CAPITAL, CONTAGION, AND FINANCIAL CRISES: WHAT STOPS A RUN FROM SPREADING?

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After the 2008-09 financial crisis, policymakers around the world focused on enacting improvements that would make the emergence of a financial crisis less likely (ex ante) and recovery from one more rapid (ex post). This Article identifies a gap in both the academic literature and the current financial regulatory framework in exploring how to limit the damage—to other firms, and to the financial system—when a crisis is ongoing. Policymakers cannot predict the origins of every future crisis, just as firefighters cannot predict the origins of every future fire. Once one begins, how can they keep the damage from spreading?

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The academic theory on financial crisis "firefighting" divides into two main camps. The "capital view" claims that runs on financial institutions are fundamentally rational, and that investors care mainly about solvency. Under this view, the best way to fight runs is to raise capital requirements ahead of time, to multiples of current levels. The "contagion view" claims instead that the lack of liquid assets both defines and causes bank runs; an institution's access to cash (and instruments like it) determines whether and when investors will withdraw funding. Under this view, the best way to fight runs is for governments to lend banks money—freely, at high rates, and against good collateral—and to promise to do so well before a crisis starts.

In this Article—the first to directly address this question empirically—we show that neither view fits the most catastrophic financial shock of the last ninety years: the 2008 Lehman Brothers bankruptcy. In some cases, banks with more capital and liquidity were actually more exposed, not less, to the market panic following Lehman's collapse. By contrast, we show that simple market correlation was a powerful predictor of exposure to the Lehman run. We also show that market valuations of large banks are more highly correlated today than they were in September 2008, creating a potential unaddressed conduit for an unexpected shock to metastasize into a contagious run.

I. INTRODUCTION

A decade removed from the peak of the 2008-09 financial crisis and after hundreds of published articles, academics and policymakers are still working to understand systemic risk in the financial sector. This long progression is as expected; "it

was not until 30 years after the Great Depression that Milton Friedman and Anna Schwartz published *A Monetary History of the United States* in 1963, with its now canonical critique of Federal Reserve Board policy in the 1930s . . . . [O]n the time scale needed to fully absorb the significance of major financial disasters, we are in the early days and should not expect to reach immediate consensus on either diagnoses or prognoses."[1] What all practitioners and scholars agree is that a crisis begins with an unexpected shock.

The unexpected shock that arrived in the early hours of September 15, 2008, was one of the most consequential 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.[3] 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.[4]

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[1] Howell F. Jackson, *Introduction: Thinking Hard About Systemic Risk, in* SYSTEMIC RISK IN THE FINANCIAL SECTOR: TEN YEARS AFTER THE GREAT CRASH 1, 2 (Douglas W. Arnert et al. eds., 2019).

[2] The voluntary insolvency petition for Lehman's U.S. holding company was filed at 1:45AM on Monday, September 15th. *See* Matt Egan, *Lehman Brothers: When the Financial Crisis Spun Out of Control*, CNN BUS. (Sept. 14, 2018), https://www.cnn.com/2018/09/30/investing/lehman-brothers-2008-crisis/index.html [https://perma.cc/LG48-5K8X].

[3] *See* Alexandra Twin, *Stocks Struggle on Bank Woes*, CNN MONEY (Sept. 12, 2008), https://money.cnn.com/2008/09/12/markets/markets_newyork/index.htm [https://perma.cc/Z7N2-R2WT].

[4] *See* ANDREW ROSS SORKIN, TOO BIG TO FAIL: THE INSIDE STORY OF HOW WALL STREET AND WASHINGTON FOUGHT TO SAVE THE FINANCIAL SYSTEM—AND THEMSELVES 536 (2010). *See also* Jennifer Hughes, *Winding Up Lehman Brothers*, FIN. TIMES (Nov. 7, 2008),

Investors were, quite understandably, unsure how to react.[5] 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, share prices and CDS spreads on large financial institutions had splintered, with some on a vastly more adverse trajectory than others.[6] Fears about Lehman had spread, but they had not spread evenly.

This Article seeks to identify gaps in the design of post-crisis regulatory reforms, by clarifying why some financial institutions experienced greater stress than others in the immediate aftermath of the Lehman bankruptcy. In doing so, we fill a gap in the academic literature and policy discussion on how to limit the damage to the financial system after a panic starts, but before it spreads. A wide range of work has examined the effect of post-crisis reforms on preventing a financial crisis *ex ante* and hastening recovery from one *ex post*. However, vanishingly little scholarship examines the effectiveness of capital and liquidity reforms on a third goal: preventing an ongoing run at one bank from spreading to others.[7] In an

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https://www.ft.com/content/e4223c20-aad1-11dd-897c-000077b07658 [https://perma.cc/2XYF-ATH4].

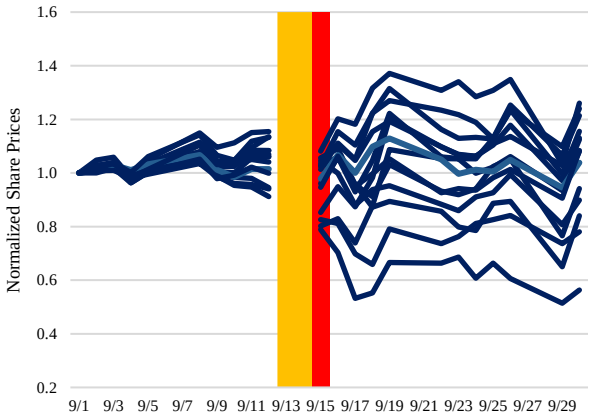
[5] *See, e.g.*, Alexandra Twin, *Stocks Get Pummeled*: *Wall Street Sees Worst Day in 7 Years, with Dow Down 504 Points, as Financials Implode*, CNN MONEY (Sept. 21, 2008), https://money.cnn.com/2008/09/15/markets/markets_newyork2/ [https://perma.cc/CZK8-UN2G] ("You have to throw out the history books because there's really nothing to compare this to . . . . We've never witnessed this before . . . [t]here's no road map for this." (internal quotation marks omitted)).

[6] *See infra* Figures 1–2.

[7] A preliminary note on vocabulary: a "run," for purposes of this Article, refers only to a single institution event and is not defined specifically by the behavior of creditors. For a further discussion of the definition we adopt, see *infra* note 101 and accompanying text. We use the terms "panic" and

atmosphere of market uncertainty, no policy task could be more important.

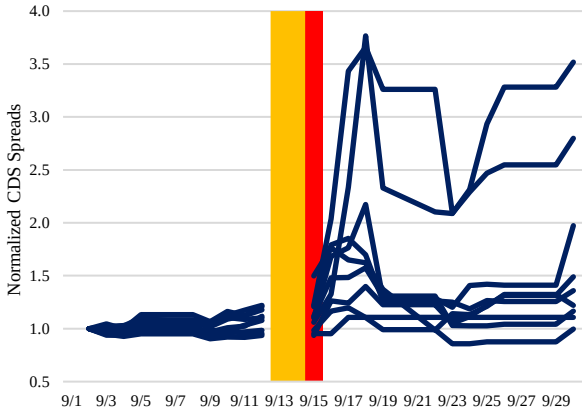
Figure 1: Share Prices Circa Lehman Bankruptcy[8]



"crisis," for which there are no precise consensus definitions, to indicate a contagious run that extends to other financial institutions. Our use of these terms draws on empirical work that finds "panics are systematic." *See* Gary Gorton, *Banking Panics and Business Cycles*, 40 OXFORD ECON. PAPERS 751, 773 (1988). For a broad-based discussion of runs, as well as runs that took place during the financial crisis, see BEN S. BERNANKE, THE FEDERAL RESERVE AND THE FINANCIAL CRISIS 64–97 (2013). *See also* BEN S. BERNANKE ET AL., FIREFIGHTING: THE FINANCIAL CRISIS AND ITS LESSONS 15 (2019) ("A financial crisis is a bank run writ large, a crisis of confidence throughout the system.").

[8] *Equity Price Data*, BLOOMBERG LP, https://www.bloomberg.com/professional/ [https://perma.cc/5C2B-XGQP]. Each line represents one of the fourteen largest U.S. banks in September 2008. The first vertical bar indicates September 13–14 (markets closed). The second vertical bar indicates September 15 (date of Lehman filing).

Figure 2: CDS Spreads Circa Lehman Bankruptcy[9]



The academic literature on this subject, until now, has divided into two main schools of thought. The "*capital view*"—expressed by Daniel Tarullo of Harvard Law School and Anat Admati of the Stanford Graduate School of Business, and by many central bankers around the globe—claims that runs are fundamentally rational, and that investors care mainly about the solvency of a financial institution.[10] When stress emerges, the institution's level of capital—how much of its funding comes from equity and similar instruments—determines whether investors will extend or withdraw funding from that institution. Under this view, the best way to fight runs is to raise capital requirements ahead of time, to multiples of their current levels.[11]

The "*contagion view*"—expressed by Hal Scott of Harvard Law School and Gary Gorton of the Yale School of

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[9] *CDS Spread Data*, BLOOMBERG LP, https://www.bloomberg.com/professional/ [https://perma.cc/5C2B-XGQP].

[10] *See* Anat R. Admati et al., *infra* note 80, at 43.

[11] *See* Daniel K. Tarullo, Governor, Fed. Reserve Sys., Speech at Princeton University: Departing Thoughts (Apr. 4, 2017), https://www.federalreserve.gov/newsevents/speech/tarullo20170404a.htm [https://perma.cc/U9N3-4KFL].

Management, and by many in the private sector—claims that runs can start for virtually any reason, not just insolvency worries. Instead, the *lack of liquid assets* both defines and causes a bank run; an institution's access to liquidity determines whether and when investors will withdraw funding.[12] Under this view, the best way to fight runs is for central banks to lend money freely at high rates against good collateral, and to promise to do so well before a crisis starts.[13]

Our results are surprising and complicate both prevailing views of contagious bank runs:

- Contrary to the capital view, institutions with *higher* levels of regulatory capital experienced *more* funding stress. One factor seems to explain this puzzling relationship: The higher an institution's 2008 regulatory capital, the more it relied on the use of debt—a relationship that persists today and, in some cases, is worse than that observed in 2008.
- Contrary to the contagion view, balance-sheet liquidity levels did not explain any variation in run exposure.
- By contrast, two simple measures strongly predicted funding stress: a simple leverage ratio, and the correlation between an institutions' share price and Lehman's. This suggests that simple measures matter more to investors in an emergency, and that tighter correlations can correspond to a faster-spreading run. Notably, and perhaps worryingly, the share prices of large U.S. financial institutions are more highly correlated with each other today than they were with Lehman a decade ago.

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[12] *See* Cardiff Garcia, "*Misunderstanding Financial Crises", a Q&A with Gary Gorton*, FIN. TIMES (Oct. 25, 2012), https://ftalphaville.ft.com/2012/10/25/1223861/misunderstanding-financial-crises-a-qa-with-gary-gorton/ [https://perma.cc/E8GH-C959].

[13] *See* Hal S. Scott, *This Should Be Trump's Top Priority on Financial Reform*, CNBC (Jan. 26, 2017), https://www.cnbc.com/2017/01/26/this-should-be-trumps-top-priority-on-financial-reform-harvard-law-professor-commentary.html [https://perma.cc/5738-E873].

Our results have important implications for the design of financial regulation, both domestically and internationally, and for the post-crisis capital and liquidity standards that are now subscribed to by over 100 countries.[14]

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

Second, our findings suggest that simpler measures 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. These implications are consistent with an old strand of the law-and-economics literature—specifically, the efficiency of information about firms, and the transaction costs involved in obtaining such information. These themes should figure prominently in our accounts of financial crises, when distinguishing fact from rumor is most difficult.

Third, 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

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[14] *See* Roberta Romano, *For Diversity in the International Regulation of Financial Institutions: Critiquing and Recalibrating the Basel Architecture,* 31 YALE J. REG. 1, 3 (2014).

differently during a crisis than in normal times, and that different regulatory tools are necessary to stop a bank run from spreading. Identifying, monitoring, and addressing the "correlation channels" that carry stress between institutions appears 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, by making bank activities safer, business models more uniform, runs less likely, and recovery more orderly.[15] However, our findings suggest those measures may involve a subtle trade-off—greater safety before a run occurs, but greater vulnerability once one begins.

Our Article proceeds as follows. Part II provides a primer of the fundamental concepts involved in our research, describes 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 results; Part IV describes the policy implications of those

[15] The penultimate Part 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 a substantive evaluation of its impact. *See infra* Part IV.

results; and Part V offers a path forward on regulatory design. Part VI concludes.

II. PRIMER ON POST-CRISIS BANK REGULATIONS

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.[16] In exchange, investors typically gain the right to a specific measure of value from a firm. For example, an investor can purchase a right to the residual value of a firm's assets or allocations of a firm's profits.[17] Alternatively, an investor can purchase a right to the value of his or her initial investment, plus some kind of interest.[18] The first of these obligations usually is called equity; however in the context of a bank, it and a

[16] *See* R.H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386 (1937).

[17] *See* Fin. Accounting Standards Bd., Equity (Topic 505): Overall (2018) [hereinafter, Fin Accounting Standards Bd., Equity], https://asc.fasb.org/section&trid=2208765 [https://perma.cc/J8TN-R3YA]; Fin. Accounting Standards Bd., Equity (Topic 505): Stock Dividends and Stock Splits (2012), https://asc.fasb.org/section&trid=2208795 [https://perma.cc/UG8D-87DG].

[18] *See* FIN. ACCOUNTING STANDARDS BD., ACCOUNTING STANDARDS UPDATE NO. 2016-19: TECHNICAL CORRECTIONS AND IMPROVEMENTS 16 (2016), https://asc.fasb.org/imageRoot/54/108316354.pdf [https://perma.cc/92FB-XM77] ("[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 a liability in the creditor's or debtor's balance sheet at the time of the restructuring.").

variety of similar financial instruments are often called capital.[19] The latter is usually called debt.[20]

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 a firm in court. Debt, by contrast, generally comes with a contractually obligated return; even if a firm invests poorly, it retains a duty to repay the investors who hold its debt (called "creditors"). In the event that a firm files for bankruptcy, the claims of secured creditors have priority over those of common shareholders.[21] Creditors' debt is often secured by firms' remaining assets, like equipment or real estate, and creditors are entitled to a share of the proceeds from the sale of those assets.[22]

The equity and debt of a firm often trade in public markets, and when new information becomes available about a firm, the price of those financial instruments can change.[23] For example, when the expected value of a firm falls, the market

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[19] Many sources either explicitly or implicitly conflate bank capital and equity. *See, e.g.*, William Alden, *What Is Bank Capital, Anyway?*, N.Y. TIMES, (July 10, 2013), https://dealbook.nytimes.com/2013/07/10/what-is-bank-capital-anyway [https://perma.cc/XC5S-L72X]. However, while the term "capital" almost always includes common equity, the two terms are not precisely coterminous. *See, e.g.*, FED. RESERVE BANK OF S.F., WHAT IS BANK CAPITAL AND WHAT ARE THE LEVELS OR TIERS OF CAPITAL? (2003), https://www.frbsf.org/education/publications/doctor-econ/2001/september/bank-capital [https://perma.cc/YW5E-XFC2].

[20] For a comparison between the features of debt and equity, see Fin. Accounting Standards Bd., Distinguishing Liabilities From Equity (Topic 480): Overview and Background (2017), https://asc.fasb.org/section&trid=2175789 [https://perma.cc/3B62-NPG8]. For a list of exceptions relating to hybrid interests, see Fin. Accounting Standards Bd., Distinguishing Liabilities From Equity (Topic 480): Scope and Scope Exceptions (2017), https://asc.fasb.org/section&trid=2175795#SL109262033-110874 [https://perma.cc/XS3F-ML6R].

[21] *See* 11 U.S.C. § 507(b) (2018).

[22] *See* 11 U.S.C. §§ 725–26.

[23] *See* Christopher Paul Saari, *The Efficient Capital Market Hypothesis, Economic Theory and the Regulation of the Securities Industry*, 29 STAN. L. REV. 1031, 1035–41 (1977).

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.[24] The price of a CDS contract is known as the "CDS spread"—the higher the probability that a credit event will occur, such as a default, the greater the spread typically becomes.[25]

In ordinary times, with respect to the funding available to it, a financial institution[26] is much like any other business. The main output of a bank is credit; it uses outside investment (e.g., deposits, bonds, common stock) to fund the creation of financial assets (e.g., loans).[27] Ideally, the bank makes more money off those assets than their investors demand for funding them. If that holds true, the bank is able to repay its creditors and earn a profit, and its shareholders' equity grows in value.

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[24] *See Credit Default Swaps*, PAC. INV. MGMT. COMPANY, https://www.pimco.com/en-us/resources/education/understanding-credit-default-swaps [https://perma.cc/UH3C-RRDZ] (last visited June 1, 2020).

[25] *See* Mark J. Flannery et. al., *Credit Default Swap Spreads As Viable Substitutes for Credit Ratings,* 158 U. PA. L. REV. 2085, 2088 (2010). The parties to a CDS contract may agree to expand the definition of a credit event might to include other events, such as firm downgrades. *See, e.g.*, Jeremy C. Kress, *Credit Default Swaps, Clearinghouses, and Systemic Risk: Why Centralized Counterparties Must Have Access to Central Bank Liquidity*, 48 HARV. J. LEGIS. 49, 52 (2011); Daniel Hemel, *Empty Creditors and Debt Exchanges*, 27 YALE J. REG. 159, 162 (2010).

[26] In the remainder of this Section, we use the term "bank" as shorthand to refer to any 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. *See infra* Section II.B.

[27] 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 5–6 (2012); Jeanne Gobat, *Banks: At the Heart of the Matter*, FIN. & DEV., June 1, 2018, at 56, 56.

However, banks also have unique characteristics that expose them to unique risks. Banks typically use short-term sources of funding, like deposits, to invest in long-term projects, like thirty-year mortgages or ten-year business loans.[28] In a "fractional reserve" banking system, the amount of money a bank invests in these projects can exceed the money it receives in funding.[29] As long as a bank's investors do not withdraw their short-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."[30] To pay some creditors, it can sell its liquid assets for cash on short notice, at a price close to their economic worth.[31] As investor demands mount, however, a bank may have to sell other, less liquid assets at less—perhaps far less—than their actual worth.[32] 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.[33]

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[28] For a less condensed discussion of this activity (on maturity transformation, liquidity transformation, and other core functions of financial intermediation), see Laura E. Kodres, *What Is Shadow Banking?*, FIN. & DEV., June 1, 2013, at 42.

[29] For detail on the mechanics of this mechanism, see Michael McLeay et al., *Money Creation in the Modern Economy*, 2014 BANK ENG. Q. BULL. 14, 17–18. *See also* MORGAN RICKS, THE MONEY PROBLEM: RETHINKING FINANCIAL REGULATION 67–72 (2016).

[30] *See supra* note 6 and accompanying text.

[31] *See, e.g.*, Stanley Fischer, Vice Chairman, Fed. Reserve Sys., Is There a Liquidity Problem Post-Crisis? 1 (Nov. 15, 2016), https://www.bis.org/review/r161118d.htm [https://perma.cc/3MVL-TBCL] (defining market liquidity as "the ability to rapidly execute sizable securities transactions at a low cost and with a limited price impact"); SUSAN MCLAUGHLIN ET AL., BANK FOR INT'L SETTLEMENTS, FOREIGN EXCHANGE LIQUIDITY IN THE AMERICAS iii (2017), https://www.bis.org/publ/bppdf/bispap90.htm [https://perma.cc/YX6U-YFE8] (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").

[32] *See* GORTON, *supra* note 27, at 45–46.

[33] *See id.* at 46.

Repeated enough times, a firm that was solvent when a run began can become insolvent before it ends.[34]

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 a 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 ninety-day loans, uses 95% of that funding to issue sixty-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.

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.[35] In the 2008 financial crisis, the run on large, diversified financial institutions occurred principally in the sale-and-repurchase (or, "repo") market.[36] To borrow in this market, an institution would typically offer investors a securitized bond, often backed by the stream of payments from a group of mortgage

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[34] For a more detailed description of the dynamic in this paragraph that incorporates an account of deposit insurance and includes working definitions of "market" and "funding liquidity," see *id.*

[35] *See* Matthew Pritsker, *The Channels for Financial Contagion*, *in* INTERNATIONAL FINANCIAL CONTAGION 67, 70–77 (Stijn Claessens & Kristin J. Forbes eds., 2001) (describing potential channels of financial contagion); *see also* Gary Gorton & Andrew Metrick, *Securitized Banking and the Run on Repo*, 104 J. FIN. ECON. 425, 430–33 (2012).

[36] *See id.* at 425–26. Note that, while the "run on repo" involved nonbanking financial institutions, large multi-line financial institutions and investment banks were major participants. *See* Darrell Duffie, *Prone to Fail: The Pre-Crisis Financial System*, 33 J. ECON. PERSP. 81, 88–90 (2019).

loans, as collateral.[37] If a borrowing institution failed to repay its (usually short-term) loan by repurchasing the bond at a premium, the investor could sell the bond.[38] 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.[39]

The story from here is familiar. Starting in late 2007, governments intervened.[40] Intervention fostered expectations of future intervention.[41] The September 15, 2008, bankruptcy of Lehman violated those expectations.[42] Markets reacted

[37] *See* Duffie, *supra* note 36.

[38] *See id.* at 91.

[39] *See id.* at 90–92.

[40] In the United States, pre-Lehman interventions included the Term Auction Facility (launched Dec. 12, 2007), the Single-Tranche Open Market Operations Facility (launched Mar. 7, 2008), the Term Securities Lending Facility (launched Mar. 11, 2008), and the Primary Dealer Credit Facility (launched Mar. 16, 2008). *See* HAL S. SCOTT, CONNECTEDNESS AND CONTAGION: PROTECTING THE FINANCIAL SYSTEM FROM PANICS 75 (2016). 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* BERNANKE ET AL., *supra* note 7, at 230; *History of Fannie Mae & Freddie Mac Conservatorships*, FED. HOUSING FIN. AGENCY, https://www.fhfa.gov/Conservatorship/Pages/History-of-Fannie-Mae--Freddie-Conservatorships.aspx [https://perma.cc/75QJ-MTDE] (last visited May 29, 2020). Other substantial interventions took place in the United Kingdom and Europe. *See Communication From the Commission to the European Council: A European Economic Recovery Plan*, COM (2008) 800 final (Nov. 26, 2008).

[41] Combatting these expectations was, at the time, among the stated intentions of the bankruptcy. *See* Secretary Hank M. Paulson Jr., *Statement by Sec. Paulson on Economy*, C-SPAN (Sept. 15, 2008), https://www.c-span.org/video/?281125-2/statement-sec-paulson-economy [https://perma.cc/EK55-V2JW] ("Moral hazard is something I don't take lightly.").

[42] We discuss the possible role of private information in our results *infra* Part III, but both financial market performance and the timeline of "Lehman weekend" support this conclusion. On Friday, September 12, 2008, equity markets were stable, and the Dow Jones Industrial Average ultimately

poorly.[43] 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.[44] After

closed up 1.8% on the week. *See* Steven Russolillo, *This Day in Crisis History: Sept. 12, 2008*, WALL ST. J. (Sept. 12, 2013), https://blogs.wsj.com/moneybeat/2013/09/12/this-day-in-crisis-history-sept-12-2008/ [https://perma.cc/9X3B-ZR5W]. 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 U.K. Financial Services Authority revealed that, under London Stock Exchange rules, Barclays would need an affirmative shareholder vote before Monday morning to move forward with the deal. *See* Andrew Ross Sorkin, *Lehman Files for Bankruptcy; Merrill Is Sold*, N.Y. TIMES (Sept. 14, 2008), https://www.nytimes.com/2008/09/15/business/15lehman.html [https://perma.cc/JQ2P-YQEK]; *Too Big to Fail: Expectations and Impact of Extraordinary Government Intervention and the Role of Systemic Risk in the Financial Crisis Before the Fin. Crisis Inquiry Comm'n*, 111th Cong. 7–8 (2010) (statement of Thomas C. Baxter, Executive Vice President and General Counsel of the Federal Reserve Bank of New York). In response to this news, on the following Tuesday, September 16, the Dow closed down 4.4%, and the S&P 500 index had fallen 4.7%. *See* Tom Lauricella et al., *Dow, Markets in Europe Post Big Falls,* WALL ST. J. (Sept. 16, 2008), https://www.wsj.com/articles/SB122152873162140589 [https://perma.cc/R23G-LDCE].

[43] *See* Lauricella, *supra* note 42. Markets hit their crisis-era lows in March 2009, with the Dow Jones Industrial Index and S&P 500 falling to their lowest points since the late 1990s. *See* Alexandra Twin, *For Dow, Another 12-Year Low*, CNN MONEY (Mar. 9, 2009), https://money.cnn.com/2009/03/09/markets/markets_newyork/ [https://perma.cc/UAB4-CNQM].

[44] In addition to the programs described *supra* note 40, the U.S. government created a secured revolving credit facility available to insurer AIG (launched September 16, 2008), the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (launched September 22, 2008), the Temporary Guarantee Program (launched September 29, 2008), the Commercial Paper Funding Facility (launched October 27, 2008), and the Term Asset-Backed Securities Loan Facility (launched November 25, 2008). *See* SCOTT, *supra* note 40, at 76. Federal Home Loan Bank advances also became an important source of liquidity. *See* JONATHON ADAMS-KANE & JAKOB WILHELMUS, MILKEN INST., THE REAL STORY BEHIND THE SURGE IN FHLB ADVANCES: MACROPRUDENTIAL POLICY CHANGED HOW BANKS BORROW 4 fig.3 (2017).

Lehman, new programs also provided institutions with capital.[45] Still others directly supported markets in specific financial products.[46] Ultimately—and consequently—the financial system avoided collapse.[47]

Early debates about the causes of the crisis focused on the adequacy of bank capital.[48] Regulators have long required banks to fund a certain proportion of their assets with money derived from equity or equity-like instruments, which could "absorb" losses if their assets lost value.[49] These requirements

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[45] U.S. capital-based programs included the Troubled Asset Relief Program (passed as part of the Emergency Economic Stabilization Act of 2008, Pub. L. No. 110-343, tit. 1, 122 Stat. 3765, 3767–800 (codified as amended at 12 U.S.C. §§ 5211–41 (2018)) and the broader Capital Purchase Program. SCOTT, *supra* note 40, at 76.

[46] The Federal Reserve also instated unlimited swap lines with four foreign central banks, and the FDIC raised its deposit insurance limit. *See* SCOTT, *supra* note 40, at 76–77.

[47] 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 during periods of financial crisis, see ALAN S. BLINDER, AFTER THE MUSIC STOPPED: THE FINANCIAL CRISIS, THE RESPONSE, AND THE WORK AHEAD (2013).

[48] Improving bank capital was a 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* Leaders' Statement, The Pittsburgh Summit 8 (Sept. 24–25, 2009), https://www.treasury.gov/resource-center/international/g7-g20/Documents/pittsburgh_summit_leaders_statement_250909.pdf [https://perma.cc/7CPE-CVGK]; Ben S. Bernanke, Chairman, Fed. Reserve Sys., The Supervisory Capital Assessment Program (May 11, 2009), https://www.federalreserve.gov/newsevents/speech/bernanke20090511a.htm [https://perma.cc/3K6S-Q3UU]; John Fell, Directorate Gen., European Cent. Bank, Address at the Conference on Bank Structure and Competition: Stress Testing in a Crisis—The European Experience (May 10, 2012).

[49] For a primer on global capital regulations and the rationales behind them, see MOODY'S ANALYTICS, REGULATION GUIDE: AN INTRODUCTION (2011), https://www.moodysanalytics.com/-/media/whitepaper/2011/11-01-03-regulation-guide-introduction.pdf [https://perma.cc/E67K-FGY6]; ANAT ADMATI & MARTIN HELLWIG, THE BANKERS' NEW CLOTHES: WHAT'S WRONG WITH BANKING AND WHAT TO DO ABOUT IT 94–95 (2013).

are typically articulated as "capital ratios," in the general form of:

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

Before the crisis, the prevailing international standards for capital regulation were the Basel II accords.[50] For the numerator of the capital ratios, Basel II distinguished between three different categories of capital—including a Tier 1 category consisting of common equity and similar instruments.[51] For the denominator, Basel II required institutions to use risk-weighted assets ("RWA") instead of the total book value of all their financial assets.[52] 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.[53] Under both approaches, when a bank's assets are riskier, Basel II requires the bank to fund those assets with more equity and equity-like instruments.[54]

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[50] Since the 1970s, 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 continued work on these standards is based). *See History of the Basel Committee*, BANK INT'L SETTLEMENTS, https://www.bis.org/bcbs/history.htm [https://perma.cc/SQ8Z-GCJL] (last visited May 29, 2020).

[51] BASEL COMM. ON BANKING SUPERVISION, INTERNATIONAL CONVERGENCE OF CAPITAL MEASUREMENT AND CAPITAL STANDARDS 244 (2006) [hereinafter BASEL COMM., BASEL II]. The other two specific inclusions in Basel II Tier 1 capital are disclosed reserves and non-cumulative perpetual preferred stock. *Id.* at 244–45.

[52] *Id.* at 244.

[53] *Id.* at 12–149.

[54] *Id.*

The numerator and denominator of the required capital ratios changed under the post-crisis Basel III accords.[55] 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.[56] For the denominator, Basel III introduced a new version of the standardized approach and limited the discretion associated with the internal ratings-based approach.[57] Basel III also created a new leverage requirement, which used no risk-weighting and included both on-balance sheet assets and off-balance sheet exposures.[58] Finally, the accords included several additional capital "buffers."[59]

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 thirty-day period.[60] To tackle the run risk associated with an over-reliance on short-term funding, Basel III also created a measure

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[55] BASEL COMM. ON BANKING SUPERVISION, BASEL III: A GLOBAL REGULATORY FRAMEWORK FOR MORE RESILIENT BANKS AND BANKING SYSTEMS 2–3 (2011) [hereinafter BASEL COMM., BASEL III].

[56] *Id.* at 13–17; *see also* Daniel K. Tarullo, Member, Bd. of Governors of the Fed. Reserve Sys., Remarks at the 2016 Financial Stability Conference: Financial Regulation Since the Crisis 8 n.9 (Dec. 2, 2016), https://www.bis.org/review/r161205f.pdf [https://perma.cc/959Q-DN2G] ("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.").

[57] BASEL COMM., BASEL III, *supra* note 55, at 3–4, 51–54.

[58] *Id.* at 4. 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. *See infra* notes 137–39 and accompanying text.

[59] BASEL COMM., BASEL III, *supra* note 55, at 54–60.

[60] BASEL COMM. ON BANKING SUPERVISION, BASEL III: THE LIQUIDITY COVERAGE RATIO AND LIQUIDITY RISK MONITORING TOOLS 1 (2013).

to ensure that banks had enough long-term funding to cover their long-term assets.[61] In November 2007, disclosure requirements from the Financial Accounting Standards Board ("FASB") also took effect, requiring publicly traded companies in the United States to disclose their total "Level 1, 2, and 3" assets.[62] Assets are divided into "levels" roughly according to how liquid they are.[63]

The Basel accords are non-binding international agreements that apply to internationally active banks; however, national regulators implement and enforce Basel standards through their own domestic regulations.[64] In the United States, for instance, regulators promulgated new capital and liquidity requirements under the Dodd-Frank Wall Street Reform and Consumer Protection Act.[65] For the Federal Reserve Board (the "Board"), these regulations included a host of "enhanced supervision and prudential standards,"[66] with capital and liquidity requirements roughly increasing with the size and complexity of financial institutions.[67] For the Office of the Comptroller of the Currency, they included a set of "heightened expectations" for large institutions.[68] For all U.S.

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[61] *See* BASEL COMM. ON BANKING SUPERVISION, BASEL III: THE NET STABLE FUNDING RATIO 1–3 (2014) [hereinafter BASEL COMM., NET STABLE FUNDING RATIO].

[62] FIN. ACCOUNTING STANDARDS BD., STATEMENT OF FINANCIAL ACCOUNTING STANDARDS NO. 157: FAIR VALUE MEASUREMENTS 12–17 (2010).

[63] *See id.*

[64] *See* BASEL COMM. ON BANKING SUPERVISION, CHARTER (2013).

[65] Dodd-Frank Wall Street Reform and Consumer Protection Act §§ 115(b)(1), 165(b)(1)(A), 12 U.S.C. §§ 5325(b)(1), 5365(b)(1)(A) (2018).

[66] *Id.*

[67] Note in particular that the federal banking agencies imposed an "enhanced Supplementary Leverage Ratio" for large financial institutions. Regulatory Capital Rules: Regulatory Capital, Enhanced Supplementary Leverage Ratio Standards for Certain Bank Holding Companies and Their Subsidiary Insured Depository Institutions, 79 Fed. Reg. 24,528 (May 1, 2014) (to be codified at 12 C.F.R. pts. 6, 208, 217, and 324).

[68] *See* OCC Guidelines Establishing Heightened Standards for Certain Large Insured National Banks, Insured Federal Savings Associations, and Insured Federal Branches; Integration of Regulations, 79 Fed. Reg. 54,518 (Sept. 11, 2014) (codified at 12 C.F.R. pts. 30, 168, and 170).

prudential regulators[69] the new regulations also mandated the development of firm recovery and resolution plans, designed to avoid or facilitate the liquidation of a large, complex financial institution without interrupting critical financial market operations or requiring public financial support.[70]

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.[71] 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 potential future changes to banks' balance sheets.[72] 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.[73]

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[69] These regulators include the Office of the Comptroller of the Currency, the Federal Deposit Insurance Corporation, and the Board of Governors of the Federal Reserve System.

[70] *See* Resolution Plans Required, 76 Fed. Reg. 67,323 (Nov. 1, 2011) (codified at 12 C.F.R. pts. 243, 381).

[71] *See* Dodd Frank Act § 165(i), 12 U.S.C. § 5365(i) (2018) (United States); BANK OF ENG., THE BANK OF ENGLAND'S APPROACH TO STRESS TESTING THE UK BANKING SYSTEM 5–8 (2015) (United Kingdom); *cf.* Takako Taniguchi & Finbarr Flynn, *Japan Will Leave Banks to Carry Out Their Own Stress Tests*, BLOOMBERG (May 9, 2016), https://www.bloomberg.com/news/articles/2016-05-09/japan-to-scrutinize-banks-stress-tests-stopping-short-of-fed?sref=m42vRBnI [https://perma.cc/56J6-N5R8] (Japan).

[72] *See, e.g.*, Press Release, Bd. of Governors of the Fed. Reserve Sys., 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 (Feb. 1, 2018), https://www.federalreserve.gov/newsevents/pressreleases/bcreg20180201a.htm [https://perma.cc/R229-V7CY].

[73] For an overview of this system as enacted shortly after the crisis, see Daniel K. Tarullo, Member, Bd. of Governors of the Fed. Reserve Sys., Speech at the Federal Reserve Bank of Chicago Annual Risk Conference: Developing Tools for Dynamic Capital Supervision (Apr. 10, 2012),

C. Prior Literature

These new regulatory and supervisory measures had a dominant stated motivation at the time they were created: "[N]o more taxpayer-funded bailouts, period."[74] On these grounds alone, regulators had good reason to focus on capital. Both before and after the crisis an extensive academic literature has explored the benefits of higher capital ratios—from minimizing the moral hazard associated with deposit

https://www.federalreserve.gov/newsevents/speech/tarullo20120410a.htm [https://perma.cc/7FVF-TV86].

[74] Helene Cooper, *Obama Signs Overhaul of Financial System*, N.Y. TIMES (July 21, 2010) (internal quotation marks omitted), https://www.nytimes.com/2010/07/22/business/22regulate.html [https://perma.cc/6VKL-PA7J]. The closely related mantle of "too big to fail" took hold in public discourse soon after the financial crisis. *See, e.g.*, Jonathan Macey, *Brave New Fed*, WALL ST. J. (Mar. 31, 2008), https://www.wsj.com/articles/SB120692412871875675 [https://perma.cc/JV5W-C66B] (describing the Bear Stearns sale as contravening the intent of existing public policies to minimize the use of the "too-big-to-fail" doctrine); Neil Irwin, *Paulson To Urge New Fed Powers*, WASH. POST (June 19, 2008), http://www.washingtonpost.com/wp-dyn/content/article/2008/06/18/AR2008061803225.html [https://perma.cc/3W2R-XPK8] ("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." (internal quotation marks omitted)); President Barack Obama, Remarks on Financial Rescue and Reform at Federal Hall (Sept. 14, 2009), https://obamawhitehouse.archives.gov/the-press-office/remarks-president-financial-rescue-and-reform-federal-hall [https://perma.cc/TQ2T-KBUQ] ("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.").

insurance,[75] to reducing the probability of insolvency,[76] to improving lending volumes in the wake of a shock.[77]

[75] *See, e.g.,* João A.C. Santos, *Bank Capital Regulation in Contemporary Banking Theory: A Review of the Literature*, 10 FIN. MKTS., INSTS. & INSTRUMENTS 41, 49–52 (2001).

[76] *See, e.g.*, Laura Chiaramonte & Barbara Casu, *Capital and Liquidity Ratios and Financial Distress: Evidence from the European Banking Industry*, 49 BRIT. ACCT. REV. 138, 139, 156–57 (2017) (describing the association between higher capital ratios and a lower probability of "failure and distress" at large EU banks).

[77] The overwhelming majority of the empirical literature on bank capital has focused on the relationship between capital and lending. That literature is outside the scope of this Article, 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. *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, 263–65, 267–68, 272–74 (1983); Joseph Noss & Priscilla Toffano, *Estimating the Impact of Changes in Aggregate Bank Capital Requirements on Lending and Growth During an Upswing*, 62 J. BANKING & FIN. 15, 15–17, 25–26 (2016) (finding that a slight increase in capital requirements results in a slight decrease in lending by UK banks); Mark Carlson et al., *Capital Ratios and Bank Lending: A Matched Bank Approach*, 22 J. FIN. INTERMEDIATION 663, 674–79, 682–86 (2013) (finding that banks whose capital ratios were relatively high had strong long growth during the 2008-2010 financial crisis); Marko Košak et al., *Quality of Bank Capital and Bank Lending Behavior During the Global Financial Crisis*, 37 INT'L REV. FIN. ANALYSIS 168, 174–76 (2015) (finding greater continuity in lending for banks with higher Tier 1 capital and retail deposit levels, but not for banks with higher Tier 2 capital or interbank deposit levels); Leonardo Gambacorta & Paolo Emilio Mistrulli, *Does Bank Capital Affect Lending Behavior?*, 13 J. FIN. INTERMEDIATION 436, 436–41, 449–52 (2004) (finding that the credit supply of well-capitalized Italian banks is not dependent on the business cycle); Sudipto Karmakar & Junghwan Mok, *Bank Capital and Lending: An Analysis of Commercial Banks in the United States*, 128 ECON. LETTERS 21, 21–23 (2015) (finding "a moderate relationship between capital ratios and business lending" through multiple business cycles); *cf.* Matthew Osborne et al., *In Good Times and in Bad: Bank Capital Ratios and Lending Rates*, 51 INT'L REV. FIN. ANALYSIS 102, 102–103, 107–12 (2017) (finding that better-capitalized banks are more likely to engage in secured household lending during upturns than in downturns); Jonathan Bridges et al., *The Impact of Capital Requirements on Bank Lending* 3–4, 16–21, 23 (Bank of Eng., Working Paper No. 486, 2014) (finding an initial decrease in lending after an increase

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.[78] These claims about an institution's *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, under this theory, banks were highly indebted. When banks suffered losses, investors, including other financial institutions, lost confidence and cut off funding, fearing that 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.[79]

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in capital requirements, followed by recovery within three years); Jose M. Berrospide & Rochelle M. Edge, *The Effects of Bank Capital on Lending: What Do We Know, and What Does it Mean?* 2–3, 13–17 (Fed. Reserve Bd. Fin. & Econ. Discussion Series, Working Paper No. 2010-44, 2010) (finding a relatively weak relationship between capital levels and loan growth); Shekhar Aiyar et al., *The International Transmission of Bank Capital Requirements: Evidence from the UK*, 113 J. FIN. ECON. 368, 368, 375–80 (2014) (finding decreased interbank lending to "non-core" countries following the introduction of higher capital requirements in the UK). However, as Berrospide and Edge note, the time frame and geographic scope of these studies seem to play a role in their results. *See* Berrospide & Edge, *supra* note 77, at 3–5.

[78] *See, e.g.*, Anat R. Admati & Martin F. Hellwig, *Bank Leverage, Welfare and Regulation, in* SYSTEMIC RISK IN THE FINANCIAL SECTOR 217 (Douglas W. Arner et al. eds., 2019); *cf.* Gorton, *supra* note 7, at 774–79 (determining, from an analysis of pre- and post-Federal Reserve Act banking crises that "[d]epositors panic when the liabilities signal is strong enough," and rejecting a "sun spot" hypothesis of depositor behavior).

[79] *See, e.g.*, ADMATI & HELLWIG, *supra* note 49, at 12; *see also* Daniel K. Tarullo, Member, Bd. of Governors of the Fed. Reserve Sys., Speech at the Clearing House Business Meeting and Conference: The Evolution of Capital Regulation 2 (Nov. 9, 2011), https://www.bis.org/review/r111110c.pdf [https://perma.cc/TJG3-MJBT] ("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

The most prominent (and voluble) counterargument to this view claims that, while higher capital might prevent runs, it also comes with substantial private and social costs.[80] However, another counterargument based in contagion theory also exists. It claims that the capital-focused account of runs is based on a faulty premise.[81]

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.[82] Under this theory, what both causes and distinguishes a run is a lack of liquidity—that is, a mismatch between the cash that bank

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with those firms, contributing to the severe liquidity strains that characterized financial markets at the time.").

[80] *See, e.g.*, Douglas Elliott et al., *Assessing the Cost of Financial Regulation* 13–56, 67 (Int'l Monetary Fund, Working Paper No. 12/233, 2012), https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Assessing-the-Cost-of-Financial-Regulation-40021 [https://perma.cc/9ASR-GBKA]; *cf.* Anat R. Admati et al., *Fallacies and Irrelevant Facts in the Discussion of Capital Regulation, in* CENTRAL BANKING AT A CROSSROADS: EUROPE AND BEYOND 33, 39–40 (Charles Goodhard et al. eds., 2014). We largely elide a third counterargument on the relationship between leverage and agency rents, where empirical research remains scant. *See, e.g.*, Gary Gorton & Andrew Winton, *Liquidity Provision, Bank Capital, and the Macroeconomy,* 49 J. MONEY, CREDIT & BANKING 5, 6 (2017); Thierno Amadou Barry et al., *Ownership Structure and Risk in Publicly Held and Privately Owned Banks*, 35 J. BANKING & FIN. 1327, 1335–39 (2011) (observing a direct relationship in sample of European banks).

[81] *See* SCOTT, *supra* note 40, 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").

[82] *See id.* at 9–13. 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 move to the run equilibrium. Douglas W. Diamond & Philip H. Dybvig, *Bank Runs, Deposit Insurance, and Liquidity*, 91 J. POL. ECON. 401, 402–04, 416–18 (1983).

creditors demand, and the cash that a bank owns or can get.[83] 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 and 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,"[84] and regulators 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.[85]

Much of the contagion literature is theoretical, but some historical evidence is consistent 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%.[86] 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.[87] Third,

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[83] *See* GORTON, *supra* note 27, at 153.

[84] *Id*. *See also* SCOTT, *supra* note 40, at 10 (describing contagion as "a liquidity-driven phenomenon" that is "not conditioned on insolvency"). These sources are ultimately rooted in Walter Bagehot's dictum to "lend freely," at "a very high rate of interest," on "good banking securities." WALTER BAGEHOT, LOMBARD STREET: A DESCRIPTION OF THE MONEY MARKET 31, 97 (Richard D. Irwin Inc., 1962) (1873). 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" to be eligible for credit from a lender of last resort, such as a central bank. SCOTT, *supra* note 40, at 181.

[85] *See* ANDREW METRICK ET AL., GRP. OF THIRTY, MANAGING THE NEXT FINANCIAL CRISIS: AN ASSESSMENT OF EMERGENCY ARRANGEMENTS IN THE MAJOR ECONOMIES 14–16 (2018), http://group30.org/images/uploads/publications/Managing_the_Next_Financial_Crisis.pdf [https://perma.cc/J97R-PYLY] (arguing for an expansion of the Federal Reserve's emergency lending powers).

[86] GORTON, *supra* note 27, at 161.

[87] Natasha Sarin & Lawrence H. Summers, *Understanding Bank Risk through Market Measures*, BROOKINGS PAPERS ECON. ACTIVITY 57, 75–76, 88–101 (2016). Sarin and Summers "suspect that without increases in

other non-liquidity explanations for Lehman seem to fall short; for example, other major financial institutions had relatively low asset and liability exposures to Lehman, suggesting that the run was not purely a function of direct counterparty risk.[88]

The claims of the capital and contagion literature fall into a gap in the academic literature. The theoretical literature focuses not on reducing the probability of a run, nor on mitigating its damage, but on what can stop a run already underway from spreading. Relatedly, the capital and contagion literature also discusses investor decision making, especially those decisions to withdraw funding on extremely short notice. By contrast, most academic work on capital has focused on its role

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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. *Id.* at 59–60. Consistent with the former explanation, several papers have argued that socially optimal levels of Tier 1 regulatory capital are substantially higher than the current required level. *See, e.g.*, Simon Firestone et al., *An Empirical Assessment of the Costs and Benefits of Bank Capital in the US* 1–2, 5 fig.1 (Fed. Reserve Bd. Fin. & Econ. Discussion Series, Working Paper No. 2017-034, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2946814 [https://perma.cc/AJ8Y-M67H] (advocating for the minimum required Tier 1 capital range to be increased to 13–26%); Martin Brooke et al., *Measuring the Macroeconomic Costs and Benefits of Higher UK Bank Capital Requirements* 7, 12–24 (Bank of Eng., Working Paper No. 35, 2015), https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-paper/2015/measuring-the-macroeconomic-costs-and-benefits-of [https://perma.cc/JMY6-4RWT] (10–14%); David Miles et al., *Optimal Bank Capital*, 123 ECON. J. 1, 26–31, 28 tbl.9 (2013) (16–20%); Jihad Dagher et al., *Benefits and Costs of Bank Capital* 11–20 (Int'l Monetary Fund, Staff Discussion Note No. SDN/16/04, 2016), https://www.imf.org/external/pubs/ft/sdn/2016/sdn1604.pdf [https://perma.cc/5R73-2U7N] (15–23%); Wayne Passmore & Alexander H. von Hafften, *Are Basel's Capital Surcharges for Global Systemically Important Banks Too Small?,* 15 INT'L J. CENT. BANKING 107, 136–44 (2019) (6.5–14.75%); FED. RESERVE BANK OF MINNEAPOLIS, THE MINNEAPOLIS PLAN TO END TOO BIG TO FAIL 43–44, 49–51 (2017), https://www.minneapolisfed.org/publications/special-studies/endingtbtf/final-proposal [https://perma.cc/VZ66-NJNX] (23.5%).

[88] SCOTT, *supra* note 40, at 29–58.

before and after a crisis (i.e., in preventing a crisis or hastening recovery from one).[89]

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 decision to file was 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.[90] This study found that large banks with lower leverage and higher degrees of reliance on deposit funding had higher post-Lehman stock returns—and that pre-Lehman regulatory capital ratios and liquidity measures did little to explain those returns.[91]

However, several attributes of this study limit its specific relevance to runs. First, its market and balance-sheet data are included on an annual basis, which is too infrequent to capture run behavior in funding markets.[92] Second, its outcome variable only captures the behavior of shareholders in equity markets.[93] Equity market capitalization is an easily

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[89] *See supra* notes 75–77 and accompanying text.

[90] Asli Demirguc-Kunt et al., *Bank Capital: Lessons from the Financial Crisis* (Int'l Monetary Fund, Working Paper No. WP/10/286, 2010), https://www.imf.org/external/pubs/ft/wp/2010/wp10286.pdf [https://perma.cc/F7K6-P8K2]. 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 conditions of the surviving institutions." Nicolas Dumontaux & Adrian Pop, *Contagion Effects in the Aftermath of Lehman's Collapse: Measuring the Collateral Damage* 2, 16–31 (Laboratoire d'Economie et de Management Nantes, Working Paper No. 2012/27, 2012), https://hal.archives-ouvertes.fr/hal-00695721/document [https://perma.cc/3TC9-ZE4K]. However, their measures of financial condition were focused 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." *Id.* at 21. These balance-sheet measures, as well as their regression specifications have the same limitations as those of Demirguc-Kunt.

[91] *See* Demirguc-Kunt et al., *supra* note 90, at 9–11.

[92] *Id.* at 7–8.

[93] *Id.* at 4.

observable component of enterprise value, and since it is a highly liquid measure, it can reflect concerns from a wide range of investors.[94] 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.[95] 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.[96]

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[94] *See* Sarin & Summers, *supra* note 87, at 58 (discussing the relationship of bank equity and debt market measures to bank exposures and asset quality).

[95] *See, e.g.*, Antonio S. Mello & John E. Parsons, *Measuring the Agency Cost of Debt*, 47 J. FIN. 1887 (1992).

[96] Demirguc-Kunt's analysis also contains a methodological flaw: Its outcome variable measures the raw change in a sample bank's stock price, controlling for the stock's beta (defined as the covariance between the stock's return and the return of the host country's stock market). Demirguc-Kunt et al., *supra* note 90, at 7. This approach has several shortcomings. First, failing to normalize raw price changes to an institution's 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 price 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. That is, Bank A may have had a higher return on equity ("ROE") than Bank B before the Lehman bankruptcy, and its ROE 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, *Optimal Use of Financial Leverage in a Corporate Capital Structure*, INVESTOPEDIA (Apr. 4, 2019), https://www.investopedia.com/articles/investing/111813/optimal-use-financial-leverage-corporate-capital-structure.asp [https://perma.cc/39K9-M3SY].

III. ANALYSIS

A. Overview of Methodology and Research Design

This Article intends to fill the gap in the academic literature and policy discussions by using Lehman's unexpected bankruptcy to examine the impact of capital and liquidity levels on large financial institutions' susceptibility to a run.[97] Recall that the Friday prior to Lehman's bankruptcy—the most recent time U.S. markets were open for trading prior to Lehman's demise—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.[98] 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.[99] 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.[100] Importantly,

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[97] 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. *See supra* notes 2–3, 42 and accompanying text. 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 supra* notes 4, 43 and accompanying text.

[98] *See supra* note 3 and accompanying text.

[99] *See supra* note 4 and accompanying text.

[100] Several studies have used similar techniques to examine other aspects of investor behavior during the 2008 crisis. *See, e.g.*, Jian Yang & Yinggang Zhou, *Credit Risk Spillovers Among Financial Institutions Around the Global Credit Crisis: Firm-Level Evidence*, 59 MGMT. SCI. 2343 (2013); Barry Eichengreen et al., *How the Subprime Crisis Went Global: Evidence from Bank Credit Default Swap Spreads,* 31 J. INT'L MONEY & FIN. 1299 (2012).

these variables are *proxies* for run behavior, constructed from *publicly available* data, rather than direct measures. As discussed above, the definition of a bank run is typically limited to the withdrawal of debt financing—in a prototypical case, the withdrawal of deposits.[101] 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. Nevertheless, we believe our market-based proxies are credible: runs on financial institutions occur when there is no trust that those institutions will repay their liabilities. That breakdown in trust is captured by movements in the market. CDS spreads, for example, capture the market price of insuring against a credit event, including default.[102] Equity prices complement CDS measures, since equities trade in thicker, more complete markets; and, because a bank can be funded mostly from debt (*viz*., deposits), a bank could

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. *See Primary Dealer Credit Facility (PDCF)*, BD. OF GOVERNORS FED. RES. SYS. (Mar. 18, 2020), https://www.federalreserve.gov/regreform/reform-pdcf.htm [https://perma.cc/73X2-RB58]; *Transaction Data, Primary Dealer Credit Facility ("PDCF"),* BD. OF GOVERNORS FED. RES. SYS., https://www.federalreserve.gov/regreform/reform-pdcf.htm [https://perma.cc/73X2-RB58]. 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 Discount Window Lending*, BD. OF GOVERNORS FED. RES. SYS. (Apr. 1, 2020), https://www.federalreserve.gov/regreform/discount-window.htm [https://perma.cc/MD9R-P6K8].

[101] *See, e.g.*, GORTON, *supra* note 27, at 9 ("A financial crisis in its pure form is an exit from bank debt, a bank run.").

[102] *See* Peipei Wang & Ramaprasad Bhar, *Information Content in CDS Spreads for Equity Returns*, 30 J. INT'L FIN. MKTS., INSTS., & MONEY 55, 57 (2014); CHRISTOPHER L. CULP ET AL., CREDIT DEFAULT SWAPS 158 (2018).

theoretically experience a fire-sale in equity markets without experiencing similar strain in debt markets.[103]

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.[104] This dynamic model utilizes daily market data to estimate the impact of 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

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[103] We can imagine one scenario that might practically fit this description: a preemptive guarantee, perhaps by a deposit insurer, to leave customer deposits intact. Such a planned resolution would reflect significant financial strain, and likely would even trigger 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.

[104] Our specification comes from Daron Acemoglu et al., *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 used to address potential serial correlations among results. *See* A. Colin Cameron & Douglas L. Miller, *A Practitioner's Guide to Cluster-Robust Inference*, 50 J. HUM. RES. 317 (2015). 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 et al., *When Should You Adjust Standard Errors for Clustering?* (Nat'l Bureau Econ. Research, Working Paper No. 24003, 2017), https://www.nber.org/papers/w24003 [https://perma.cc/H787-L6SM]. Notably, we also conducted our analysis of U.S. institutions without clustering and, separately, with a different clustering method (bootstrapped clustered standard errors). Our results are directionally identical and robust under all three specifications, and are available on request.

observed variation during our time window to the Lehman bankruptcy.[105]

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

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 of the regression specification, α_i captures firm-specific characteristics; 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.[106]

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[105] 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 (a "normal" return is usually defined as the return on a broad-based index, like the S&P 500). For a detailed description of event study methodologies, see Norman Strong, *Modelling Abnormal Returns: A Review Article*, 19 J. BUS. FIN. & ACCT. 533 (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, showing how trends in those returns changed following the Lehman filing. 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. *See infra* notes 4, 43 and accompanying text.

[106] 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 one1 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 prior to Lehman's collapse, using balance sheet measures from the most recent quarterly filings prior to the Lehman bankruptcy, or more recent market information, as available.[107]

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.[108] The fitted lines in these charts show that, counterintuitively, banks with greater balance 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* ("AR T1") by the firms listed in Appendix D (AR T1/RWA).[109] 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, rather than Basel II.[110] 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 thus limited to the 2008 risk-weighted denominator. However, we can and do construct the Basel II Tier 1

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[107] *See infra* Table 1 for a summary of measures used and *infra* Appendix B for descriptive statistics.

[108] *See infra* Appendix G.

[109] *See infra* Appendix D.

[110] U.S. regulators finalized the Basel II capital rules for advanced approach 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* Risk-Based Capital Standards: Advanced Capital Adequacy Framework — Basel II 72 Fed. Reg. 69,288, 69,301–02 (Dec. 7, 2007) (codified at 12 C.F.R. pts 3, 208, 225, 325, 559–60, 563, and 567).

numerator, reflecting the then-imminent regulatory requirement for U.S. banking organizations.[111]

Next, we run a series of tests to examine how investors weighed the regulatory capital measures available to them at the time of the Lehman filing. To isolate the Basel II numerator, we test a ratio of Basel II Tier 1 capital ("B2 T1") over total assets ("TA") (B2 T1/TA). To isolate the Basel I denominator, we test a ratio of common equity ("CE") 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 Basel III numerator measures: Basel III Tier I capital ("B3 T1") and Basel III CET1 ("CET1").[112] We test each proxy over 2008 risk-weighted assets (B3 T1/RWA, CET1/RWA) and total assets (B3 T1/TA and CET1/TA).[113] 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.[114] 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") a measure of credit that investors can withdraw on short notice, which is

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[111] Notably, the Basel II Tier 1 definition was almost identical to the Basel I Tier 1 definition, adding only non-cumulative perpetual preferred stock to Basel I's paid-up share capital/common stock and disclosed reserves. *Compare* BASEL COMM., BASEL II, *supra* note 51, at 244–45, *with* BASEL COMM. ON BANKING SUPERVISION, INTERNATIONAL CONVERGENCE OF CAPITAL MEASUREMENT AND CAPITAL STANDARDS 14 (1988).

[112] *See infra* Appendix C.

[113] It is not possible to reconstruct a Basel III risk-weighted denominator proxy using data publicly available in 2008.

[114] *See supra* note 62 and accompanying text.

now addressed as part of Basel III (STWF/TA).[115] 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 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 one.[116]

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 (hereinafter, the "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.[117] A higher correlation suggests that market shocks affect the share prices of two institutions in similar sign and magnitude. If the correlation has high explanatory power, it suggests that 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. 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

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[115] *See* BASEL COMM., NET STABLE FUNDING RATIO, *supra* note 61, at 1.

[116] 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* Fin. Accounting Standards Bd., Debt (Topic 470): Overall (2016).

[117] The specific formula used to calculate the daily change in the share price is $\log(p_t / (p_t - 1))$, applied to end-of-day share prices from January 2007 through July 2008.

Lehman owed to other parties at the time of its failure.[118] However, given the statutory penalties for misstating claims in the liquidation of a securities dealer,[119] this data may be the best available measure of relative counterparty exposures to Lehman at the time of insolvency.

[118] The reasons for this looseness include that the proxy (a) does not distinguish between claims payable to the institution or its transferee and 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. 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). Lehman's Chapter 11 voluntary petition suggests that initial claims may have even less of a relationship to investor behavior than the ultimate award figures we used. Lehman's largest unsecured creditor in that petition was Citibank, N.A., with an astonishing $138 billion in exposure—more than eleven times the second-largest unsecured creditor. Voluntary Petition at Schedule 1, *In re* Lehman Bros. Holdings Inc., 404 B.R. 752 (Bankr. S.D.N.Y. 2009) (No. 08-13555), 2008 WL 4200597. Its sixth-largest unsecured creditor was also a branch of Citibank, N.A., with another $275 million in exposures. *Id.* Based on call report filings, these claims were 11.9% of Citibank, N.A.'s unweighted assets, and 147% of its reported Basel II Tier 1 capital. *See* Citibank N.A., Call Report, at 10, 57 (June 30, 2009). This initial petition only included one other bank from our U.S. sample and four other banks from the separate non-U.S. Global Systemically Important Bank ("G-SIB") sample, and it excluded other in-sample banks that ultimately filed award claims. *See* Voluntary Petition, *supra* note 118, at Schedule 1. 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.

[119] Lehman bankruptcy proceedings occurred under the Securities Investor Protection Act, which bars false statements of account and acts of fraudulent conversion. *See In re* Lehman Bros. Inc., No. 08-01420JMPSIPA, 2008 WL 5423214 (Bankr. S.D.N.Y. Nov. 26, 2008); 15 U.S.C. §§ 78jjj(c)(1)(C)(ii), (c)(2) (2018).

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 twenty-seven largest U.S. banking institutions by total consolidated assets as of September 2008, as well as those investment banks that later converted to bank holding companies (which were then receiving public assistance, and are now subject to the same post-crisis prudential reforms as the other twenty-seven institutions in our sample[120]).[121]

[120] *See* Sorkin, *infra* note 177.

[121] Where "total assets" are indicated above, for firms filing the Y-9C we specifically use 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 The Charles Schwab Corporation,* FED. FIN. INSTS. EXAMINATION COUNCIL (2019), https://www.ffiec.gov/nicpubweb/nicweb/InstitutionProfile.aspx?parID_Rssd=1026632&parDT_END=99991231 [https://perma.cc/HMD6-C2J4]; *E*TRADE Financial Corporation*, FED. FIN. INSTS. EXAMINATION COUNCIL (2019), https://www.ffiec.gov/nicpubweb/nicweb/InstitutionProfile.aspx?parID_Rssd=3412583&parDT_END=99991231 [https://perma.cc/TN6D-76NN]. We omitted from our sample twenty-two non-U.S. G-SIBs, as identified by the Financial Stability Board. *See* FIN. STABILITY BD., 2017 LIST OF GLOBALLY SYSTEMICALLY IMPORTANT BANKS (G-

B. Summary of Results

The full results of our analysis can be found in Appendices E and F.[122] Here, we briefly review our results for each explanatory variable. In short, only Basel II Tier 1 leverage and the 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—that is, the more an institution had, the more exposed it was to the run.

1. Simple Panel Fixed-Effects Regression Results

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

The estimated coefficient on reported Tier 1 capital (AR T1/RWA) was found to be 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

SIBS) (2017), https://www.fsb.org/wp-content/uploads/P211117-1.pdf [https://perma.cc/47FA-RXTW]. 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 any broad conclusions about non-U.S. jurisdictions or institutions.

[122] *See infra* Appendices E–F.

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 relationship. 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[123]) may have resided in its risk-weighting system, rather than its definition of capital.[124] Bolstering this suggestion, simple leverage (CE/TA) and the reported Tier 1 capital ratio (AR T1/RWA) were negatively correlated before the Lehman filing. That is, the higher an institution's Basel I ratio, the more leveraged it was likely to be.[125]

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 performed worse than reported Basel I measures in

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[123] *See* Mark E. Van Der Weide & Jeffrey Y. Zhang, *Bank Capital Requirements after the Financial Crisis, in* THE OXFORD HANDBOOK OF BANKING 707, 708 (Allen N. Berger et al. eds., 3d ed. 2019).

[124] For more on the potential challenges associated with risk-weighting, see Andrew G. Haldane, Exec. Dir., Bank of Eng,, Speech at the Federal Reserve Bank of Atlanta: Constraining Discretion in Bank Regulation 4 (Apr. 9, 2013), https://www.bankofengland.co.uk/-/media/boe/files/paper/2013/constraining-discretion-in-bank-regulation.pdf?la=en&hash=46E1F9BF24E99D85DBC28746A190ABBC5DA785E2, [https://perma.cc/NF7D-RQ2Q] ("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, Keynote Address at the International Conference of Banking Supervisors: Safer, But Not Safe Enough 3 (Nov. 29, 2018), https://www.bis.org/bcbs/events/icbs20/vickers.pdf [https://perma.cc/R9HK-EB3B].

[125] *See infra* Table 2.

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.[126] 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*)

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 investors.

For *funding fragility*, 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.

126 *See id.*

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

2. 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), the 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 the 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 the Lehman correlation captures the variation in run exposures suggested by the two other variables, except in equity markets, where counterparty information still retained some independent explanatory power.

3. Overall Results

Of all fifteen right-hand side variables, only three were statistically significant and directionally intuitive in both CDS and equity markets: one leverage measure (B2 T1/TA), one correlation measure (the 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 (CET1) had less explanatory power than its antecedent Basel II measure.
- Similarly, our *balance sheet liquidity* proxies were not intuitively predictive of investor behavior. Our proxies behaved just as the regulatory capital variables did: The higher the levels, the greater an 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 the variation observed in run exposures, in the intuitive direction; CET1 risk-based capital also explains a substantial amount of the variation in run exposures, but in the counterintuitive direction; and liquidity

results are still highly clustered. In short, the institutions most exposed to the Lehman run were not those with the lowest levels of capital or balance sheet liquidity.

IV. POLICY IMPLICATIONS

Our results target a specific question—namely, what actually mattered during the Lehman market panic? How did the "fire" spread once it started? To be sure, our results are limited by the nature and context of the Lehman bankruptcy, and 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.

Instead, our results address the window after a fire has started and is about to spread. This window is small, but it has outsized consequences for the path a financial crisis will take, as well as the public and private costs of that crisis. As such, our results bear directly on the capital versus contagion debate; shed light on the causes of systemic bank runs; and suggest critical policy steps that could be taken to address run vulnerability at large financial institutions.

A. Bank Runs Aren't (Always) About Cash

Balance sheet liquidity did little to stop a run on institutions 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 results to institutions with low levels of balance sheet liquidity. Financial institutions had relatively few liquid assets entering 2008,[127]

[127] In 2008, across the entire banking sector highly liquid assets were less than 15% of total assets, compared to approximately 25% today. *See* BD.

and by the time Lehman filed for bankruptcy, markets had already experienced months of volatility.[128] Investors might have (quite reasonably) assumed that post-Lehman redemptions would dwarf whatever liquid assets banks had on hand, and accordingly discounted the most recent balance sheet liquidity figures they had available to them 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 liquidity facilities in addition to the discount window in September 2008.[129] 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.[130] On September 14, the Board publicly announced a "significant broadening" of the collateral eligible to be posted at two of their liquidity facilities, and increased the frequency and quantity of funds institutions could borrow from those facilities.[131] The day it filed, Lehman took out another $28 billion in overnight loans from the Federal Reserve, and other primary dealers took out $13.25 billion.[132] Thus, although banks' balance sheet assets may have been highly illiquid, the large banks themselves were seemingly awash in liquidity. While the Federal Reserve did not disclose full and precise figures contemporaneously, investors would have known this

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OF GOVERNORS FED. RESERVE SYS., FEDERAL RESERVE SUPERVISION AND REGULATION REPORT 6 fig.7 (2018).

[128] *See VIX Index Historical Data,* CHI. BD. OPTIONS EXCH., http://www.cboe.com/products/vix-index-volatility/vix-options-and-futures/vix-index/vix-historical-data [https://perma.cc/BY4Z-F5MK].

[129] *See* SCOTT, *supra* note 40, at 75.

[130] *See Transaction Data*, *supra* note 100.

[131] Press Release, Fed. Reserve Bd. of Governors, Federal Reserve Board Announces Several Initiatives to Provide Additional Support to Financial Markets, Including Enhancements to its Existing Liquidity Facilities (Sept. 14, 2008), https://www.federalreserve.gov/newsevents/pressreleases/monetary20080914a.htm [https://perma.cc/NJ8E-EN62].

[132] *See Transaction Data*, *supra* note 100.

government provided liquidity was available for large financial institutions' use.[133]

This high level of public support creates a second counterargument: Investors were indifferent to balance sheet liquidity issues because institutions could access potentially unlimited amounts of 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, this counterargument would imply two inconsistent facts: that 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 run at all. That is, if the liquidity needs of those large financial institutions were sure to be met, then even Lehman Brothers would still have been standing.[134]

At a 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

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[133] The Federal Reserve disclosed details on the entities that received assistance from crisis-era special facilities in December 2010. *See id*. In 2012, it began regularly publishing details regarding discount window lending activity, roughly two years after the activity takes place. *See Credit and Liquidity Programs and the Balance Sheet*, BD. OF GOVERNORS FED. RES. SYS. (Aug. 13, 2019), https://www.federalreserve.gov/monetarypolicy/bst_lendingdepository.htm [https://perma.cc/GJ44-56DA]; *Transaction Data, Discount Window Lending,* BD. OF GOVERNORS FED. RES. SYS., https://www.federalreserve.gov/regreform/discount-window.htm [https://perma.cc/YPW7-RNUM].

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

about the fidelity of bank balance sheets to uncertainty surrounding the 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 with pre-crisis reserve rules.[135] However, regulatory capital measures led to two disconcerting results—the first regarding risk-weighting and the capital denominator, and the second regarding reforms agreed under Basel III.

First, we found no specification, in any sample or 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).[136] 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 after accounting for the well-known shortcomings in pre-

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[135] *See* RAJ GNANARAJAH, CONG. RESEARCH SERV., R45339, BANKING: CURRENT EXPECTED CREDIT LOSS (CECL) 1–2 (2018); Eugene A. Ludwig & Paul A. Volcker, *Banks Need Long-Term Rainy Day Funds*, WALL ST. J. (Nov. 16, 2012), https://www.wsj.com/articles/SB10001424127887324556304578120721147710286 [https://perma.cc/HS28-9S2T].

[136] *See infra* Table 2.

crisis risk-weighting rules. Leverage limits—which have been a part of U.S. banking regulation since 1981, before the first Basel accords—are intended to complement risk-based capital requirements.[137] Leverage ratios impose the same "regulatory capital charge" for every asset,[138] 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 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.[139]

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.[140] As such, we

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[137] *See* Michael Brei & Leonardo Gambacorta, *The Leverage Ratio Over the Cycle* 2 (Bank for Int'l Settlements, Working Paper No. 471, 2014), https://www.bis.org/publ/work471.pdf [https://perma.cc/Z6QG-MQEY].

[138] *See* Van Der Weide & Zhang, *supra* note 123, at 726.

[139] *See* BERNANKE ET AL., *supra* note 7, 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").

[140] *See* BANK INT'L SETTLEMENTS, BASEL III LEVERAGE RATIO FRAMEWORK 1 (2017) ("The leverage ratio is also intended to reinforce the risk-based capital requirements with a simple, non-risk-based 'backstop.'"); Jaime Caruana, Gen. Manager, Bank for Int'l Settlements, Promontory Annual Lecture: Financial Regulation, Complexity and Innovation 1 (June 4, 2014), https://www.bis.org/speeches/sp140604.htm [https://perma.cc/E8YK-GLKB] (describing "the leverage ratio as a backstop to the risk-weighted measure"); Daniel K. Tarullo, Member, Fed. Reserve Bd. of Governors, Opening Statement to Meeting of Board of Governors (Apr. 8, 2014), https://www.federalreserve.gov/newsevents/press/bcreg/bcreg20140408a-tarullo-statement.htm [https://perma.cc/SEV6-9EFQ] (saying the "leverage ratio serves as a critical backstop to the risk-based capital requirements," immediately prior to the Board of Governors vote on the enhanced supplementary leverage ratio); Mervyn King, Governor, Bank of Eng., Banking—From Bagehot to Basel, and Back Again 6–7 (Oct. 20, 2010), https://www.bis.org/review/r101028a.pdf [https://perma.cc/T2XB-VLXM] (noting that "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

would expect Basel III to change these fire-sale relationships, so that an institution holding higher levels of regulatory capital would correspond with (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 the 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.[141]

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 sample, and in equity markets, their relationship to run exposure was weaker than that observed of the equivalent Basel II measures.

England advocated a simple leverage ratio as a key backstop to capital requirements").

[141] Critically, no U.S. advanced approach institutions are in parallel run today. Recent empirical work on loan-levels has found evidence of potential manipulation in risk-weighting. *See* Matthew C. Plosser & João A.C. Santos, *Banks' Incentives and the Quality of Internal Risk Models*, 31 REV. FIN. STUD. 2080 (2018) (finding a downward bias in risk-rating at lower-capital banks after reviewing a sample of post-crisis Shared National Credits); Giovanni Ferri & Valerio Pesic, *Bank Regulatory Arbitrage Via Risk Weighted Assets Dispersion*, 33 J. FIN. STABILITY 331 (2017) (finding a larger degree of risk-weight manipulation at less capitalized banks in a sample of 239 institutions); *see also* Mike Mariathasan & Ourada Merrouche, *The Manipulation of Basel Risk-Weights*, 23 J. FIN. INTERMEDIATION 300 (2014) (examining risk-weight manipulation *vis-a-vis* Basel II requirements).

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 adds retained earnings and accumulated other comprehensive income (i.e., unrealized gains) and subtracts three categories of intangible assets.[142] In turn, Basel III Tier 1 capital includes the definition of CET1, but adds "additional Tier 1 capital," Additional Tier 1 Capital under Basel III is defined by a list of fourteen criteria, several of which include sub-criteria.[143]

In one interpretation of our results, investors placed less faith in the specific measures Basel III added to regulatory capital (or, placed more faith in the measures Basel III stripped away). 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.[144]

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.[145] Our results suggest that instead—or, at least, as a corollary—time constraints and other transaction costs might place some limits on that

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[142] *See infra* Appendix A.

[143] *See infra* Appendix H.

[144] *See, e.g.*, Andrew G. Haldane, Exec. Dir., Bank of Eng., Remarks at the American Economic Association: Capital Discipline (Jan. 9, 2011), https://www.bis.org/review/r110325a.pdf [https://perma.cc/UP73-EHZ2]; William Coen, *Ring-Fencing's Global Impact*, BANKING PERSP., Summer 2018, at 36, 39 ("Simply put: One cannot and should not relentlessly pursue risk sensitivity as a goal in itself; it must be balanced with simplicity and comparability.").

[145] *See* Gary Gorton & Guillermo Ordoñez, *Collateral Crises*, 104 AM. ECON. REV. 343, 344 (2014); Tri Va Dang et al., Ignorance, Debt, and Financial Crises 3–4 (Apr. 1, 2015) (unpublished manuscript) (on file with the *Columbia Business Law Review*).

information-sensitivity. That is, 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).[146] A common shock can certainly hit one or more institutions simultaneously, like the failure of a single counterparty, the

[146] The definition of an exogenous shock in the economic literature is not fixed. *See* Panos Varangis et al., Exogenous Shocks in Low Income Countries: Economic Policy Issues and the Role of the International Community 2–4 (Nov. 20, 2004) (unpublished manuscript) (on file with the *Columbia Business Law Review*). 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 [https://perma.cc/7588-6ET2].

downgrade of a common creditor, or a cybersecurity attack.[147] 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.[148]

Run behavior in 2008 displayed a similar dynamic. Lehman Brothers (figuratively) caught fire the day it filed for

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[147] A dissent to the final report of the Financial Crisis Inquiry Commission highlighted an alleged common shock as a cause of the 2008 crisis. FIN. CRISIS INQUIRY COMM'N, THE FINANCIAL CRISIS INQUIRY REPORT 419 (2011) (dissenting statement of Vice Chairman Bill Thomas and Commissioners Keith Hennessy and Douglas Holtz-Eakin). The Commission majority declined to adopt this view. *See id.* at xviii–xx.

[148] Several key figures from the financial crisis have recently embraced the same analogy. *See* BERNANKE ET AL., *supra* note 7, at 21, 112 ("Fire prevention had failed. Now the fate of the [financial] system would depend on fire-fighting. . . . [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.").

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 market participants. Instead, investors may have drawn conclusions about their vulnerability from the simplest available measure—that is, whether a particular financial institution had 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 of one falls, the value of the other will fall, too.[149] Regardless of why the link between them exists; regardless of whether they actually owe money to each other or a common 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 two banks are tied together, and one is faltering, what rational investor would remain exposed to the other?

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[149] Keynes developed his 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. *See* JOHN MAYNARD KEYNES, THE GENERAL THEORY OF EMPLOYMENT, INTEREST AND MONEY 147–64 (1936). What is a contestant's optimal strategy? Per Keynes:

> It is not a case of choosing those [faces] which, to the best of one's judgment, are really the prettiest, nor even those which 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 practise the fourth, fifth and higher degrees.

Id. at 156.

V. IMPLICATIONS FOR REGULATORY DESIGN

A. Supervisory Stress Tests

The identification of correlation channels offers several implications for improving the design of our post-crisis regulatory framework—the first of which pertains to government "stress tests" of financial institutions. At the height of the 2008-09 financial crisis, the Federal Reserve created the Supervisory Capital Assessment Program to estimate the potential losses at large banks in the event economic and financial conditions worsened further.[150] Since then, the Federal Reserve moved to the current stress testing assessment—the Comprehensive Capital Analysis and Review—to evaluate whether the largest financial institutions with operations in the United States have sufficient capital to absorb future potential losses and continue to lend under stressed conditions.[151] In this process, the Federal Reserve simulates macroeconomic scenarios like a recession in which GDP falls and the unemployment rate rises significantly. In the 2019 stress test cycle, for example, the Federal Reserve tested banks against a hypothetical global recession in which the unemployment rate in the United States rose to 10%.[152] The stressed banks were required to show that they could continue to meet minimum capital requirements in the face of those hypothetical macroeconomic shocks.[153]

Our results strongly suggest that it is not enough to simply stress test financial institutions using broad-based aggregate

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[150] *See* Ben S. Bernanke, Chairman, Fed. Reserve Sys., Speech at the 2009 Financial Markets Conference in Jekyll Island, Georgia: The Supervisory Capital Assessment Program (May 11, 2009), https://www.federalreserve.gov/newsevents/speech/bernanke20090511a.htm [https://perma.cc/8UZU-YMMD].

[151] *See supra* notes 71–73 and accompanying text.

[152] *See* BD. OF GOVERNORS FED. RESERVE SYS., 2019 SUPERVISORY SCENARIOS FOR ANNUAL STRESS TESTS REQUIRED UNDER THE DODD-FRANK ACT STRESS TESTING RULES AND THE CAPITAL PLAN RULE 4–5 (2019).

[153] *See id.*

economic shocks, nor even by 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 an idiosyncratic stress at a specific institution, rather than a broad shock to the system itself.[154] A lack of widespread direct counterparty exposure to a failing bank forecloses one avenue towards financial strain, but it does not guarantee safety from a run.

Correlations can change over time—they can either form or disappear, strengthen or weaken—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.[155] 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.[156] Alarmingly, the share prices of many of these institutions are even *more* highly correlated today, exceeding even their highest 2008 correlation with Lehman.[157]

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[154] *See* ADMATI & HELLWIG, *supra* note 49, 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.").

[155] *See infra* Table 3.

[156] *See supra* note 6 and accompanying text. Notably, existing research suggests that market correlations increase during a financial crisis, making the divergent behavior of specific institutions' equity and CDS values even more notable. *See, e.g.*, Silvio Contessi et al., *How Did the Financial Crisis Alter the Correlations of U.S. Yield Spreads?* (Fed. Reserve Bank of St. Louis, Working Paper No. 2013-005D, 2014), https://files.stlouisfed.org/files/htdocs/wp/2013/2013-005.pdf [https://perma.cc/HC8P-CWN5].

[157] 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 ET AL., FINANCIAL ACCESS AND STABILITY: A ROAD MAP FOR THE MIDDLE EAST AND NORTH AFRICA 313–16 (2011),

Monitoring these channels at a high frequency—more than the annual frequency of supervisory stress tests—would offer a more precise insight into which institutions would be vulnerable should a shock occur and spread. This would be akin to firefighters monitoring firebreaks in a neighborhood they serve; epidemiologists and public health experts monitoring the use of water sources in an area vulnerable to cholera; or cybersecurity experts monitoring data hubs in advance of a cyber attack. In all four cases, the information provided can help direct scarce public resources to where they can be most effective, when the potential impact is highest and the time for planning is lowest.

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http://documents.worldbank.org/curated/en/343771468052798123/pdf/649370PUB0Fina00Box361550B00Public0.pdf [https://perma.cc/MUY4-SEBM]. 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. *See* Randall Morck et al., *The Information Content of Stock Markets: Why Do Emerging Markets Have Synchronous Stock Price Movements?*, 58 J. FIN. ECON. 215 (2000). 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—reveals current co-movement at levels similar to that observed 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. *See infra* Table 3.

Table 3: Pairwise Correlation Coefficients – 2008 and 2018[158]

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*

[158] *Equity Price Data*, *supra* note 8.

B. "Monoculture Risk" in the Financial Sector

Our results also speak to the fact that correlation does not exist in a vacuum. Correlation can 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,[159] and other banking institutions have made substantial cuts to their investment banking units.[160] Increased correlation may indicate that the activities of large, consolidated banks are converging, as other research indicates, toward a more retail-focused, stable, and profitable business model.[161] Importantly, this convergence involves an intuitive trade-off between greater stability in normal times, and greater risk in the event of a contagious run. A close analogy is monoculture: planting the same bountiful crop year after year, while risking that a single pest or pathogen may spoil your entire yield. To the extent this "monoculture risk" exists, it represents a profound challenge at the very heart of the post-crisis macroprudential framework—in part because it increases the chances that regulators will face the simultaneous failure of several large financial institutions during a future crisis.[162]

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[159] *See* Sorkin, *infra* note 177.

[160] *See* 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/ [https://perma.cc/SV5R-S2KR].

[161] *See* Rungporn Roengpitya et al., *Bank Business Models: Popularity and Performance* 15–19 (Bank of Int'l Settlements, Working Paper No. 682, 2017), https://www.bis.org/publ/work682.pdf [https://perma.cc/DF5M-7CD5] (identifying, in a panel of 178 banks, a post-crisis trend in institutions transitioning to a retail banking model, and observing that such retail-focused institutions experience lower cost-to-income ratios and higher and more stable return on equity).

[162] *See* BERNANKE ET AL., *supra* note 7, 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").

C. Revisiting Post-Crisis International Capital Standards

Our findings also reiterate the point that international capital standards are not evergreen, including those crafted since the last financial crisis. Regulators' existing experience also reflects this point. In 2011, then-Federal Reserve Governor Daniel Tarullo criticized the old Basel II definition of risk-based capital in a speech:

> [A]t least some of the instruments that qualified as "Tier 1 capital" for regulatory purposes [under Basel II] were not reliable buffers against losses, at least not on a going concern basis. It is instructive that during the height of the crisis, counterparties and other market actors looked almost exclusively to the amount of tangible common equity held by financial institutions in evaluating the creditworthiness and overall stability of those institutions. They essentially ignored the Tier 1 and total risk-based capital ratios in regulatory requirements. 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.[163]

Nearly a decade after those remarks, our results suggest that the Basel III definition may now face similar issues, which merits further investigation. By definition, the inverse relationship between our Basel III-based leverage measures (B3 T1/TA and CET1/TA) and simple leverage (CE/TA) reflects a substitution away from common equity and toward 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

[163] *See* Tarullo, *supra* note 79, at 3.

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?

D. Preparing Disclosures in Advance

Our results also suggest that improving disclosures, particularly those surrounding credit exposures and credit risk, could enormously impact institutions' pre-crisis behavior. Recall that, to account for the possibility that investors acted on private information about Lehman itself, we assessed 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 aggregated the total amount awarded on claims either held by or transferred from an institution in our sample (or one of its subsidiaries or affiliates).

If our hypothesis about informational efficiency is correct, these kind of 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 147% of its reported Tier 1 capital[164]—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-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

[164] *See* Voluntary Petition, *supra* note 118, at Schedule 1.

view regulators now have of the legal structure of large financial institutions?

E. Herd Behavior and Market Structure

Finally, our results hint at the potential danger of 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 drive around 85% of daily U.S. trading volumes, much of it based on momentum strategies that could encourage herd behavior.[165] Automation could allow investors to process extremely complex information on short notice, or it could encode their existing beliefs—biased or not—and amplify market swings, which may also involve investor runs through the correlation channels.

We conclude by noting that network and agent-based models of financial stress might have the potential to help answer these questions.[166] However, our results also show the explanatory value of very simple and transparent models in complicated times. Regulators, investors, and institutions all understandably struggle to decide what information is trustworthy during a crisis. Certainty may be an ideal condition, but it is often scarce when markets are highly volatile. In its absence,

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[165] *See, e.g.*, Gregory Zuckerman et al., *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 [https://perma.cc/UD8P-25U7].

[166] *See, e.g.*, Jeremy Oldfather et al., *Bank Complexity: Is Size Everything?*, FEDS NOTES (July 15, 2016), https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/bank-complexity-is-size-everything-20160715.html [https://perma.cc/5W28-M7EB]; Fabio Caccioli et al., *Network Models of Financial Systemic Risk: A Review*, 1 J. COMPUTATIONAL SOC. SCI. 81 (2017) (summarizing computational science research into network models of financial crises); Richard Bookstaber & Mark Paddrik, *An Agent-based Model for Crisis Liquidity Dynamics* (Office of Fin. Research, Working Paper No. 15-18, 2015), https://www.financialresearch.gov/working-papers/files/OFRwp-2015-18_Agent-based-Model-for-Crisis-Liquidity-Dynamics.pdf [https://perma.cc/834G-UC89].

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 it was a decade ago.

VI. CONCLUSION

This Article focused squarely on the unexpected 2008 Lehman bankruptcy as a case study to examine the evolution of a market panic. Our analysis shows that institutions with higher levels of regulatory capital experienced more funding stress during the weeks immediately after Lehman's failure. Balance sheet liquidity levels did not seem to predict exposure to stress. In contrast, two simple measures strongly predicted the discriminate actions of participants in equity and debt markets: a simple leverage ratio, and the correlation between institutions' share price and Lehman's. This suggests that simple measures matter more to investors in an emergency, and that tighter correlations can correspond to a faster-spreading run. Our results have important implications for the design of financial regulation, both domestically and internationally, and for the post-crisis capital and liquidity standards that are now subscribed to by over 100 countries.[167]

We would be remiss to not mention the recent and historic volatility in equity and debt markets caused by COVID-19. U.S. market volatility in March matched that observed around the Lehman bankruptcy.[168] Equity prices tumbled, and CDS spreads of financial institutions widened sharply.[169] At the time of writing, this crisis is ongoing. However, early signs strongly support the central findings discussed in this Article. Market participants have not behaved indiscriminately, even when the Dow Jones Industrial Average fell 10%

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[167] *See* Romano, *supra* note 14.

[168] *See VIX Index Historical Data,* CHI. BD. OPTIONS EXCH., http://www.cboe.com/products/vix-index-volatility/vix-options-and-futures/vix-index/vix-historical-data [https://perma.cc/BY4Z-F5MK].

[169] *See* IÑAKI ALDASORO ET AL., BANK FOR INT'L SETTLEMENTS, EFFECTS OF COVID-19 ON THE BANKING SECTOR: THE MARKET'S ASSESSMENT 2 fig.1 (2020).

on one day and jumped 9% the next day.[170] The situation demands a fuller analysis when the crisis subsides. However, we remain confident that business models and correlations matter, and they matter disproportionately during a panic.[171]

[170] *See* Stan Choe & Alex Veiga, *Dow Closes Down 10% in Worst Day on Wall Street Since 1987*, CHI. TRIBUNE (Mar. 12, 2020), https://www.chicagotribune.com/coronavirus/ct-nw-coronavirus-stock-market-reaction-20200312-c736p4egzjak3nnqblzj46db6a-story.html [https://perma.cc/68UT-KWDB]; Alexa Veiga & Damian J. Troise, *Stocks Surge on Wall Street, Almost Erasing Thursday's Historic Dow Plunge*, CHI. TRIBUNE (Mar. 13, 2020), https://www.chicagotribune.com/coronavirus/ct-nw-coronavirus-stock-market-reaction-20200313-quxsrtlae5bzhl6o2v672ijcei-story.html [https://perma.cc/DT6L-BUT8].

[171] *See* Vipal Monga, *Oil Crash Is Bad News for Regional Banks That Went Big on Energy*, WALL ST. J. (Mar. 16, 2020), https://www.wsj.com/articles/oil-crash-is-bad-news-for-regional-banks-that-went-big-on-energy-11584352803 [https://perma.cc/KQ8Y-83XK] (describing the vulnerability of banks whose business models focus on the energy sector); David Benoit & Leslie Scism, *The Fed Cut Is the Deepest for Banks and Insurers*, WALL ST. J. (Mar. 3, 2020), https://www.wsj.com/articles/the-fed-cut-is-the-deepest-for-banks-and-insurers-11583277221 [https://perma.cc/HJQ7-PM4P] (suggesting that banks more dependent on net interest income will suffer more than their peers in the very low interest rate environment).

VII. APPENDIX

A: Definitions of Key Regulatory Terms and Ratios

Table 4: Definitions[172]

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[173]
Common Equity Tier 1 Capital (Basel III numerator)[174]	Common Equity+ 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]

[172] Basel II ratios are taken from BASEL COMM., BASEL II, *supra* note 51. Basel III ratios are taken from BASEL COMM., BASEL III, *supra* note 55.

[173] *See infra* Appendix H for the full criteria of what may be included as "Additional Tier 1 Capital".

[174] The elements in this row are abbreviated for clearer comparison to the Basel II Tier 1 measure. *See* BASEL COMM., BASEL II, *supra* note 51, at 13–15 (providing a full definition of CET1, as well as fourteen criteria for inclusion of instruments as "common shares").

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)	$\frac{\text{Tier 1 Capital (Basel III)}}{\text{Total Leverage Exposure}}$

B: Descriptive Statistics

Table 5: 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

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[175]

+ 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[176]
- BHCK3163 Goodwill
- BHCK2148 Net deferred tax assets
- BHCK0426 Other intangible assets

Table 6: 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, our proxy is based on the Federal Reserve Y-9C line items described above. As a

175 For a description of these proxies, see BD. OF GOVERNORS FED. RESERVE SYS., INSTRUCTIONS FOR PREPARATION OF CONSOLIDATED FINANCIAL STATEMENTS FOR HOLDING COMPANIES: REPORTING FORM FR Y-9C (2020).

176 The Y-9C calls for this item to be reported as a negative value. *See id.* at 31. As such, although the definition calls for it to be subtracted, it is added here.

robustness check, 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 twenty-eight ratios is 97%, and the median is 96%.

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 7: 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.[177]

As a robustness check, 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 twenty ratios is 107% and the median is 108%.

[177] *See* Andrew Ross Sorkin, *As Goldman and Morgan Shift, a Wall St. Era Ends*, N.Y. TIMES (Sept. 21, 2008), https://dealbook.nytimes.com/2008/09/21/goldman-morgan-to-become-bank-holding-companies/ [https://perma.cc/8WVJ-N2N2].

D: In-Sample Institutions

Table 8: Sample Institutions[178]

Institution	Share Price/Mkt. Cap. Data Sept. 2008	CDS Spreads Data Sept. 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

[178] Information obtained from institutions' filed FR Y-9Cs. *See Holding Company Data*, FED. RES. BANK OF CHI., https://www.chicagofed.org/banking/financial-institution-reports/bhc-data [https://perma.cc/4KRW-Z52J].

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

E: Simple Panel Fixed-Effects Regression Results

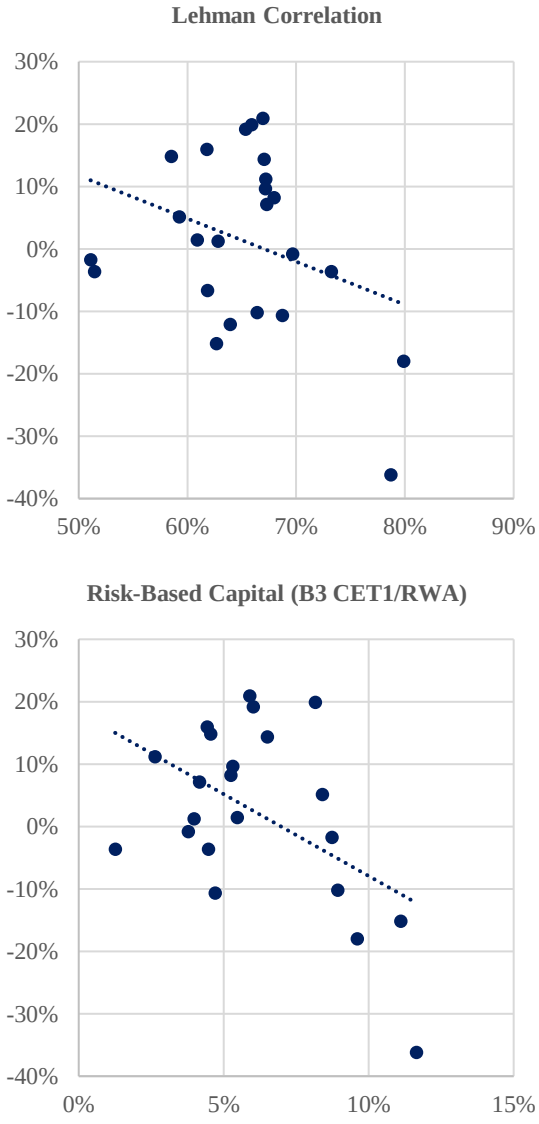
Capital Measure	*Share Price*	*Five-Year CDS Spread*	*One-Year CDS Spread*
CE/RWA	$\hat{\phi} = -0.034$ $s.e. = 0.400$ $R^2 = 0.765$ $n = 21$	$\hat{\phi} = 3.496$ $s.e. = 3.103$ $R^2 = 0.679$ $n = 6$	$\hat{\phi} = 4.577$ $s.e. = 3.456$ $R^2 = 0.803$ $n = 6$
AR T1/RWA	$\hat{\phi} = -0.555$ $s.e. = 0.644$ $R^2 = 0.766$ $n = 22$	$\hat{\phi} = 2.394$ $s.e. = 2.738$ $R^2 = 0.665$ $n = 7$	$\hat{\phi} = 5.750 *$ $s.e. = 2.289$ $R^2 = 0.820$ $n = 6$
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	$\hat{\phi} = 0.114$ $s.e. = 0.536$ $R^2 = 0.765$ $n = 24$	$\hat{\phi} = -3.261 *$ $s.e. = 1.638$ $R^2 = 0.650$ $n = 9$	$\hat{\phi} = -4.386 *$ $s.e. = 2.254$ $R^2 = 0.731$ $n = 8$

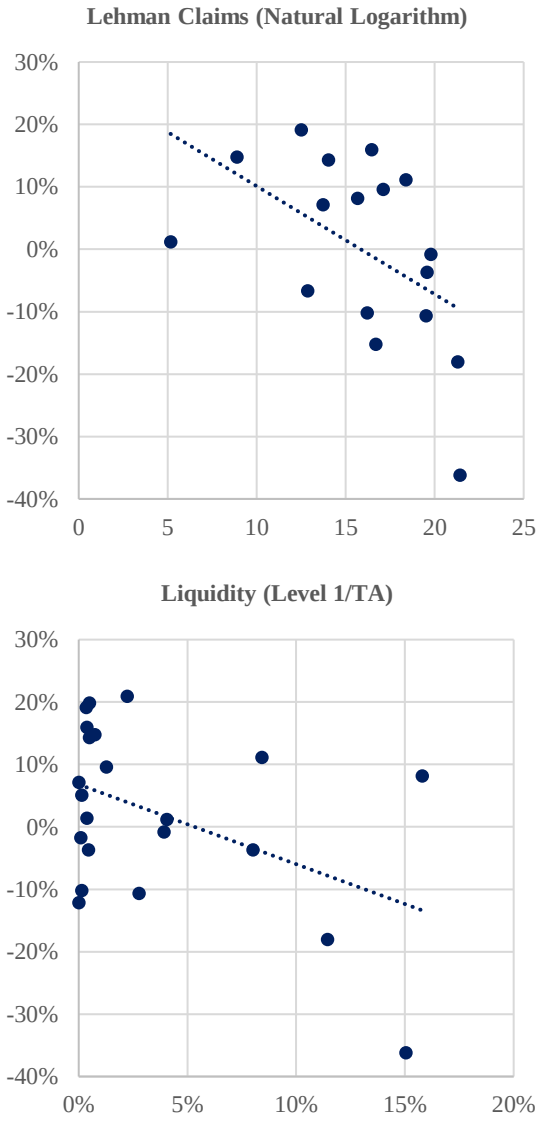
Non-Capital Measure		*Share Price*	*Five-Year CDS Spread*	*One-Year CDS Spread*
Liquidity	L1/TA	$\hat{\phi} = -0.961$ ** $s.e. = 0.349$ $R^2 = 0.792$ $n = 22$	$\hat{\phi} = 2.824$ * $s.e. = 1.435$ $R^2 = 0.671$ $n = 8$	$\hat{\phi} = 4.785$ * $s.e. = 2.426$ $R^2 = 0.772$ $n = 7$
	Cash + Equivalents/TA	$\hat{\phi} = -0.279$ ** $s.e. = 0.129$ $R^2 = 0.766$ $n = 24$	$\hat{\phi} = -2.194$ $s.e. = 1.559$ $R^2 = 0.652$ $n = 9$	$\hat{\phi} = -4.788$ * $s.e. = 2.380$ $R^2 = 0.749$ $n = 8$
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	$\hat{\phi} = -0.014$ *** $s.e. = 0.004$ $R^2 = 0.807$ $n = 17$	$\hat{\phi} = 0.061$ ** $s.e. = 0.019$ $R^2 = 0.698$ $n = 8$	$\hat{\phi} = 0.094$ *** $s.e. = 0.024$ $R^2 = 0.791$ $n = 8$

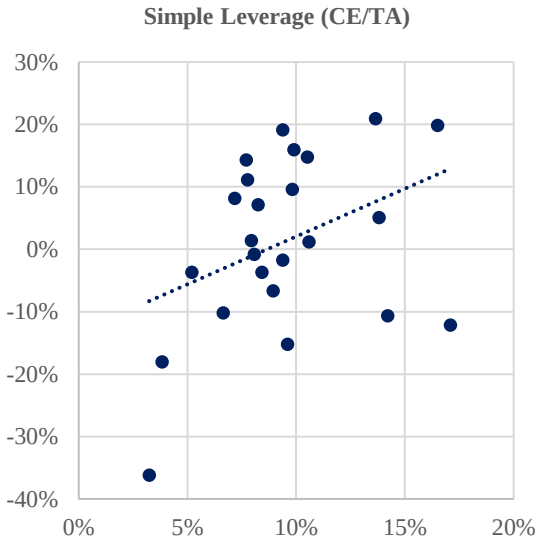
F: Multiple Panel Fixed-Effects Regression Results

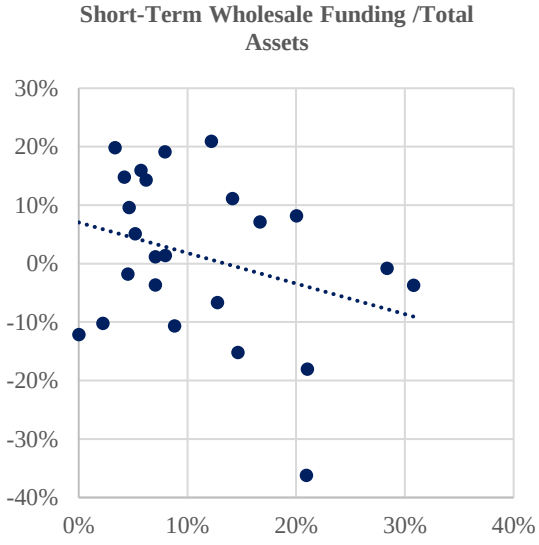
$m_{1,i}$	$m_{2,i}$	U.S. Banking Institution Sample					
		Share Price		*Five-Year CDS Spread*		*One-Year CDS Spread*	
Lehman Correlation	Lehman Claims	$\hat{\phi} = -0.702$ ** $s.e. = 0.342$ $R^2 = 0.848$ $n = 17$	$\hat{\phi} = -0.008$ * $s.e. = 0.004$ $R^2 = 0.848$ $n = 17$	$\hat{\phi} = 4.373$ ***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

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




Lehman Claims (Natural Logarithm)
30%
20%
10%
0%
-10%
-20%
-30%
-40%
0
5
10
15
20
25
Liquidity (Level 1/TA)
30%
20%
10%
0%
-10%
-20%
-30%
-40%
0%
5%
10%
15%
20%


Simple Leverage (CE/TA)
30%
20%
10%
0%
-10%
-20%
-30%
-40%
0%
5%
10%
15%
20%


Short-Term Wholesale Funding /Total Assets
30%
20%
10%
0%
-10%
-20%
-30%
-40%
0%
10%
20%
30%
40%

H: Criteria for Additional Tier 1 Capital (Basel III)[179]

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 must not exercise a call unless:

1) 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[180]; or

2) The bank demonstrates that its capital position is well above the minimum capital requirements after the call option is exercised.[181]

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[179] The entirety of Appendix H is borrowed from BASEL COMM., BASEL III, *supra* note 55, at 15–17.

[180] *Id*. at 16 n.15 ("Replacement issues can be concurrent with but not after the instrument is called.").

[181] *Id*. at 16 n.16 ("Minimum refers to the regulator's prescribed minimum requirement, which may be higher than the Basel III Pillar 1 minimum requirement.").

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[182];
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;

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 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)

[182] *Id.* at 16 n.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.").

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 re-capitalization [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), proceeds must be immediately available without limitation to an operating entity[183] 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.

[183] *Id.* at 17 n.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.").