of the Federal Reserve System, "Usage of Federal Reserve Credit and Liquidity Facilities" (Dec. 9, 2013), https://www.federalreserve.gov/regreform/reform-transaction.htm; Board of Governors of the Federal Reserve System, "Primary Dealer Credit Facility (PDCF)" (Feb. 12, 2016), https://www.federalreserve.gov/regreform/reform-pdcf.htm; Board of Governors of the Federal Reserve System, "Discount Window Lending" (Sep. 28, 2018), https://www.federalreserve.gov/regreform/discount-window.htm.

[85] *See, e.g.*, Gorton, *supra* note 19 at 9 ("A financial crisis in its pure form is an exit from bank debt, a bank run").

[86] *See* Peipei Wang and Ramaprasad Bhar, "Information content in CDS spreads for equity returns," 30 *J. of Int'l. Fin. Markets, Inst., and Money* 55 (May 2014); Christopher L. Culp, Andria van der Merwe, and Bettina J. Stärkle, "The Informational Content of CDS Spreads," in Christopher L Culp *et al.*, *Credit Default Swaps* (2018).

[87] The combination of equity and CDS measures has another advantage: Because a bank can be funded entirely from debt (e.g., deposits), a bank could theoretically experience a fire-sale in equity markets, without experiencing similar strain in debt markets. We can imagine one scenario that might practically fit this description: a preemptive resolution, perhaps by a deposit insurer, guaranteed to leave customer deposits intact. A planned resolution would reflect significant financial strain, and likely a credit even triggering payment on a CDS contract—but it would not fit the traditional definition of a run, since creditors would not be withdrawing any funding, and direct cost-of-debt measures (*e.g.*, cost of deposits) might not reflect the strain at all. *See, e.g.*, "CIT files for 5th largest U.S. bankruptcy," *CNN Money* (Nov. 1, 2009), https://money.cnn.com/2009/11/01/news/companies/cit_group/?postversion=2009110118; "CIT CDS Credit Event Auction," *Markit creditex* (Nov. 20, 2009), http://creditfixings.com/information/affiliations/fixings/auctions/2009/citgrp/index.shtml.

[88] Our specification comes from Daron Acemoglu, David H. Autor & David Lyle, "Women, War, and Wages: The Effect of Female Labor Supply on the Wage Structure at Midcentury," 112 *J. Pol. Econ.* 497 (2004) and employs clustered standard errors. Clustering standard errors is a now-commonplace technique to address potential serial correlation among results. *See* A. Colin Cameron and Douglas L. Miller, "A Practitioner's Guide to Cluster-Robust Inference," 50 *J. Human Res.* 317 (Spring 2015), http://jhr.uwpress.org/content/50/2/317.refs. Clustering shrinks the effective size of our sample, reducing it from several hundred observations (the share price and CDS spread of each institution, on each day) to several dozen (several weeks of daily share prices and CDS spreads, for each institution). Given the normalization of share prices in our sample, and the uniform application of the Lehman shock across our entire population, there is an argument against using clustering. *See* Alberto Abadie, Susan Athey, Guido Imbens,

Lehman's bankruptcy. The regression holds constant firm-specific outcomes and time-specific outcomes—that is, any trends associated with a particular firm or day before the Lehman run occurred. Keeping these trends "fixed" adds confidence that our model is appropriately attributing the observed variation during our time window to the Lehman bankruptcy.[89]

$$y_{i,t} = \alpha_i + \alpha_t + \alpha_i \cdot t + \gamma \cdot d_{LEH} + \phi \cdot d_{LEH} \cdot m_i + \varepsilon_{i,t}$$

On the left-hand side, $y_{i,t}$ is the share price, five-year CDS spread, or one-year CDS spread of financial institution *i* on day *t*, normalized by its value on the first trading day of September 2008. Our window for this data runs from September 1 to 19, capturing the rest of the trading week after the Lehman filing and the two weeks beforehand. On the right-hand side, α_i captures firm-specific characteristics, which also captures firm-specific m_i; α_t captures aggregate time effects; $\alpha_i \cdot t$ captures firm-specific time trends; and d_{LEH} is a dummy variable for the period following September 15, 2008, the day when Lehman collapsed. The dummy variable equals zero on the days prior to September 15, 2008, and switches to one on that day and afterward. The coefficient of interest is ϕ, which corresponds to the interaction term between the Lehman failure dummy and the regulatory ratio of interest at financial institution *i* prior to Lehman's failure, captured by m_i. (We also tested a related regression specification that employs daily changes, as opposed to cumulative changes, of share prices and CDS spreads. In that specification, the dummy variable equals 1 on September 15, 2008, and zero otherwise. The results are qualitatively identical and are available on request.)

Third, we test a broad set of explanatory variables that could have impacted investor behavior, using balance sheet measures from the most recent quarterly filings prior to the Lehman bankruptcy, or more recent market information as available. (*See* **Table 1** for a summary of measures used and **Appendix B** for descriptive statistics.)

It is worth noting that our core results, described below, are visible even without this panel fixed-effects regression approach or variations thereof. **Appendix G** contains a series of bivariate correlation charts, with the cumulative change in share prices on the vertical axis and the explanatory variable on the horizontal axis. The fitted lines in these charts show that, counterintuitively, banks with greater balance-

and Jeffrey Wooldridge, "When Should You Adjust Standard Errors for Clustering?" NBER Working Paper No. 24003 (Nov. 2017), https://www.nber.org/papers/w24003. Notably, we also conducted our analysis of U.S. institutions without clustering and, separately, with a different clustering method (bootstrapped clustered standard errors; s*ee* Judson Caskey, estimating equations programs for multi-way clustered standard errors, UCLA Anderson School of Management (retrieved Jan. 2, 2019), https://sites.google.com/site/judsoncaskey/data). Our results are directionally identical and robust under all three specifications and are available on request.

[89] Studies looking at similar phenomena sometimes employ an abnormal return event study, which looks at the deviation of a firm's equity returns from an underlying normal return (usually the return on a broad-based index, like the S&P 500). *See* Norman Strong, "Modelling Abnormal Returns: A Review Article," 19(4) J. of Bus. Finance & Accounting 533 (Jun. 1992). An abnormal return event study is, in a sense, a narrower specification of the panel regression we use. However, our specification has two advantages: First, by focusing on interaction effects, it sheds light on changes in the first derivative of equity returns. Second, it avoids the challenge of fixing a reference return for the underlying market, which was affected substantially itself by the performance of the financial institution returns of interest.

sheet liquidity and regulatory capital experienced *more* funding strain, not less, and that share-price correlation with Lehman was intuitively associated with greater funding strain.

For **capital**, we first test the Tier 1 Capital ratio as reported by the firms listed in **Appendix D** (AR T1/RWA). These numbers have an important caveat: In fall 2008, large U.S. institutions were still reporting figures under the older (and less granular) Basel I accords, not Basel II.[90] Because public accounting and regulatory disclosures do not correspond to the Basel II risk-weighting categories, we cannot reconstruct the Basel II capital denominator at the time, and are limited to the 2008 risk-weighted denominator. However, we can and do construct the Basel II tier 1 numerator, reflecting the regulatory "state of the art" in 2008 and a then-imminent regulatory requirement for U.S. banking organizations.[91]

Next, we run a series of tests to examine how investors weighed the regulatory capital measures available at the time of the Lehman filing. To isolate the Basel II numerator, we test a ratio of Basel II Tier 1 capital over total assets (B2 T1/TA). To isolate the Basel I denominator, we test a ratio of common equity over 2008 risk-weighted assets (CE/RWA).

To assess whether the new Basel III measures better predict investor behavior, we also calculate and test a proxy for the new Basel III numerator measures: Basel III Tier I capital ("B3 T1") and Basel III CET1 ("CET1") (*see* **Appendix C**). We test each proxy over 2008 risk-weighted assets (B3 T1/RWA, CET1/RWA) and total assets (B3 T1/TA and CET1/TA).[92] Finally, we leave the Basel requirements behind entirely and test a simple leverage measure (CE/TA).

For **liquidity**, as discussed above, pre-Lehman investors had access to roughly a year's worth of new FASB fair value accounting measures for most institutions. To examine how relevant these measures were to investor behavior, we construct and test a Level 1 asset ratio (L1/TA). To see if investor behavior reflected more conventional indicators of liquidity, we also test holdings of cash and cash equivalents (Cash + Equivalents/TA).

For **funding fragility**, we test each institution's overall reliance on short-term wholesale funding (STWF/TA), a measure of credit that investors can withdraw on short notice, which is now addressed as part of Basel III.[93] In theory, however, large redemptions of STWF do not endanger a bank with enough liquid assets to cover those redemptions. To test whether this interaction of funding and liquidity

[90] U.S. regulators finalized the Basel II capital rules for advanced approaches banks in November 2007 and required a minimum of four quarters of "parallel run," in which institutions would calculate both Basel I and Basel II capital ratios, but would only report Basel I figures. *See* Board of Governors of the Federal Reserve System, "Board approves final rules to implement Basel II risk-based capital framework," press release (Nov. 2, 2007), https://www.federalreserve.gov/newsevents/pressreleases/bcreg20071102a.htm.

[91] Notably, the Basel I Tier 1 definition was almost identical to the Basel II Tier 1 definition, adding only non-cumulative perpetual preferred stock to Basel I's paid-up share capital/common stock and disclosed reserves. *See* Basel Committee on Banking Supervision, "International Convergence of Capital Measurement and Capital Standards" (Jul. 1988, rev. Apr. 1998), https://www.bis.org/publ/bcbsc111.pdf, at 14.

[92] Unfortunately, it was not possible to reconstruct a Basel III risk-weighted denominator proxy using data publicly available in 2008; *see infra* Sec. IV.

[93] Basel Committee on Banking Supervision, "Basel III: the net stable funding ratio" (Oct. 2014), https://www.bis.org/bcbs/publ/d295.pdf; *see also* German Lopez-Espinosa, Antonio Moreno, Antonio Rubia, and Laura Valderrama, "Short-Term Wholesale Funding and Systemic Risk: A Global Covar Approach," International Monetary Fund Working Paper No. 12/46 (Feb. 1, 2012), https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Short-Term-Wholesale-Funding-and-Systemic-Risk-A-Global-Covar-Approach-25720.

predicted investor behavior, we also test ratios of liquid assets to STWF (L1/STWF and Cash + Equivalents/STWF), expecting less run exposure at an institution with a ratio near or above 1.[94]

We also investigate a market-based measure available to all investors and the general public at the time of the crisis: **correlation** in equity returns. We construct a proxy (Lehman Correlation) by calculating the correlation between each bank's day-over-day change in share price and the equivalent changes for Lehman, over a long window preceding the Lehman bankruptcy filing.[95] A higher correlation suggests that market shocks affect the share prices of the two institutions in similar sign and magnitude. If correlation has high explanatory power, it suggests investors may have relied more heavily on high-level market proxies—rather than balance-sheet measures—to assess an institution's exposure to the Lehman shock.

Finally, to account for the possibility that investors acted on **private information** about Lehman itself, we assess the direct exposure of each institution in our sample to Lehman in the United States. Using information from the Lehman U.S. bankruptcy trustee, we aggregate the total amount awarded on claims either held by or transferred from an institution in our sample (or one of its subsidiaries or affiliates). At best, this measure is a loose proxy of actual counterparty exposures, or the actual amounts Lehman owed to other parties at that time.[96] However, given the statutory penalties for misstating claims

[94] These measures follow the broad form of the working capital or "current" ratio (current assets/current liabilities); however, those definitions cover maturities of one year or less. *See* Financial Accounting Standards Board, "Debt (Topic 470): Simplifying the Classification of Debt in a Classified Balance Sheet (Current vs. Noncurrent)," Proposed Accounting Standards Update Exposure Draft (Jan. 10, 2017), https://www.fasb.org/cs/ContentServer?c=Document_C&cid=1176168748705&d=&pagename=FASB%2FDocument_C%2FDocumentPage.

[95] The specific formula used to calculate the daily change in the share price is $\log\left(\frac{p_t}{p_{t-1}}\right)$, applied to end-of-day share prices from January 2007 through July 2008.

[96] The reasons for this looseness include: The proxy (a) does not distinguish between claims payable to the institution or its transferee, rather than trustee or custody claims payable to one of the institution's customers; (b) potentially double-counts claims transferred from one in-sample institution to another; and (c) does not reflect claims on non-U.S. Lehman entities. *See* Rosalind Wiggins and Andrew Metrick, "The Lehman Brothers Bankruptcy E: The Effect on Lehman's U.S. Broker-Dealer," Yale Program on Financial Stability Case Study 2014-3E-V1 (Apr. 7, 2015), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2588556. The greatest shortcoming, however, is that our proxy is based on the total amount awarded (which could understate true exposures) rather than the total amount claimed (which could overstate true exposures). However, Lehman's Chapter 11 voluntary petition suggests that initial claims may have even less of a relationship to investor behavior than the ultimate awards figures we used. Lehman's largest unsecured creditor in that petition was Citibank, N.A., with an astonishing $138 billion in exposure—more than 11 times the second-largest unsecured creditor. Its 7th largest unsecured creditor was also a branch of Citibank, N.A., with another $275 million in exposures. Based on call report filings, these claims were 11.3% of Citibank, N.A.'s unweighted assets, and 173% of its reported Basel II Tier 1 capital. This initial petition only included one other bank from our U.S. sample and four other banks from a separate non-U.S. Global Systemically Important Bank ("G-SIB") sample, and it excluded other in-sample banks that ultimately filed awarded claims. Based only on the information in this petition, we would expect Citibank to experience a faster pace of withdrawals than any other institution by several orders of magnitude. Instead, the fastest pace was at institutions like Goldman Sachs and Morgan Stanley, who were not listed among Lehman's largest unsecured creditors. *See SIPC v. Lehman Brothers Holdings Inc.*, No. 08-13555 (S.C.C.) (Bankr. S.D.N.Y. Sep. 19, 2008), voluntary petition, https://document.epiq11.com/document/getdocumentbycode/?docId=1130940&projectCode=LBH.

in the liquidation of a securities dealer, the U.S. claims may be the best available measure of relative counterparty exposures to Lehman at the time of insolvency.[97]

Table 1: Explanatory (RHS) Variables Under Consideration

RWA Denominator "Capital Ratios"	TA Denominator "Leverage Ratios"	STWF Denominator and Various Proxies
CE / RWA	CE / TA	Level 1 / STWF
AR Tier 1 / RWA	B2 Tier 1 / TA	Cash / STWF
B3 Tier 1 / RWA	B3 Tier 1 / TA ("simple leverage ratio")	Lehman Correlation
B3 CET1 / RWA	B3 CET 1 / TA	Lehman Claims
	Level 1 / TA ("liquidity proxy")	
	Cash / TA ("liquidity proxy")	
	STWF / TA	

For our initial sample, we include the 27 largest U.S. banking institutions by total consolidated assets as of September 2008, and investment banks that later converted to bank holding company status (which were then receiving public assistance, which subsequently received still more, and which are subject to the same post-crisis prudential reforms).[98]

b. Results

The full results of our analysis can be found in **Appendices E** and **F**. Here, we briefly review results for each explanatory variable. In short, only Basel II Tier 1 leverage and Lehman correlation predicted run behavior in the intuitive direction across all markets. By contrast, balance-sheet liquidity and regulatory capital either had no statistically significant relationship to run behavior, or an unexpected relationship—the more an institution had, the more exposed it was to the run.

i. Simple Panel Fixed-Effects Regression Results

[97] Lehman bankruptcy proceedings occurred under the Securities Investor Protection Act, which bars false statements of account, *see* 15 U.S.C. § 78aaa(c)(1)(C)(ii), and acts of fraudulent conversion, *see* 15 U.S.C. § 78aaa(c)(2). Data used for the proxy measure is available on the Lehman trustee website, *SIPC v. Lehman Brothers Holdings Inc.*, No. 08-01420 (S.C.C.) (Bankr. S.D.N.Y. Sep. 19, 2008), voluntary petition, https://dm.epiq11.com/#/case/LBI/info.

[98] As such, where "total assets" are indicated above, for firms filing the Y-9C, we specifically use their total consolidated assets. Note, however, that we exclude Charles Schwab and E*TRADE Financial, which are both savings & loan holding companies, in the baseline panel regressions. *See* "Charles Schwab Corporation, The," National Information Center, Federal Financial Institutions Examination Council (accessed Feb. 22, 2019), https://www.ffiec.gov/nicpubweb/nicweb/InstitutionProfile.aspx?parID_Rssd=1026632&parDT_END=99991231; "E*TRADE Financial Corporation," National Information Center, Federal Financial Institutions Examination Council (accessed Feb. 22, 2019), https://www.ffiec.gov/nicpubweb/nicweb/InstitutionProfile.aspx?parID_Rssd=3412583&parDT_END=99991231. We omitted our application of the same specification to data from 22 non-U.S. G-SIBs, as identified by the Financial Stability Board. Data in this non-U.S. sample is highly heterogeneous, representing a wide set of jurisdictions, regulatory mechanisms, and policy decisions in the implementation of the various Basel accords. As such, it cannot adequately support conclusions about non-U.S. jurisdictions or institutions.

For **capital**, we would expect the estimated coefficients to be significant, and to imply that higher capital levels were consistently associated with higher share prices and lower CDS spreads (*i.e.*, positive and negative, respectively). For no measure of regulatory capital is this true.

The estimated coefficient on reported Tier 1 capital (AR T1/RWA) is significant only for one-year CDS spreads. Even in this limited result, the coefficient points in the wrong direction—suggesting that institutions that were *better* capitalized for regulatory purposes were *more* exposed to run behavior. For every other capital measure with risk-weighted assets in the denominator, the results are even starker: No risk-based measure was associated with run exposure in equity markets, and in CDS markets, they pointed towards greater exposure to the Lehman run.

Abandoning risk-weighting and adopting the post-crisis definition of capital produces very different results, but only in CDS markets. Simple leverage (CE/TA) and Basel II Tier 1 leverage (B2 T1/TA) are both intuitive and statistically significant for one-year and five-year spreads, implying that institutions with less reliance on debt were less exposed to the Lehman run. When used with an unweighted capital denominator (TA), the new Basel III numerators (B3 T1, B3 CET1) exhibited the same relationships. Of all four measures, however, only Basel II Tier 1 leverage had predictive power in equity markets.

Together, these results suggest the challenges associated with Basel I (several of which had been noted before the crisis) may have resided in its risk-weighting system, rather than its definition of capital.[99] Bolstering this suggestion, simple leverage (CE/TA) and the reported Tier 1 capital ratio (AR T1/RWA) were negatively correlated before the Lehman filing; the higher an institution's Basel I ratio, the more leveraged it was likely to be (*see* **Table 2**).

Since Basel III was aimed at making regulatory capital more equity-like, we would expect the Basel III definitions of capital to be associated with lower run exposure. However, the Basel III numerator proxies (B3 T1/TA and CET1/TA) instead perform worse than reported Basel I measures in explaining investor behavior around Lehman. A separate test shows why: For institutions in our U.S. sample, the Basel III Tier 1 ratio (B3 T1/RWA) is even more negatively correlated with simple leverage (CE/TA) today than the Basel I Tier 1 ratio was before Lehman's failure (*see* **Table 2**). The more regulatory capital an institution has under Basel III, the greater its reliance on debt.

Table 2: Correlation Between Basel Capital Ratios and Simple Leverage, 2008 and 2018

	2008Q2 (CE/TA, AR T1/RWA)	*2018Q2 (CE/TA, B3 T1/RWA)*
U.S. G-SIB	-0.047 (*n=24*)	-0.270 (*n=27*)
Non-U.S. G-SIB	0.387 (*n=20*)	-0.161 (*n=19*)

[99] *See, e.g.*, Daniel K. Tarullo, *Banking on Basel: The Future of International Financial Regulation* (2008). For more on potential challenges associated with risk-weighting, see also Andrew G. Haldane, "Constraining discretion in bank regulation," paper presented at the Federal Reserve Bank of Atlanta Conference on "Maintaining financial stability: holding a tiger by the tail(s)," Atlanta, GA (Apr. 9, 2013), https://www.bis.org/review/r130606e.pdf, at 3 ("At least at an aggregate level, bank risk weights appear to have borne, at best, a tenuous relationship with risk. At worst, they were a contrarian indicator"); John Vickers, "Safer, But Not Safe Enough," keynote address at the 20th International Conference of Banking Supervisors, Abu Dhabi (Nov. 29, 2018), https://www.bis.org/bcbs/events/icbs20/vickers.pdf.

For **balance-sheet liquidity**, the results are similarly counterintuitive. Neither liquidity proxy (L1/TA, Cash + Equivalents/TA) is consistently positive and significant across outcome variables. Instead, both measures are negative and statistically significant in equity markets—suggesting equity investors withdrew funding more quickly from institutions with more balance-sheet liquidity. The lone exception (Cash + Equivalents/TA, in one-year CDS markets) suggests a greater sensitivity to the most liquid assets among those investors.

For **funding fragility** (STWF), a greater reliance on short-term wholesale funding was associated with a lower share price, but not with wider one-year or five-year CDS spreads. As far as the interaction between liquidity and funding fragility, results are mixed. Only one proxy explains run exposure as expected, and in only one market (Cash + Equivalents/STWF, in one-year CDS spreads). By contrast, our other proxy (Level 1/STWF) was associated with lower share prices in equity markets, and had no explanatory power in other markets.

By contrast, simple return **correlation** is uniformly statistically significant at $\alpha = 0.01$ (***) across all markets, as is the **Lehman claims** proxy variable.

ii. Compound Panel Fixed-Effects Regression Results

Three measures are robust and directionally intuitive in every permutation of our U.S. sample: Basel II Tier 1 leverage (B2 T 1/TA), Lehman correlation, and Lehman claims. Next, we test the overlap among these variables using a modified regression specification:

$$y_{i,t} = \alpha_t + \alpha_i \cdot t + \beta_1 \cdot m_{1,i} + \beta_2 \cdot m_{2,i} + \gamma \cdot d_{LEH} + \phi_1 \cdot d_{LEH} \cdot m_{1,i} + \phi_2 \cdot d_{LEH} \cdot m_{2,i} + \varepsilon_{i,t}$$

Several variables are identical to our prior specification, including $y_{i,t}$ (normalized share price/CDS spread of institution *i* on day *t*); α_t (aggregate time effects); $\alpha_i \cdot t$ (institution-specific time trends); and d_{LEH} (a dummy for September 15, 2008). However, we have removed α_i (institution-specific characteristics) and replaced it with $m_{1,i}$ and $m_{2,i}$, two specific regulatory ratios of interest for institution i. ϕ_1 and ϕ_2 are the coefficients of interest, capturing the interaction between the Lehman failure dummy and $m_{1,i}$ and $m_{2,i}$, respectively. If ϕ_1 remains statistically significant after controlling for ϕ_2, it suggests that $m_{1,i}$ has explanatory power above and beyond that of $m_{2,i}$ (and vice versa).

Our results are a powerful endorsement of the explanatory power of return correlation. When controlling for Lehman correlation, both Lehman claims and Basel II Tier 1 leverage (B2 T1/TA) lost significance, with only one exception: Lehman claims retained weak significance in equity markets. This suggests that Lehman correlation captures the variation in run exposure suggested by the two other variables, except in equity markets, where counterparty information still retained some independent explanatory power.

iii. Overall Results

Of all 15 right-hand-side variables, only three were statistically significant and directionally intuitive explanatory variables in both CDS and equity markets: one leverage measure (**B2 T1/TA**), one correlation measure (**Lehman correlation**), and one counterparty exposure measure (**Lehman claims**). Of these, the correlation measure was the most powerfully predictive of run exposure.

- For **capital**, every measure with 2008 risk-weighted assets in the denominator showed either statistically insignificant or counterintuitive results: The higher the ratio, the more quickly investors reduced their equity exposure, and the higher the implied probability of default. Focusing only on the numerator, the most stringent Basel III definition of capital had less explanatory power than its predecessor Basel II measures.

- Similarly, our **balance-sheet liquidity** proxies were not intuitively predictive of investor behavior. One proxy behaved just as the regulatory capital variables did: The higher the levels, the greater the institution's exposure to the Lehman run.

- Our measure of **funding fragility** only had explanatory power in equity markets, not CDS markets.

- Our **correlation** measure performed as well as—or better than—our proxy for private information about Lehman's direct counterparty exposures.

Finally, as an intuitive check, we plot a subset of explanatory variables against cumulative changes in share price over our post-crisis window. These simple results are consistent with our analysis: Correlation, claims, and leverage explain a substantial amount of variation in run exposure, in the intuitive direction; CET1 risk-based capital also explains a substantial amount of variation in run exposure, but in the counterintuitive direction; and liquidity results are still highly clustered. In short, the institutions most exposed to the Lehman run were not the ones with the lowest levels of capital or balance-sheet liquidity.

IV. ANALYSIS

Our results target a specific question: the impact of commonly cited prudential measures on the vulnerability of financial institutions to a contagious run. They are limited by the nature and context of the Lehman bankruptcy, which occurred in a financial industry already known to be insufficiently liquid and undercapitalized, after six months of extraordinary government support. They do not speak to the *ex ante* role of capital or liquidity in preventing a crisis, nor to their *ex post* role in hastening recovery from one. The existing literature is clear on both those points, and nothing in our results qualifies or contradicts them. (Similarly, our results are limited by our small sample size—which, itself, is limited to the population of large banks in existence during one of the most severe financial shocks of the last century.)

Instead, our results address the narrow window after a run has started but before it spreads, at the same regulated institutions that have been the focus of a large number of post-crisis reforms. This window is small, but it can have outsized consequences for the path of a financial crisis, as well as the public and private costs of that crisis. As such, our results bear directly on the capital vs. contagion debate; shed light on the causes of systemic bank runs; and suggest critical policy steps to address run vulnerability at large financial institutions.

a. Runs Aren't (Always) About Cash

Balance-sheet liquidity did little to stop a run on an institution by investors in the wake of Lehman's filing; on the contrary, in several markets and by several measures, institutions with a greater

share of liquid assets on their balance sheets experienced faster outflows. This result is unexpected, and despite two strong counterarguments, it is difficult to dismiss entirely.

The first counterargument would limit our result to low levels of balance-sheet liquidity. Financial institutions had relatively few liquid assets entering 2008, and by the time Lehman filed for bankruptcy, the markets had already experienced months of volatility.[100] Investors might have (quite reasonably) assumed that post-Lehman redemptions would dwarf whatever liquid assets banks had on hand, and discounted the four-month-old 2Q08 balance-sheet liquidity figures entirely.

However, the market had another critical source of liquidity at the time Lehman fell: the United States government, which followed Bagehot's dictum and was operating four relevant facilities in addition to the discount window in September 2008.[101] Five months earlier, when Bear Stearns failed, Lehman itself had borrowed an average of $2.2 billion a day (and $15.2 billion total) from just one of those facilities.[102] On September 14, the Federal Reserve publicly announced a "significant broadening" of the eligible collateral for two facilities, and it increased the frequency and quantity of funds institutions could borrow.[103] The day it filed, Lehman took out another $28 billion in overnight loans from the Federal Reserve, and other primary dealers took out $15 billion.[104] Banks' balance-sheet assets may have been highly illiquid, but the large banks themselves were seemingly awash in liquidity; the Federal Reserve did not disclose full and precise figures contemporaneously, but investors would have known this liquidity was available for use.[105]

This high level of public support creates a second counterargument: Investors were indifferent to balance-sheet liquidity because institutions could access potentially unlimited government cash. (In other words, instead of holding only at low levels of liquidity, our results would only hold at high levels of liquidity.) However, that would imply two inconsistent facts: Investors (a) ran on large financial institutions, because the government was no longer guaranteed to support them, and (b) disregarded the balance sheets of those institutions, because the government was guaranteed to support them. Even if those facts were both true, then under contagion theory, there would have been no reason for investors to

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[100] Across the entire banking sector, highly liquid assets were less than 15 percent of total assets in 2008, compared to more than 25 percent today. *See* Board of Governors of the Federal Reserve System, "Federal Reserve Supervision and Regulation Report – November 2018" (Nov. 14, 2018), https://www.federalreserve.gov/publications/2018-11-supervision-and-regulation-report-banking-system-conditions.htm, at Fig. 7 ("Highly liquid assets as a share of total assets").

[101] Scott, *supra* note 31; *see also* Committee on the Financial System, "Central bank operations in response to the financial turmoil," Bank of International Settlements, CGFS Paper No. 31 (Jul. 2008), https://www.bis.org/publ/cgfs31.pdf (detailing non-U.S. interventions prior to Lehman's failure); *see* Group of Thirty, *supra* note 71; Geithner and Metrick, *supra* note 71.

[102] *See* Board of Governors of the Federal Reserve System, "Primary Dealer Credit Facility" (Feb. 12, 2016), https://www.federalreserve.gov/regreform/reform-pdcf.htm.

[103] Board of Governors of the Federal Reserve System, "Federal Reserve Board announces several initiatives to provide additional support to financial markets, including enhancements to its existing liquidity facilities," press release (Sep. 14, 2008), https://www.federalreserve.gov/newsevents/pressreleases/monetary20080914a.htm.

[104] *Id*.

[105] The Federal Reserve disclosed details on the entities that received assistance from crisis-era special facilities in December 2010; in 2012, it began regularly publishing details regarding discount-window lending activity, roughly two years after the activity takes place. *See* Board of Governors of the Federal Reserve System, "Credit and Liquidity Programs and the Balance Sheet: Lending to depository institutions" (Jul. 24, 2017), https://www.federalreserve.gov/monetarypolicy/bst_lendingdepository.htm.

run at all; if the liquidity needs of those institutions were sure to be met, then even Lehman Brothers would still have been standing.[106]

At minimum, then, the relationship between liquidity and run behavior is more complex than contagion theory might suggest. During the Lehman run, any number of other factors may have affected that relationship—from doubts about the fidelity of bank balance sheets to the uncertain nature of public support for financial markets. To the extent those other factors matter, however, it is difficult to argue that the Lehman run was "all about cash."

b. Leverage—But Not Regulatory Capital—Can Predict How a Run Spreads

By contrast, simple balance-sheet measures of capital performed remarkably well in explaining an institution's susceptibility to a run. Basel II Tier 1 leverage was robust across tests, even more consistently than simple leverage (CE/TA), suggesting that investors paid attention to both common equity and loan-loss reserves, despite well-documented issues around pre-crisis reserve rules.[107] However, regulatory capital measures led to two disconcerting results—the first regarding risk-weighting and the capital denominator, and the second regarding reforms under Basel III.

We found no specification, in any sample, in any market, where a higher risk-weighted capital ratio corresponded to less run exposure. In fact, the opposite was true; investors generally withdrew funding faster from institutions with *more* capital as a proportion of risk-weighted assets. This result made little sense, until we found that the Tier 1 ratio as reported in 2008 (with a Basel I risk-weighted denominator) was negatively associated with common-equity leverage (with an unweighted denominator).[108] In other words, the better-capitalized an institution was under outstanding regulatory measures in 2008, the more highly leveraged it was.

This result suggests a surprising regulatory design issue, even accounting for the well-known shortcomings in pre-crisis risk-weighting rules. Leverage limits—which have been a part of U.S. banking regulation since 1981, before the first Basel accords[109]—are intended to complement risk-based capital requirements. Leverage ratios impose the same "regulatory capital charge" for every asset, giving institutions an incentive to hold riskier assets (which pay a higher return). Risk-weighting limits a bank's ability to act on that incentive, but even if the risk weights are incorrect, a leverage requirement can still serve as a "backstop," and keep a bank from assuming too high an overall level of debt. In short, an institution with a higher risk-weighted capital ratio should hold more equity—not less.[110]

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[106] There is, of course, a counterfactual argument as well: The runs on Lehman and other financial institutions would have been much worse without access to government liquidity. No natural experiment exists to test this argument, and we do find it plausible; however, given the combination of our results and the sheer volume of liquidity support available at the time of the crisis, we cannot reject the null hypothesis that liquidity levels play no role in run behavior.

[107] *See, e.g.*, Raj Gnanarajah, "Banking: Current Expected Credit Loss (CECL)," Congressional Research Service R45339 (Oct. 9, 2018), https://fas.org/sgp/crs/misc/R45339.pdf, at 1; Eugene A. Ludwig and Paul A. Volcker, "Banks Need Long Term Rainy-Day Funds," *Wall St. J.* (Nov. 16, 2012), https://www.wsj.com/articles/SB10001424127887324556304578120721147710286.

[108] S*ee infra* table 2.

[109] *See* Michael Brei and Leonardo Gambacorta, "The leverage ratio over the cycle," BIS Working Papers No. 471 (Nov. 2014), https://www.bis.org/publ/work471.pdf at 2; *see also* 12 CFR § 217.10(4).

[110] *See* Bernanke et al., *supra* note 5 at 25 (describing capital as "the flip side of leverage; the more an institution relies on borrowing, the lower its capital levels, and the greater its exposure to shocks").

Basel I and II did not include a leverage minimum, but Basel III did—and made extensive changes to risk-weighting—to serve as precisely this kind of backstop.[111] As such, we would expect Basel III to change these fire-sale relationships, so that more regulatory capital would correspond to (a) lower leverage and (b) less run vulnerability. We cannot fully test Basel III capital requirements against run vulnerability, since it is not possible to create a rough proxy for the Basel III denominator using public data. However, Basel III did not change the relationship between regulatory capital and simple leverage. In fact, that relationship has gotten even stronger: At U.S. banks, simple leverage (CE/TA) and reported Tier 1 capital ratio (T1/RWA) are even more negatively correlated today than they were in 2008—and now, unlike then, non-U.S. G-SIBs display the same negative correlation.[112]

Our findings also suggest these issues may extend to the Basel III numerator. Again, Basel III redefined Tier 1 Capital as having two components: Common Equity Tier 1, and Additional Tier 1. Common Equity Tier 1 was intended to closely reflect common equity. However, even without a risk-weighted denominator, our two Basel III numerator proxies failed to predict consistently post-Lehman run behavior across markets. Higher Basel III Tier 1 and CET1 levels, in other words, were not always associated with a lower risk of a run in our 2008 samples, and in equity markets, their relationship to run exposure was weaker than the relationship of the equivalent Basel II measures.

c. Contagion Theory: Capital, Complexity, and Information Scarcity

The policy changes made from Basel II to Basel III may shed light on the reasons for this discrepancy. The Basel III CET1 capital numerator includes the Basel II definition of Tier 1 capital, but it adds retained earnings and accumulated other comprehensive income (*i.e.*, unrealized gains) and subtracts three categories of intangible assets. In turn, Basel III Tier 1 capital includes the definition of CET1, but it adds "additional Tier 1 capital," based on a 14-point list of criteria, several of which include sub-criteria (*see* **Appendix H**).

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[111] *See, e.g.*, Basel Committee on Banking Supervision, "Basel III leverage ratio framework – Executive Summary" (Oct. 25, 2017), https://www.bis.org/fsi/fsisummaries/b3_lrf.htm ("The leverage ratio is also intended to reinforce the risk-based capital requirements with a simple, non-risk-based "backstop""); Jaime Caruana, "Financial regulation, complexity and innovation," remarks to the Promontory Annual Lecture (Jun. 4, 2014), https://www.bis.org/speeches/sp140604.htm (describing "the leverage ratio as a backstop to the risk-weighted measure"); Daniel K. Tarullo, opening statement to meeting of Board of Governors of Federal Reserve System (Apr. 8, 2014), https://www.federalreserve.gov/newsevents/press/bcreg/bcreg20140408a-tarullo-statement.htm (saying the "leverage ratio serves as a critical backstop to the risk-based capital requirements," immediately prior to FRB vote on enhanced supplementary leverage ratio); Sir Mervyn King, "Banking—from Bagehot to Basel, and back again," remarks to Buttonwood Gathering (Oct. 20, 2010), https://www.bis.org/review/r101028a.pdf (noting "the regulatory framework needs to contain elements that are robust with respect to changes in the appropriate risk weights, and that is why the Bank of England advocated a simple leverage ratio as a key backstop to capital requirements").

[112] Critically, no U.S. advanced approaches institutions are in parallel run today. Recent loan-level empirical work has also found evidence of potential manipulation in risk-weighting. *See* Matthew C. Plosser and João A.C. Santos, "Banks' Incentives and the Quality of Internal Risk Models," 31 Rev. of Fin. Stud. 2080 (2018), https://www.newyorkfed.org/research/staff_reports/sr704.html (reviewing sample of Shared National Credits from after the financial crisis, but largely before U.S. implementation of Basel III, demonstrating downward bias in risk-rating at lower-capital banks); Giovanni Ferri and Valerio Pasic, "Bank regulatory arbitrage via risk weighted assets dispersion," 33 *J. of Fin. Stability* 331 (Dec. 2017) (finding arbitrage at less capitalized banks in sample of 239 institutions); *see also* Mike Mariathasan and Ourada Merrouche, "The manipulation of Basel risk-weights," 23 *J. of Fin. Intermediation* 300 (Jul. 2014), https://doi.org/10.1016/j.jfi.2014.04.004 (examining similar behavior vis-a-vis Basel II risk weights); Andrea Beltratti and Giovanna Paladino, "Basel II and regulatory arbitrage. Evidence from financial crises," 39 *J. of Empirical Fin.* 180 (Dec. 2016).

In one interpretation of our results, investors placed less faith in the specific measures that Basel III added to regulatory capital, or placed more faith in the measures Basel III stripped away. That hypothesis deserves further analysis, as discussed below. However, a simpler explanation could account for almost all of our capital-related findings, one that policymakers have raised elsewhere: More complex measures might just matter less in the middle of a run.[113]

Contagion theorists claim that creditors become more information-sensitive during a crisis, sparked by the possibility that others have private information about the value of their previously safe, cash-like assets.[114] Our results suggest that instead—or, at least, as a corollary—time constraints and other transaction costs might place some limits on that information-sensitivity.[115] If a measure is simple and information-rich, investors may be more sensitive to changes in it. If a measure is too complex or opaque, or if it requires additional vetting to make it trustworthy, they may disregard it, or even take it as cause for concern. In this view, investors don't just care about greater information during a run; they care about the efficiency of that information, as well as the cost of obtaining it, verifying it, and making it meaningful.

d. Storms, Fires, and Correlation Channels

Another result supports the idea that informational efficiency matters: The simplest explanatory variable in our sample was also the most robust. Return correlation predicted run behavior as well as any balance-sheet measure and better than our proxy for actual Lehman counterparty exposures. Correlation retained explanatory power even when holding leverage constant, and its significance persisted across samples and markets. In other words, it matters that the system-wide run began at Lehman Brothers—and if it had begun at another institution, it would have happened differently.

Based on the strength of this result, the analogy between contagious runs and "shocks" might be inapt, or at least incomplete. A shock implies an exogenous event that buffets firms equally, destroying some and preserving others according to their individual "shock absorbers" (like capital).[116] A common shock can certainly hit one or more institutions simultaneously, like the failure of a single counterparty,

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[113] *See, e.g.*, Andrew G. Haldane, "Capital discipline," remarks at the American Economic Association, Denver, CO (Jan. 9, 2011), https://www.bis.org/review/r110325a.pdf; William Coen, "Ring-Fencing's Global Impact," 6(3) *Banking Persp.* 37, 39 (2018) ("Simply put: One cannot and should not relentlessly pursue risk sensitivity as a goal in itself; it must be balanced with simplicity and comparability").

[114] *See* Gorton and Ordoñez, *supra* note 58; Tri Va Dang, Gary Gorton, and Bengt Holmstrom, "Ignorance, Debt, and Financial Crises," Yale and NBER Working Paper (Apr. 2015), http://www.columbia.edu/~td2332/Paper_Ignorance.pdf.

[115] There is a wealth of theoretical literature on the effect of transaction costs on investor behavior; for a summary, see Darrell Duffie, "Presidential Address: Asset Price Dynamics with Slow-Moving Capital," 65 *J. of Fin.* 1237 (Aug. 2010), https://www.darrellduffie.com/uploads/pubs/DuffieAFAPresidentialAddress2010.pdf. Like much of this literature, we depart from the assumption that investors are loss-averse—put simply, that they would like their assets to increase in value, and they would prefer their assets to not lose value.

[116] The definition of an exogenous shock in the economic literature is not fixed; *see* Panos Varangis, Sona Varma, Angelique de Plaa, and Vikram Nehru, "Exogenous Shocks in Low Income Countries: Economic Policy Issues and the Role of the International Community," World Bank background paper (Nov. 20, 2004), http://siteresources.worldbank.org/INTDEBTDEPT/PolicyPapers/20747753/Varangis-Varma-dePlaa-Nehru.pdf. However, the analogy of capital to a "shock absorber" is still common. *See, e.g.*, Paul J. Davies, "This New Banking Shock Absorber Might Fail to Impress," *Wall St. J.* (Dec. 29, 2015), https://www.wsj.com/articles/this-new-banking-shock-absorber-might-fail-to-impress-1451391539.

the downgrade of a common creditor, or a cybersecurity attack.[117] But a shock need not be common to cause a contagious run; instead, all that's needed is a conduit that carries investor concerns (and withdrawals) from one financial institution to another.

A separate analogy clarifies this distinction. The "shock" analogy treats contagious runs like a storm hitting a neighborhood with little warning. Chance plays a role in the homes that are spared, along with factors that a homeowner can't necessarily foresee or control, like poor weather-proofing or a weak foundation. Generally, though, the storm affects the entire neighborhood, and only the strongest houses survive.

By contrast, our results suggest that a contagious run is more like a fire, which starts inside a single neighborhood home. Factors such as fire-proofing, sprinklers, and smoke alarms are all relevant to whether the blaze starts, but after it does, they are irrelevant to whether it consumes the neighborhood. The fire can move directly to adjacent houses, but proximity is hardly the only way it can spread; an updraft, flaming debris, or burning embers can carry the flames clear across town. Residents in neighboring properties would probably flee their homes, but so would other residents who knew they were vulnerable—for example, if they knew they lived downwind from the blaze.[118]

Run behavior in 2008 displayed a similar dynamic. Lehman Brothers (figuratively) caught fire the day it filed for bankruptcy, and investors looked hurriedly for who would burn next. Counterparty exposures were one way for withdrawals, collateral calls, haircuts, and other run-related behavior to spread, but those exposures were mostly private information and opaque to the markets. Instead, investors may have drawn conclusions about their vulnerability from the simplest available measure: Has a particular financial institution followed Lehman's trajectory in the past?

These "correlation channels" were reliable conduits for post-Lehman run risk. From an investor's perspective, their role is as intuitive as Keynes's "beauty contest": If the market sees two banks as closely linked, then naturally, when the value one falls, the value of the other will fall, too. [119] Regardless of why the link between them exists; regardless of whether they actually owe money to each other or a common

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[117] A dissent to the final report of the Financial Crisis Inquiry Commission highlighted an alleged common shock as a cause of the 2008 crisis. The Commission majority declined to adopt this view. *See* Keith Hennessey, Douglas Holz-Eakin, and Bill Thomas, "Dissenting Statement," *The Financial Crisis Inquiry Report* (Jan. 2011), at 419; *see also* Peter J. Wallison, "Dodd-Frank and the Myth of Interconnectedness," *Wall St. J.* (Feb. 9, 2012), https://www.wsj.com/articles/SB10001424052970204468004577164871060718662.

[118] Several key figures from the financial crisis have recently embraced the same analogy. *See* Bernanke et al., *supra* note 5 at 31 ("Fire prevention had failed. Now the fate of the [financial] system would depend on fire-fighting"), 111 ("[T]he U.S. economy and financial system today may be less prone to modest brush fires but more vulnerable to a major inferno if, despite updated and improved fire codes, a conflagration were to begin"). The analogy has also been used in the context of social networks and contagious disease; *see* Nicholas A. Christakis and James H. Fowler, *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives* (2009), at 132 ("If we light a tree on fire, whether this turns into a conflagration or a campfire depends a lot on what is going on around the tree: how close it is to other trees, how dry the terrain, how large or dense the forest").

[119] Keynes developed this famous hypothetical to explain herd behavior in equity markets. In short: A newspaper contest requires contestants to pick out the six most attractive photos out of many. The winner is the entrant whose list most closely resembles everyone else's most popular selections. What is a contestant's optimal strategy? Per Keynes: "It is not a case of choosing those [faces] that, to the best of one's judgment, are really the prettiest, nor even those that average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees." John Maynard Keynes, *The General Theory of Employment, Interest, and Money* (1936), Ch. 12.

third party; regardless of whether their obligations are guaranteed in bankruptcy; regardless of whether the government may lend them money, or even invest in them—regardless of all of this: If these two banks are tied together, and one is faltering, what rational investor would remain exposed to the other?

V. POLICY IMPLICATIONS

The role of correlation has several policy implications. First, it is not enough to stress-test financial institutions using broad-based economic shocks, nor even using direct or indirect counterparty exposures. A bank's ability to survive a stress event depends, in part, on the specific nature and location of that event within the financial sector—especially since financial crises often start with stress at a specific institution, rather than a broad shock to the system itself.[120] A lack of direct counterparty exposures to a failing bank forecloses one avenue towards financial strain, but it does not guarantee safety from a run.

Second, correlations can change, and correlation channels can either form or disappear, with substantial implications for contagious runs. In the weeks and months before the Lehman bankruptcy, the share prices of many large financial institutions were already highly correlated (*see* **Table 3**). These correlations read like a topographical map for the near-term crisis that followed, despite the extent to which prices and CDS spreads splintered on the day of the Lehman filing.[121] Alarmingly, the share prices of many of these institutions are even more highly correlated today, exceeding even the highest 2008 correlation with Lehman.[122]

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[120] *See, e.g.*, Ryozo Himono, "Post-Basel III agenda for the global regulatory community," remarks at DICJ-IADI conference, Tokyo, Japan (Feb. 16, 2017), https://www.fsa.go.jp/common/conference/danwa/20170216.pdf ("Typically, however, a G-SIB fails in an environment where other banks, financial markets and the real economy are weak and vulnerable as well"); Admati and Hellwig, *supra* note 40 at 75 ("[T]he question of whether banks should be allowed to fail rarely arises as a matter of principle. Rather a particular bank is in trouble and the authorities must decide whether to let it go into bankruptcy or a similar process or to allow it to continue operating, possibly after an injection of public money").

[121] Notably, existing research suggests that market correlations increase during a financial crisis, making the divergent behavior of specific financial institution equity and CDS values even more notable. *See, e.g.*, Silvio Contessi, Perangelo De Pace, and Massimo Guidolin, "How Did the Financial Crisis Alter the Correlations of U.S. Yield Spreads?" Federal Reserve Bank of St. Louis Working Paper 2013-005D (May 2014), https://files.stlouisfed.org/files/htdocs/wp/2013/2013-005.pdf.

[122] Separately, we also examined two measures of overall financial sector equity correlation. The first, share-price synchronicity, is a fixture in development economics literature as a proxy for capital-market thickness; *see* Roberto R. Rocha, Zsofia Arvai, and Subika Farazi, *Financial Access and Stability: A Road Map for the Middle East and North Africa* (World Bank, Sep. 2011), Appendix B, http://siteresources.worldbank.org/MENAEXT/Resources/Financial_Flagship_Report_Middle_East_North_Africa_2011_AppendixB.pdf. One version of this measure regresses the return of stock i at time t on broad market returns at time *t*, using a market-wide index, and takes the resulting r^2 value as a measure of stock co-movement. *Id.* at 4; *see also* Randall Morck, Bernard Yeung, and Wayne Yu, "The Information Content of Stock Markets: Why Do Emerging Markets Have Synchronous Stock Price Movements?" 58 *J. Fin Econ.* 215 (2000), https://www.nber.org/china/shangmorck.pdf. We adapt this measure using a mix of KBW Nasdaq and Dow financial-sector and banking indices, and find high synchronicity in the period immediately before the Lehman bankruptcy and low synchronicity immediately after, with synchronicity between those levels for the equivalent dates in 2018. However, a simpler measure—the cross-sectional standard deviation of daily changes in the share price of our in-sample institutions—revealed current co-movement at levels similar to immediately before the financial crisis. Results of these analyses are available upon request; however, as discussed above, we believe these aggregate measures fail to capture important information about share-price correlation between specific institutions.

Table 3: Pairwise Correlation Coefficients – 2008 and 2018

January 2007 - July 2008

	JPM	BAC	C	WFC	GS	MS	DB	LEH
JPM	*1.00*							
BAC	0.84	*1.00*						
C	0.77	0.82	*1.00*					
WFC	0.81	0.83	0.76	*1.00*				
GS	0.74	0.69	0.76	0.69	*1.00*			
MS	0.75	0.74	0.79	0.73	0.83	*1.00*		
DB	0.68	0.64	0.70	0.63	0.72	0.68	*1.00*	
LEH	*0.68*	*0.70*	*0.73*	*0.67*	*0.80*	*0.79*	*0.63*	*1.00*

January 2017 - July 2018

	JPM	BAC	C	WFC	GS	MS	DB
JPM	*1.00*						
BAC	**0.92**	*1.00*					
C	**0.87**	**0.84**	*1.00*				
WFC	0.76	0.73	0.71	*1.00*			
GS	**0.81**	**0.79**	**0.77**	0.63	*1.00*		
MS	**0.86**	**0.86**	**0.80**	0.68	**0.82**	*1.00*	
DB	0.58	0.55	0.56	0.47	0.54	0.55	*1.00*

Source: Bloomberg LP. In the top table, cells are shaded green to red according to higher correlation with Lehman. In the bottom table, bold print indicates a coefficient higher than that institution's 2008 level, and red cell highlighting indicates a coefficient higher than the maximum in the 2008 sample (0.80).

Return correlation is very unlikely to exist in a vacuum; it may reflect risks, exposures, or activities that are common among financial institutions. Since the crisis, the largest stand-alone investment banks have become bank holding companies, and other banking institutions have made substantial cuts to their investment banking units.[123] Increased correlation may indicate that the activities of large, consolidated banks are converging, as other research indicates, on a more retail-focused, more

[123] Mark DeCambre, "Barclays is about to make it official: Investment banking is dead almost everywhere," *Quartz* (May 8, 2014), https://qz.com/207478/barclays-is-about-to-make-make-it-official-investment-banking-is-dead-almost-everywhere/.

stable, and more profitable business model.[124] Our research reveals, however, that this convergence may involve a trade-off—between greater stability in normal times, and greater risk in the event of a contagious run.[125] A close analogy is monoculture: planting the same crop year after year, and risking a pest or pathogen that will spoil your entire yield. To the extent this "monoculture risk" exists, it represents a profound challenge at the very heart of macroprudential supervision[126]—in part, because it increases the chances that regulators will face the simultaneous failure of several large financial institutions during a future crisis.[127]

Our Basel III results also deserve further analysis, particularly those on the risk-based capital paradigm that has led Basel efforts since the 1980s. By definition, the inverse relationship between our Basel III-based leverage measures (B3 T1/TA and CET1/TA) and simple leverage (CE/TA) reflects substitution away from common equity and to other Basel III-eligible funding. What was the relationship between those other forms of funding and run behavior during the Lehman run? Did some predict run behavior especially well or poorly? Risk weights also changed dramatically from Basel II to Basel III. Would these risk weights have altered the inverse relationship between the Basel II Tier 1 capital ratio (B2 T1/RWA) and post-Lehman run behavior? More broadly, is it possible to improve the existing risk-based capital framework, enabling it to stanch an ongoing contagious run, in addition to making the occurrence of one less likely and the consequences of one less dire?

An unresolved question also hovers over our results: Would better disclosures have changed post-Lehman outcomes? For example, the Federal Reserve recently approved a rule limiting the exposure of certain bank holding companies and foreign banking organizations to a single counterparty.[128] If our hypothesis about informational efficiency is correct, counterparty exposures could have been more relevant than return correlation in the post-Lehman panic, yet have been too expensive and cumbersome to obtain. If that information had been public in 2008—for example, Citibank N.A.'s unsecured Lehman claim of more than $138 billion, or more than 173% of its reported Tier 1 capital[129]—would measures like correlation and leverage have been so closely associated with investor behavior? In turn, would limiting counterparty exposures have also limited the spread of the Lehman run? Or would second- and third-

[124] *See* Rungporn Roengpitya, Nikola Tarashev, Kostas Tsatsaronis and Alan Villegas, "Bank business models: popularity and performance," Bank of International Settlements Working Paper No. 682 (Dec. 2017), https://www.bis.org/publ/work682.pdf (identifying a post-crisis transition towards retail banking, with lower cost-to-income ratios and higher and more stable return on equity, in a panel of 178 banks).

[125] For example, in our U.S. sample, a 1 percentage point increase in CE/TA had roughly the same effect on market capitalization as a 4 percentage point decrease in correlation with Lehman. (Note that, even under the most conservative linearity assumption, the effect on run risk of a 3-percentage-point increase in CE/TA would offset a corresponding 12-percentage-point increase in correlation—less than several increases in correlation among large U.S. institutions from 2008 to 2018.) If this relationship remains durable, it suggests that other prudential interventions may offset the effects of higher pairwise correlation.

[126] *See* Samuel G. Hanson, Anil K. Kashyap, and Jeremy C. Stein, "A Macroprudential Approach to Financial Regulation," 25 *J. Econ. Persp.* (Winter 2011), https://www.aeaweb.org/articles?id=10.1257/jep.25.1.3 (discussing distinction between microprudential and macroprudential supervision).

[127] *See also* Bernanke et al., *supra* note 5 at 121 (arguing that new resolution powers are "likely to be more effective in managing the failure of a Lehman-type firm in an otherwise stable environment than when other firms are also in danger and the entire system is on the edge of panic").

[128] Board of Governors of the Federal Reserve System, "Federal Reserve Board approves rule to prevent concentrations of risk between large banking organizations and their counterparties from undermining financial stability," press release (Jun. 14, 2018), https://www.federalreserve.gov/newsevents/pressreleases/bcreg20180614a.htm.

[129] *See SIPC v. Lehman Brothers Holdings Inc.*, *supra* note 96.

degree exposures, and the uncertainty around them in a chaotic market, have caused independent damage? How would these same counterfactuals apply to resolution planning, and to the more detailed view regulators now have of the legal structure of large financial institutions?

Finally, our results cannot speak to a critical trend that has emerged since 2008: the widespread adoption of algorithmic trading. By some accounts, algorithmic trading and other forms of automated investment now drives 85% of daily U.S. volumes, much of it based on momentum strategies that could encourage herd behavior.[130] Automation could allow investors to process more complex information on short notice, or it could encode and amplify their existing beliefs—biased or not—and amplify market swings, including investor runs through the correlation channels discussed above. Which of these trends holds under ordinary circumstances, and which is likely to hold during a crisis?

Network and agent-based models of financial stress have the potential to help answer these questions.[131] However, our results also show the explanatory value of simple models in complicated times. Regulators, investors, and institutions all understandably struggle to decide what information is trustworthy during a crisis. (In some fields, that struggle is the very definition of a crisis.[132]) Certainty may be an ideal condition, but it is often scarce when markets are highly volatile. In its absence, it seems, investors may see simplicity as the best available substitute—and by some of the simplest measures, the risk of a contagious run is higher today than a decade ago.

[130] *See, e.g.*, Gregory Zuckerman, Rachael Levy, Nick Timiraos, and Gunjan Banerji, "Behind the Market Swoon: The Herdlike Behavior of Computerized Trading," *Wall St. J.* (Dec. 25, 2018), https://www.wsj.com/articles/behind-the-market-swoon-the-herdlike-behavior-of-computerized-trading-11545785641.

[131] *See, e.g.*, Jeremy Oldfather, Stefan Gissler, and Doriana Ruffino, "Bank Complexity: Is Size Everything?" FEDS Note (Jul. 15, 2016), https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/bank-complexity-is-size-everything-20160715.html; Richard Bookstaber and Mark Paddrik, "An Agent-based Model for Crisis Liquidity Dynamics," Office of Financial Research Working Paper 15-18 (Sep. 16, 2015), https://www.financialresearch.gov/working-papers/files/OFRwp-2015-18_Agent-based-Model-for-Crisis-Liquidity-Dynamics.pdf; *see also* Fabio Caccioli, Paolo Barucca, and Teruyoshi Kobayashi, "Network models of financial systemic risk: A review," 1 *J. Comp. Soc. Sci.* 81 (Nov. 21, 2017), https://link.springer.com/article/10.1007/s42001-017-0008-3 (summarizing computational science research into network models of financial crises).

[132] *See, e.g.*, Thomas Kuhn, *The Structure of Scientific Revolutions* (3d. ed., 2012), at xliii (defining "crisis" as "induced by repeated failure to make an anomaly conform").

APPENDICES

Appendix A: Definitions of Key Regulatory Terms and Ratios[133]

Tier 1 Capital (Basel II numerator)	Common Equity + Disclosed Reserves + Non-Cumulative Perpetual Preferred Stock
Tier 1 Capital (Basel III numerator)	Common Equity Tier 1 Capital + Additional Tier 1 Capital[134]
Common Equity Tier 1 Capital (Basel III numerator)[135]	Common Equity[136] + Stock Surplus (Share Premium) from Common Equity + Disclosed Reserves + Retained Earnings + Accumulated Other Comprehensive Income *net of* [Goodwill + Net Deferred Tax Assets + Other Intangible Assets]
Tier 1 Capital Ratio (Basel II)	$\frac{\text{Tier 1 Capital (Basel II)}}{\text{Risk Weighted Assets (Basel II)}}$
Common Equity Tier 1 Ratio (Basel III)	$\frac{\text{CET1}}{\text{Risk Weighted Assets (Basel III)}}$
Tier 1 Leverage Measure (Basel III)	$\frac{\text{Tier 1 Capital (Basel III)}}{\text{Total Leverage Exposure}}$

[133] Basel II ratios are taken from Basel Committee on Banking Supervision, *supra* note 41. Basel III ratios are taken from Basel Committee on Banking Supervision, *supra* note 45.
[134] See **Appendix H** for full criteria.
[135] The elements in this row are abbreviated for clearer comparison to the Basel II Tier 1 measure. *See* Basel Committee on Banking Supervision, *supra* note 45 at 13-15 (providing full definition of CET1, as well as 14 criteria for inclusion of instruments in "common shares").
[136] *Id.* at 13 ("Includes shares issued by the bank and common shares issued by consolidated subsidiaries and held by third parties").

Appendix B: Descriptive Statistics

RHS Variable	*Mean*	*Median*	*Std.*	*N*
AR T1/RWA	0.093	0.089	0.031	24
B2 T1/TA	0.068	0.065	0.019	22
B3 CET1/RWA	0.061	0.054	0.027	22
B3 CET1/TA	0.050	0.045	0.032	27
B3 T1/RWA	0.068	0.061	0.024	22
B3 T1/TA	0.054	0.050	0.031	27
CE/RWA	0.115	0.105	0.052	21
CE/TA	0.091	0.084	0.035	27
L1/TA	0.031	0.007	0.048	25
Cash/TA	0.044	0.025	0.052	27
STWF/TA	0.112	0.079	0.087	27
L1/STWF	0.222	0.140	0.241	24
Cash/STWF	0.580	0.288	0.808	26
Lehman Correlation	0.642	0.656	0.080	26
Lehman Claims	15.676	16.329	4.275	18

Appendix C: Basel III Common Equity Tier 1 ("CET1") Capital Proxies and Robustness Checks

Y-9C Common Equity Tier 1 ("CET1") Proxy for U.S. Banking Institutions

+ BHCK3230 Common stock (par value)

+ BHCK3240 Surplus (exclude all surplus related to preferred stock)

+ BHCK3247 Retained earnings

+ BHCKB530 Accumulated other comprehensive income

+ BHCKA130 Other equity capital components[137]

- BHCK3163 Goodwill

- BHCK2148 Net deferred tax assets

- BHCK0426 Other intangible assets

U.S. CET1 Proxy Comparison Using Y-9C

Bank	Ratio	Bank	Ratio	Bank	Ratio	Bank	Ratio
ALLY	94%	CMA	91%	JPM	99%	RF	87%
AXP	94%	COF	89%	KEY	90%	SCHW	98%
BAC	97%	DFS	96%	MS	101%	STI	90%
BBT	93%	ETFC	97%	MTB	88%	STT	109%
BK	111%	FITB	96%	NTRS	102%	SYF	102%
C	95%	GS	100%	NYCB	98%	USB	99%
CFG	89%	HBAN	94%	PNC	112%	WFC	99%

For all but two U.S. institutions (see below), our proxy is based on the Federal Reserve Y-9C line items described above. As a robustness check (above), we construct our CET1 proxy using 2018:Q2 for each firm listed above, and divide the resulting measure by that firm's publicly reported 2018:Q2 CET1 value (*e.g.*, if the CET1 proxy is $35 billion and the publicly reported CET1 value is $38 billion, the ratio reported above is 35/38 = 92%). In the table above, the mean of the 28 ratios is 97%, and the median is 96%.

[137] The Y-9C calls for this item to be reported as a negative value; as such, although the definition calls for it to be subtracted, it is added here.

Bloomberg Common Equity Tier 1 ("CET1") Proxy for G-SIBs

+ BS_SH_CAP_AND_APIC

+ BS_RETAIN_EARN

+ ARD_ACC_OTH_COMPREHENSIVE_INC

- BS_GOODWILL

- OTHER_INTANGIBLE_ASSETS_DETAILED

- BS_DEF_TAX_LIAB

Table 2: G-SIB CET1 Proxy Comparison Using Bloomberg

Bank	Ratio	Bank	Ratio	Bank	Ratio	Bank	Ratio
1288 HK Equity	108%	939 HK Equity	103%	DB US Equity	127%	NDA SS Equity	110%
3988 HK Equity	105%	ACA FP Equity	105%	GLE FP Equity	127%	RBS LN Equity	112%
8306 JP Equity	95%	BARC LN Equity	117%	HSBA LN Equity	116%	RY CN Equity	100%
8316 JP Equity	94%	BNP FP Equity	109%	HVM GR Equity	111%	SAN SM Equity	96%
8411 JP Equity	99%	CSGN SW Equity	72%	INGA NA Equity	108%	UBSG SW Equity	135%

For institutions in our non-U.S. G-SIB sample, our CET1 proxy is based on the Bloomberg ticker items described above. We also use this CET1 proxy for Goldman Sachs and Morgan Stanley, which converted to bank holding companies shortly after the Lehman bankruptcy and (consequently) did not report Y-9C values before it.[138]

As a robustness check (above), we again construct our CET1 proxy using 2018:Q2 for each firm listed above, and divide the resulting measure by that firm's publicly reported 2018:Q2 CET1 value. (The exceptions are 1288 HK Equity, the reported value for which comes from 2017:Q4, and HVM GR Equity, the reported value for which comes from 2016:Q3.) In the table above, the mean of the 20 ratios is 107% and the median is 108%.

[138] *See* Andrew Ross Sorkin, "As Goldman and Morgan Shift, a Wall St. Era Ends," *N.Y. Times* (Sep. 21, 2008), https://dealbook.nytimes.com/2008/09/21/goldman-morgan-to-become-bank-holding-companies/.

Appendix D: In-Sample Institutions[139]

Institution	Share Price/Mkt. Cap. Data Sep. 2008	CDS Spreads Data Sep. 2008
JPMorgan Chase	1	1
Bank of America	1	1
Citigroup	1	1
Wells Fargo	1	1
Goldman Sachs	1	1
Morgan Stanley	1	1
Bank of New York Mellon	1	0
State Street	1	0
Northern Trust	1	0
U.S. Bancorp	1	0
PNC Financial	1	0
Capital One	1	1
Charles Schwab	1	0
BB&T Corp.	1	0
SunTrust Inc.	1	0
American Express	1	1
Ally Financial	0	1
Citizens Financial	0	0
Fifth Third	1	0
KeyCorp	1	0
M&T Bank	1	0
Huntington	1	0
Discover Financial Services	1	0
Synchrony Financial	0	0
Comerica Inc.	1	0
E*TRADE Financial	1	0
SVB Financial Group	1	0
NY Community Bancorp	1	0
Total	26	9

[139] Source: FR Y-9C. *See* Board of Governors of the Federal Reserve System, "FR Y-9C" (Oct. 3, 2018), https://www.federalreserve.gov/apps/reportforms/reportdetail.aspx?sOoYJ+5BzDal8cbqnRxZRg==.

Appendix E: Simple Panel Fixed-Effects Regression Results

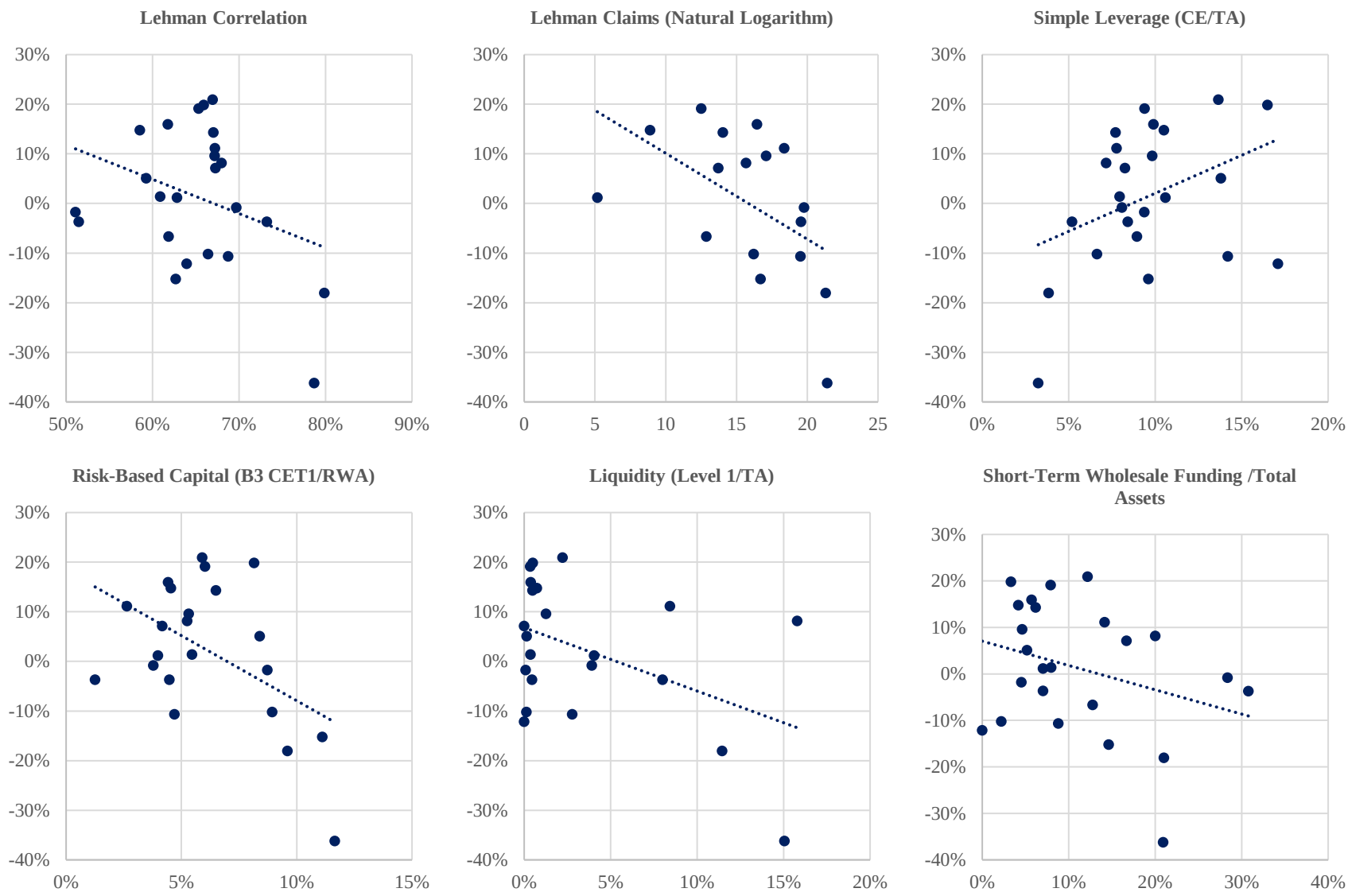
Capital Measure	*Share Price*	*Five-Year CDS Spread*	*One-Year CDS Spread*
CE/RWA	$\hat{\phi} = -0.034$ $s.e. = 0.400$ $R^2 = 0.765$ $n = 21$	$\hat{\phi} = 3.496$ $s.e. = 3.103$ $R^2 = 0.679$ $n = 6$	$\hat{\phi} = 4.577$ $s.e. = 3.456$ $R^2 = 0.803$ $n = 6$
AR T1/RWA	$\hat{\phi} = -0.555$ $s.e. = 0.644$ $R^2 = 0.766$ $n = 22$	$\hat{\phi} = 2.394$ $s.e. = 2.738$ $R^2 = 0.665$ $n = 7$	$\hat{\phi} = 5.750\ *$ $s.e. = 2.289$ $R^2 = 0.820$ $n = 6$
B3 T1/RWA	$\hat{\phi} = -1.150$ $s.e. = 0.833$ $R^2 = 0.773$ $n = 22$	$\hat{\phi} = 4.883\ *$ $s.e. = 2.118$ $R^2 = 0.694$ $n = 7$	$\hat{\phi} = 7.071\ **$ $s.e. = 2.183$ $R^2 = 0.846$ $n = 6$
B3 CET1/RWA	$\hat{\phi} = -0.701$ $s.e. = 0.862$ $R^2 = 0.769$ $n = 22$	$\hat{\phi} = 3.391$ $s.e. = 2.202$ $R^2 = 0.681$ $n = 7$	$\hat{\phi} = 6.357\ **$ $s.e. = 2.159$ $R^2 = 0.841$ $n = 6$
CE/TA	$\hat{\phi} = 0.914$ $s.e. = 0.606$ $R^2 = 0.771$ $n = 24$	$\hat{\phi} = -3.596\ *$ $s.e. = 1.821$ $R^2 = 0.672$ $n = 9$	$\hat{\phi} = -8.956$ $s.e. = 5.561$ $R^2 = 0.754$ $n = 8$
B2 T1/TA	$\hat{\phi} = 2.081\ *$ $s.e. = 1.013$ $R^2 = 0.780$ $n = 21$	$\hat{\phi} = -15.366\ **$ $s.e. = 5.822$ $R^2 = 0.715$ $n = 6$	$\hat{\phi} = -18.452\ *$ $s.e. = 7.629$ $R^2 = 0.832$ $n = 6$
B3 T1/TA	$\hat{\phi} = 0.109$ $s.e. = 0.581$ $R^2 = 0.765$ $n = 24$	$\hat{\phi} = -3.584$ $s.e. = 2.058$ $R^2 = 0.652$ $n = 9$	$\hat{\phi} = -5.682\ **$ $s.e. = 2.168$ $R^2 = 0.733$ $n = 8$
B3 CET1/TA	$\hat{\phi} = 0.114$ $s.e. = 0.536$ $R^2 = 0.765$ $n = 24$	$\hat{\phi} = -3.261\ *$ $s.e. = 1.638$ $R^2 = 0.650$ $n = 9$	$\hat{\phi} = -4.386\ *$ $s.e. = 2.254$ $R^2 = 0.731$ $n = 8$

Non-Capital Measure		*Share Price*	*Five-Year CDS Spread*	*One-Year CDS Spread*
Liquidity	L1/TA	$\hat{\phi} = -0.961$ ** $s.e. = 0.349$ $R^2 = 0.792$ $n = 22$	$\hat{\phi} = 2.824$ * $s.e. = 1.435$ $R^2 = 0.671$ $n = 8$	$\hat{\phi} = 4.785$ * $s.e. = 2.426$ $R^2 = 0.772$ $n = 7$
	Cash + Equivalents/TA	$\hat{\phi} = -0.279$ ** $s.e. = 0.129$ $R^2 = 0.766$ $n = 24$	$\hat{\phi} = -2.194$ $s.e. = 1.559$ $R^2 = 0.652$ $n = 9$	$\hat{\phi} = -4.788$ * $s.e. = 2.380$ $R^2 = 0.749$ $n = 8$
Funding Fragility	STWF/TA	$\hat{\phi} = -0.533$ *** $s.e. = 0.170$ $R^2 = 0.778$ $n = 24$	$\hat{\phi} = 0.728$ $s.e. = 0.739$ $R^2 = 0.649$ $n = 9$	$\hat{\phi} = -0.797$ $s.e. = 1.902$ $R^2 = 0.729$ $n = 8$
	L1/STWF	$\hat{\phi} = -0.151$ * $s.e. = 0.079$ $R^2 = 0.790$ $n = 21$	$\hat{\phi} = 0.457$ $s.e. = 0.301$ $R^2 = 0.664$ $n = 8$	$\hat{\phi} = 0.810$ $s.e. = 0.452$ $R^2 = 0.763$ $n = 7$
	Cash + Equivalents/STWF	$\hat{\phi} = -0.003$ $s.e. = 0.017$ $R^2 = 0.767$ $n = 23$	$\hat{\phi} = -0.293$ $s.e. = 0.186$ $R^2 = 0.653$ $n = 9$	$\hat{\phi} = -0.437$ ** $s.e. = 0.179$ $R^2 = 0.739$ $n = 8$
Correlation	Lehman Correlation	$\hat{\phi} = -0.747$ *** $s.e. = 0.195$ $R^2 = 0.788$ $n = 24$	$\hat{\phi} = 3.540$ *** $s.e. = 0.958$ $R^2 = 0.718$ $n = 8$	$\hat{\phi} = 4.580$ *** $s.e. = 0.896$ $R^2 = 0.833$ $n = 7$
	Lehman Claims	$\hat{\phi} = -0.014$ *** $s.e. = 0.004$ $R^2 = 0.807$ $n = 17$	$\hat{\phi} = 0.061$ ** $s.e. = 0.019$ $R^2 = 0.698$ $n = 8$	$\hat{\phi} = 0.094$ *** $s.e. = 0.024$ $R^2 = 0.791$ $n = 8$

Appendix F: Multiple Panel Fixed-Effects Regression Results

$m_{1,i}$	$m_{2,i}$	U.S. Banking Institution Sample					
		Share Price		*Five-Year CDS Spread*		*One-Year CDS Spread*	
Lehman Correlation	Lehman Claims	$\widehat{\phi} = -0.702$ ** $s.e. = 0.342$ $R^2 = 0.848$ $n = 17$	$\widehat{\phi} = -0.008$ * $s.e. = 0.004$ $R^2 = 0.848$ $n = 17$	$\widehat{\phi} = 4.373$ *** $s.e. = 1.663$ $R^2 = 0.820$ $n = 7$	$\widehat{\phi} = -0.025$ $s.e. = 0.027$ $R^2 = 0.820$ $n = 7$	$\widehat{\phi} = 5.517$ *** $s.e. = 1.819$ $R^2 = 0.879$ $n = 7$	$\widehat{\phi} = -0.022$ $s.e. = 0.027$ $R^2 = 0.879$ $n = 7$
B2 T1/TA	Lehman Correlation	$\widehat{\phi} = 0.375$ $s.e. = 0.564$ $R^2 = 0.824$ $n = 21$	$\widehat{\phi} = -0.705$ *** $s.e. = 0.203$ $R^2 = 0.824$ $n = 21$	$\widehat{\phi} = 6.982$ $s.e. = 9.373$ $R^2 = 0.826$ $n = 6$	$\widehat{\phi} = 5.472$ ** $s.e. = 2.479$ $R^2 = 0.826$ $n = 6$	$\widehat{\phi} = 10.226$ $s.e. = 12.482$ $R^2 = 0.887$ $n = 6$	$\widehat{\phi} = 7.022$ ** $s.e. = 3.532$ $R^2 = 0.887$ $n = 6$

Appendix G: Simple Regression of Selected Explanatory Variables on Cumulative Changes in Share Price



Appendix H: Criteria for Additional Tier 1 Capital (Basel III)[140]

1) Issued and paid-in;

2) Subordinated to depositors, general creditors, and subordinated debt of the bank;

3) Is neither secured nor covered by a guarantee of the issuer or related entity or other arrangement that legally or economically enhances the seniority of the claim vis-à-vis bank creditors;

4) Is perpetual, *i.e.*, there is no maturity date and there are no step-ups or other incentives to redeem;

5) May be callable at the initiative of the issuer only after a minimum of five years:
    a. To exercise a call option a bank must receive prior supervisory approval; and
    b. A bank must not do anything which creates an expectation that the call will be exercised; and
    c. Banks [sic] must not exercise a call unless:
        i. They replace the called instrument with capital of the same or better quality and the replacement of this capital is done at conditions which are sustainable for the income capacity of the bank[141]; or
        ii. The bank demonstrates that its capital position is well above the minimum capital requirements after the call option is exercised.[142]

6) Any repayment of principal (*e.g.*, through repurchase or redemption) must be with prior supervisory approval and banks should not assume or create market expectations that supervisory approval will be given

7) Dividend/coupon discretion:
    a. The bank must have full discretion at all times to cancel distributions/payments[143];
    b. Cancellation of discretionary payments must not be an event of default
    c. Banks must have full access to cancelled payments to meet obligations as they fall due; [and]
    d. Cancellation of distributions/payments must not impose restrictions on the bank except in relation to distributions to common stockholders.

8) Dividends/coupons must be paid out of distributable items;

[140] Taken from Basel Committee on Banking Supervision, *supra* note 45 at 15 (with corrections for punctuation and changes where bracketed).
[141] FN 15: "Replacement issues can be concurrent with but not after the instrument is called." *Id.*
[142] FN 16: "Minimum refers to the regulator's prescribed minimum requirement, which may be higher than the Basel III Pillar 1 minimum requirement." *Id.*
[143] FN 17: "A consequence of full discretion at all times to cancel distributions/payments is that 'dividend pushers' are prohibited. An instrument with a dividend pusher obliges the issuing bank to make a dividend/coupon payment on the instrument if it has made a payment on another (typically more junior) capital instrument or share. This obligation is inconsistent with the requirement for full discretion at all times. Furthermore, the term 'cancel distributions/payments' means extinguish these payments. It does not permit features that require the bank to make distributions/payments in kind." *Id.*

9) The instrument cannot have a credit sensitive dividend feature, that is a dividend/coupon that is reset periodically based in whole or in part on the banking organisation's [sic] credit standing;

10) The instrument cannot contribute to liabilities exceeding assets if such a balance sheet test forms part of national insolvency law;

11) Instruments classified as liabilities for accounting purposes must have principal loss absorption through either (i) conversion to common shares at an objective pre-specified trigger point or (ii) a write-down mechanism which allocates losses to the instrument at a pre-specified trigger point. The write-down will have the following effects:
    a. Reduce the claim of the instrument in liquidation;
    b. Reduce the amount re-paid when a call is exercised; and
    c. Partially or fully reduce coupon/dividend payments on the instrument;

12) Neither the bank nor a related party over which the bank exercises control or significant influence can have purchased the instrument, nor can the bank directly or indirectly have funded the purchase of the instrument;

13) The instrument cannot have any features that hinder recapitalization [sic], such as provisions that require the issuer to compensate investors if a new instrument is issued at a lower price during a specified time frame; [and]

14) If the instrument is not issued out of an operating entity or the holding company in the consolidated group (*e.g.*, a special purpose vehicle – "SPV"), proceeds must be immediately available without limitation to an operating entity[144] or the holding company in the consolidated group in a form which meets or exceeds all of the other criteria for inclusion in Additional Tier 1 capital.

[144] FN 18: "An operating entity is an entity set up to conduct business with clients with the intention of earning a profit in its own right." *Id.*