Benefits and Costs of a Higher Bank Leverage Ratio

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Abstract

Banking legislation in the United States has historically been driven more by the politics of banking than by sound economic analysis. Legislation enacted after the most recent and severe banking crisis since the Great Depression has resulted in bank capital requirements becoming more complex. In this paper, we estimate the marginal benefits and costs arising from increasing the simple leverage ratio from 4 percent to 15 percent. We use annual data from 1892 to 2014 to estimate the benefits of a higher leverage ratio on reducing the adverse effects of a banking crisis. We weigh these benefits against the costs in terms of reduced lending that arise when banks pass the higher equity costs resulting from a higher leverage ratio onto borrowers. We find that the marginal benefits equal or exceed marginal costs under a wide variety of assumptions. A tax advantage of debt or a greater fraction of corporate funding coming from bank loans tends to lower the net marginal benefit. On the other hand, a larger cost of a crisis—assuming that banking crises generate permanent shocks or have a longer duration—or an increased discount rate tends to increase the net marginal benefit.

JEL codes: D61, G28, K20, L51, N21, N22, N41, N42

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1. Introduction

Banks continue to play an important role in contributing to economic growth, but in various countries and at various points in time, banking crises have contributed to declines in overall economic activity. The typical policy response in such situations has been for affected countries to implement banking reforms in an attempt to prevent the reoccurrence of such events.

It is widely believed that minimum capital requirements are essential to promote a safe and sound banking industry. Given that capital requirements became more complex in the years leading up to and following the 2007–2009 crisis, it seems appropriate to compare the benefits and costs of a simpler, higher capital requirement. In particular, we examine the benefits and costs of a higher leverage ratio, defined as the ratio of equity capital to total assets.[1]

Quantifying the benefits and costs proves challenging, given the variety of ways to estimate them (Coates 2015). In addition, financial regulation can have general equilibrium effects that render the measurement of benefits and costs even harder than measurement of other forms of regulation (Cochrane 2014). Our benefit-cost analysis, broadly speaking, applies the methodology that Miles, Yang, and Marcheggiano (2013) developed for the United Kingdom to estimate the benefits and costs of increasing the ratio of book equity to total asset leverage from 4 percent to 15 percent. We use this value because Begenau and Landvoigt (2015) find 15 percent

[1] The existing literature on this topic does not uniformly use the term "leverage ratio"; "capital ratio" and "capital-to-asset ratio" are also sometimes used. Therefore, to describe our findings in this paper, we use the three terms interchangeably to refer to the ratio of equity capital to total assets, unless we specify otherwise.

to be an optimal figure, and it is sometimes proposed in US policy circles (e.g., the Terminating Bailouts for Taxpayer Fairness Act of 2013).[2]

Calculating the benefits in the framework of Miles, Yang, and Marcheggiano (2013) requires estimating (1) the loss per crisis and (2) changes in the probability of a crisis from a change in the capital ratio. Estimates of the loss per crisis seem straightforward, but it is more challenging to estimate the relationship between changes in the probability of a crisis from a change in the capital ratio. Without actual historical data on bank capital, Miles, Yang, and Marcheggiano (2013) assume that a higher bank capital ratio reduces the probability of a crisis, which in turn reduces the loss of GDP. To establish the merits of this assumption, they estimate the distribution of real per capita GDP shocks across a panel of countries between 1821 and 2008. The authors show that GDP shocks relate to bank asset shocks, and they examine the level of capital that would be large enough to absorb the shock to asset values following a GDP shock. To estimate costs, Miles, Yang, and Marcheggiano (2013) estimate the extent to which increasing the capital ratio for banks may increase the cost of capital, which in turn gets passed on to firms, thereby raising the cost of capital for firms and lowering real capital formation and GDP.

Using these estimates of benefits and costs, Miles, Yang, and Marcheggiano (2013) then calculate the "optimal" capital ratio as that which equates marginal costs and benefits. From there, they calculate the total net benefits. They find that the benefits of raising the capital ratio exceed the costs and that the "optimal" capital to asset leverage ratio can be as high as 20 percent of total assets, although generally it is less than half that amount. When converted to a risk-weighted measure that lowers capital requirements applied to certain assets classes, such as US

[2] Terminating Bailouts for Taxpayer Fairness Act of 2013, S. 798, 113th Cong. (2013).

Treasury securities or mortgages and mortgage-backed securities, the 20 percent optimal leverage ratio translates to a 47 percent ratio of capital to risk-weighted assets.

To estimate the benefits of a higher capital-to-asset leverage ratio for the United States, we make assumptions similar to those of Miles, Yang, and Marcheggiano for the cost of a crisis and loss per crisis. Miles, Yang, and Marcheggiano (2013), like Cline (2016), use data across countries and over time to estimate how changes in the capital ratio may be associated with changes in the probability of a crisis, even though banking systems and regulations can differ greatly across countries. For two reasons we deviate from their approach and instead estimate the relationship between changes in capital and changes in the probability of a banking crisis.

First, Calomiris and Haber (2014) and Bordo, Redish, and Rockoff (2015) highlight how the unique institutional features of the US banking system have contributed to the high frequency of crises in the United States. Second, historical aggregate banking sector data for the United States make it possible to estimate the relationship between changes in the probability of a crisis and changes in capital during the 1892–2014 period. We use Jalil's (2014) study of the 1825–1929 period to identify major US banking crises between 1892 and 1929, which occurred in 1893 and 1907. We also include the 1930–1933 banking crisis during the Great Depression, the 1987–1992 savings and loan (S&L) crisis, and the 2007–2009 crisis. To measure capital, we use the ratio of aggregate bank capital to aggregate total bank assets, which can be computed as far back as the 19th century.

We use probit regressions to estimate the relationship between changes in the probability of a crisis and changes in capital. We find similar results if we use logit or complementary log-log regression (the latter being better suited for rare events). That finding suggests that assuming crises are normally distributed or symmetric does not substantively drive the results. From the probit estimates, we compute the marginal effects at representative values of the ratio of lagged aggregate capital to total assets. The marginal effects at representative values schedule serves as our estimated relationship between changes in the probability of a crisis and changes in the capital ratio.

On the cost side, similar to Miles, Yang, and Marcheggiano (2013), we estimate the extent to which a higher leverage ratio may raise the cost of capital—a cost that banks might pass on to firms, thereby raising the cost of capital for firms and lowering real capital formation and GDP. However, instead of using data for just the six largest bank holding companies, we use data for all bank holding companies with at least $1 billion in total assets between 1996 and 2014.

A key input in calculating the costs of higher capital is the fraction of corporate funding coming from bank loans. Miles, Yang, and Marcheggiano start with a baseline of 33 percent for the United Kingdom and argue that it would be lower for the United States. By contrast, Cline assumes that the fraction of corporate funding coming from bank loans equals 33 percent and that an additional 33 percent of corporate funding comes from nondepository institution loans. Using flow of funds data, we estimate that ratio to be 7 percent between 1996 and 2014; however, we also consider the extreme case, in which bank loans make up 66 percent of corporate funding, to compare with Cline's results. And last, unlike Miles, Yang, and Marcheggiano (2013) and Cline (2016), we assume that the offset suggested by Modigliani and Miller (1958) does not exist; more equity-financed banks, in spite of the lower leverage and higher degree of safety, would not offer a lower return on equity. We make this assumption because we find no relationship between estimated bank betas and book leverage.

Although we do report some findings about "optimal" capital ratios, as in Miles, Yang, and Marcheggiano (2013) and Cline (2016), we focus primarily on comparing the marginal benefits and costs, and we examine the conditions under which the benefits of a higher leverage ratio exceed the costs. We find that raising the leverage ratio from 4 percent to 15 percent has benefits that equal or exceed the costs. Our findings lend some support to calls for higher capital, such as that in Admati and Hellwig (2013).

The next section of this paper provides a historical perspective on the enactment of several major banking laws in the United States and a fairly general discussion of the factors that have led to these laws. We then turn to our analysis of the benefits and costs of implementing a simple capital requirement—namely, the increase in the equity leverage ratio from 4 to 15 percent—before concluding.

2. US Bank Failures and Crises, Banking Laws, and Benefit-Cost Analyses

Throughout US history, banking laws have been driven in large part by the politics of banking interests, rather than by a careful benefit-cost analysis carried out by state or federal legislators or regulators. Quite frequently, these laws are a response to a banking crisis, which occurs when many banks contemporaneously fail or suffer serious financial difficulties. As a first approximation, bank failures can be understood using the traditional textbook model of a bank that creates deposits (which have short-term maturities) and uses these funds to originate and book loans (which tend to have longer-term maturities), giving rise to a so-called maturity mismatch. The maturity mismatch means that should depositors suddenly wish to convert deposits into cash, a bank may be forced to sell loans at a loss. Because deposit withdrawals occur on a first-come, first-served basis, sudden and widespread conversions, or bank runs, become a possibility. A run might occur if the public learns of the poor quality of a bank's investments, a crisis that could provide an incentive for depositors to line up at that bank to redeem their deposits before the bank's cash is depleted. Nondeposit short-term funding, such as a repurchase agreement, is also subject to runs (see Gorton and Metrick 2012). If depositors fear—correctly or not—that other banks have the same problem, runs could spread throughout the entire banking industry, with banks becoming insolvent as they sell loans at fire-sale prices to meet the withdrawals.[3]

This basic textbook model of a bank limits the scope for thinking about preventing bank failures. The basic model can be made more realistic by allowing the bank to create deposits and sell securities (such as stock and long-term bonds) and use those funds to originate and book loans and to make investments, such as purchasing Treasury securities.[4] Some of the securities a bank sells to the public in this case might even be treated as regulatory capital, to the extent that they represent longer-term and non-run-prone forms of bank funding. In principle, the higher the fraction of funding that comes from such securities, especially common stock, the lower the risk of a bank run because depositors are far better protected by the investors in those securities, who take first losses in the event that the bank encounters financial difficulties.

With this somewhat more realistic description of a bank in mind, a more realistic explanation of bank failures emerges. Failures have resulted not only from bank runs, but also from banking laws and regulations that limited the range of activities in which banks could engage and the geographical areas in which they could operate. Far too often, the rationale for enacting banking laws has been not to correct perceived market failures, but rather to promote

[3] See, for instance, the discussion by Kelly and O'Grada (2000), who show how account closures spread within a social network of Irish immigrants originating from the same Irish counties and living in New York during a minor run in 1854 and a major run during the Panic of 1857.

[4] Black (1993), for instance, argues that adding securities and investments to a bank's balance sheet means that loans and deposits are decoupled. DeYoung and Yom (2008) also provide evidence that the asset side of bank balance sheets is largely independent of the liability side.

the special interests of select banks. Restrictive regulatory environments also reduce competition. Those laws and regulations often create unintended consequences.

Calomiris and Haber (2014), for example, observe that the political collusion between populist politicians and banking interests has led to regulations that contributed to frequent banking crises. They argue that the period since 1980 reflects a shift toward collusion between what they call urban populist interests and larger banks. But Calomiris and Haber (2014) argue that before this period—from roughly 1810 to the 1980s—banking laws primarily reflected a collusion between small banking interests and populist politicians acting on their behalf—a collusion that dominated banking politics. Accordingly, while the 2007–2009 crisis occurred when larger commercial and investment banks contributed to a housing price boom and bust mainly through the securitizations of subprime home mortgages, before that, US banking crises resulted primarily from banks that were relatively small. We provide some empirical evidence that may lend support to this view in the section on establishing a higher capital ratio.

A. Smaller Bank Era

A key to understanding why the United States experienced so many crises is that bank charters were granted only by the states until the 1860s, when the Office of the Comptroller of the Currency (OCC) was established to issue national charters. The introduction of the OCC created a dual banking system, which for a long time essentially limited national banks to what state banks were allowed to do. It was in the interest of small banks to lobby their state legislatures to enact laws preventing banks chartered out of state from operating or acquiring banks in their jurisdictions. Branching was prohibited in some states, especially in the North and Midwest, after the charter of the Second Bank of the United States lapsed in 1836. The combination of restrictions on interstate banking and branching, which were not relaxed until fairly recently, meant that banks in the United States have traditionally been poorly diversified across regions and thus were prone to insolvency risks and bank runs.

Figure 1 provides a timeline of the enactment of major banking laws along with the evolution of the capital-to-asset ratio. The figure identifies laws that altered the regulatory environment, including the restrictions on banks.[5] For much of this period, the collusion between populist politicians and small banking interests was dominant. Laws since the Depository Institutions Deregulation and Monetary Control Act of 1980[6] reflect the change in the political environment, which eventually gave rise to a new collusion between urban populist interests and larger banks.

Laws are usually passed to address a crisis, but these laws and their implementing regulations may have unintended consequences that contribute to future crises. For instance, with the onset of the Great Depression, it was the small banks, rather than the larger banks, that wanted federal deposit insurance.[7] In the run-up to the most recent crisis, such insurance may have had the unintended consequence of reducing depositors' and shareholders' aversion to risk.

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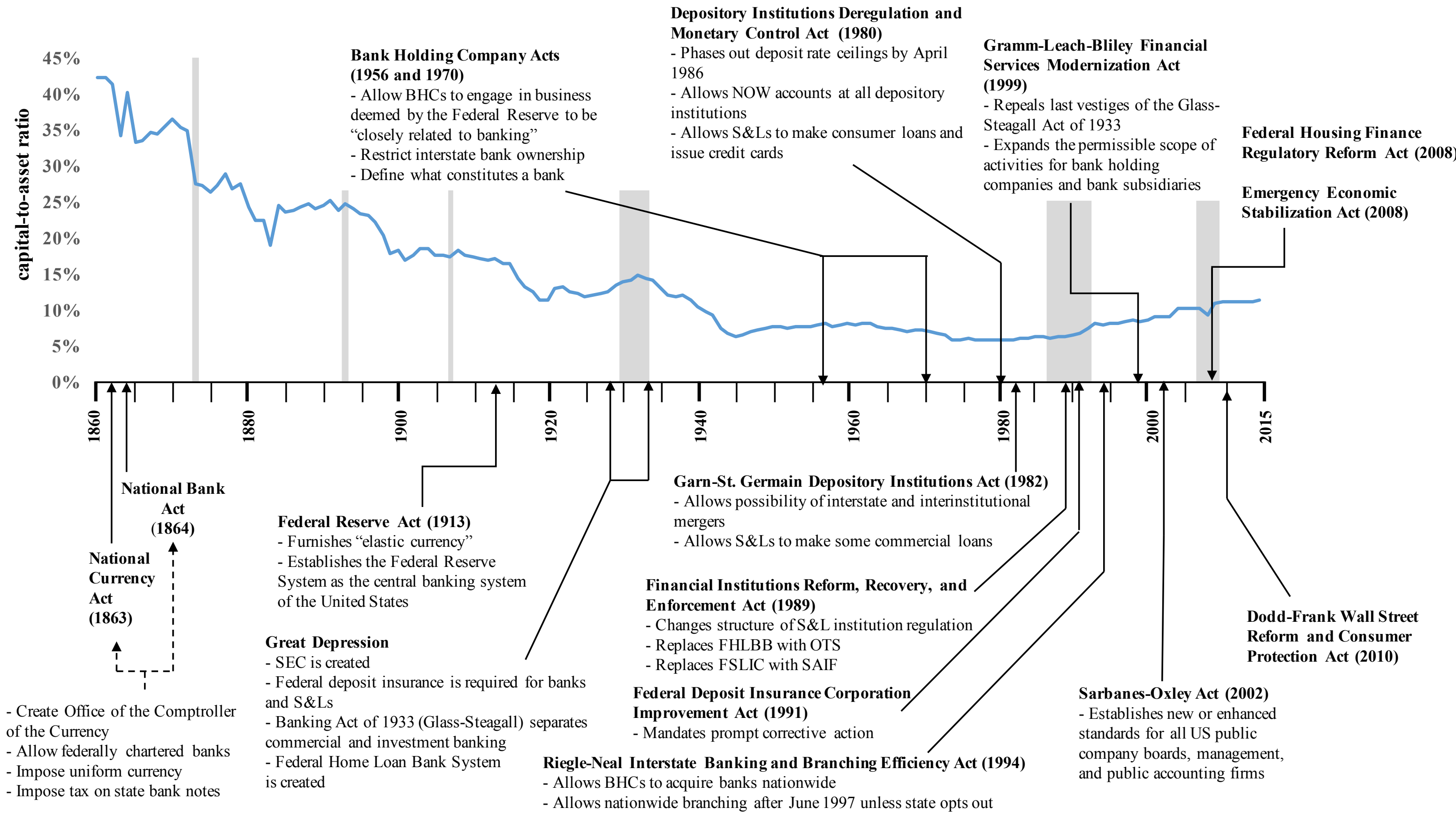
[5] The Bank Holding Company Act of 1956 (12 U.S.C. §§ 1841 et seq.) limited the definition of bank holding companies to those with an equity interest in two or more banks. This definition allowed single-bank-holding companies to continue to own stakes in nonbank firms. The Banking Holding Company Act Amendments of 1970 (Pub. L. No. 91-607, 84 Stat. 1760) closed this loophole.

[6] Depository Institutions Deregulation and Monetary Control Act of 1980, Pub. L. No. 96-221, 94 Stat. 132 (1980).

[7] According to Economides, Hubbard, and Palia (1999), "The lobbying pressure for deposit insurance came from small banks. Large banks, as represented by the American Bankers Association, resisted the legislation in its final form."

Figure 1. Timeline of Major US Banking Laws and Bank Capital-to-Asset Ratios



Notes: Shaded areas indicate crisis periods. BHC = bank holding company; FHLBB = Federal Home Loan Bank Board; FSLIC = Federal Savings and Loan Insurance Corporation; NOW = negotiable order of withdrawal; OTS = Office of Thrift Supervision; S&Ls = savings and loans; SAIF = Savings Association Insurance Fund; SEC = Securities and Exchange Commission.

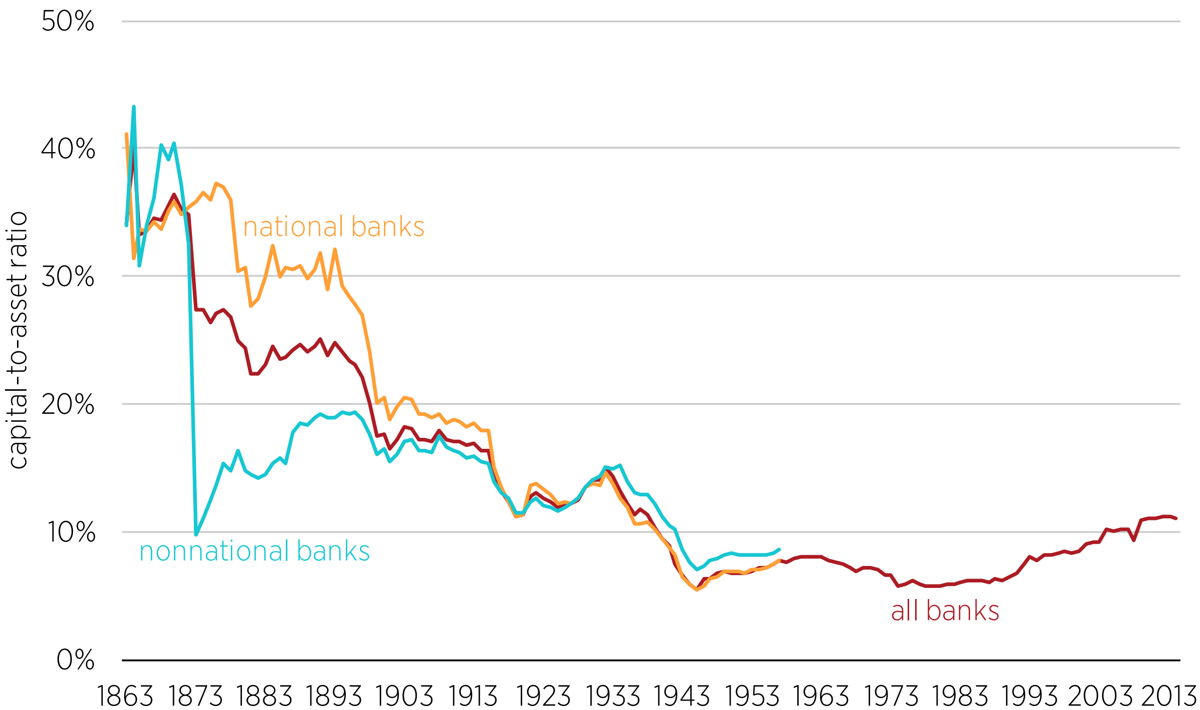
Sources: James R. Barth, Gerard Caprio Jr., and Ross Levine, *Guardians of Finance: Making Regulators Work for US* (Cambridge, MA: MIT Press, 2012); US Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1957* (Washington, DC: US Department of Commerce, 1961); and Federal Deposit Insurance Corporation.

Most important, figure 1 also shows that the capital-to-asset ratio of banks steadily declined over time, from 42.3 percent in 1861 to a low of 5.7 percent in 1974, before subsequently increasing to 11.3 percent in 2015.[8] In this regard, "Prior to the 1980s, bank supervisors in the United States did not impose specific numerical capital adequacy standards. Instead, supervisors applied informal and subjective measures tailored to the circumstances of individual institutions."[9] The Dodd-Frank Wall Street Reform and Consumer Protection Act (Pub. Law 111-203; 124 Stat. 1376), enacted in July 2010, requires employing more regulators with greater powers, yet there's no indication that increasing the regulatory burden on banks offers a good substitute for simply maintaining a higher capital ratio.

Figure 2 depicts the capital-to-asset ratios for all banks, for national banks, and for nonnational banks. When national banks first appeared, their capital-to-asset ratios were much higher than those of nonnational banks, but the gap closed over time. The regulator of national banks, the OCC, gradually reduced capital requirements to enable national banks to compete with state banks, which federal authorities tried unsuccessfully to drive out of business by taxing the currency they issued. According to Members of the Staff, Board of Governors of the Federal Reserve System (1941, 45), "It was expected that the national banks would supersede the State banks and provision was made for the easy conversion of State banks into national banks without interruption to their business and without losing their corporate identities; but these expectations were not realized."

[8] It is widely known that "banks maintained relatively high though declining capital-to-asset ratios throughout the 1800s and early 1900s. Indeed, years ago Wesley Lindow observed that 'Early in the 1800's, the ratio of capital to total assets ranged around 60% and drifted down steadily thereafter. By the early 1900's this ratio had fallen to about 20% and the rapid expansion of bank assets during World War I and the 1920's pulled it down below 13%'" (Barth 1991, 10–11).
[9] See FDIC, "An Update on Emerging Issues in Banking," January 14, 2003.

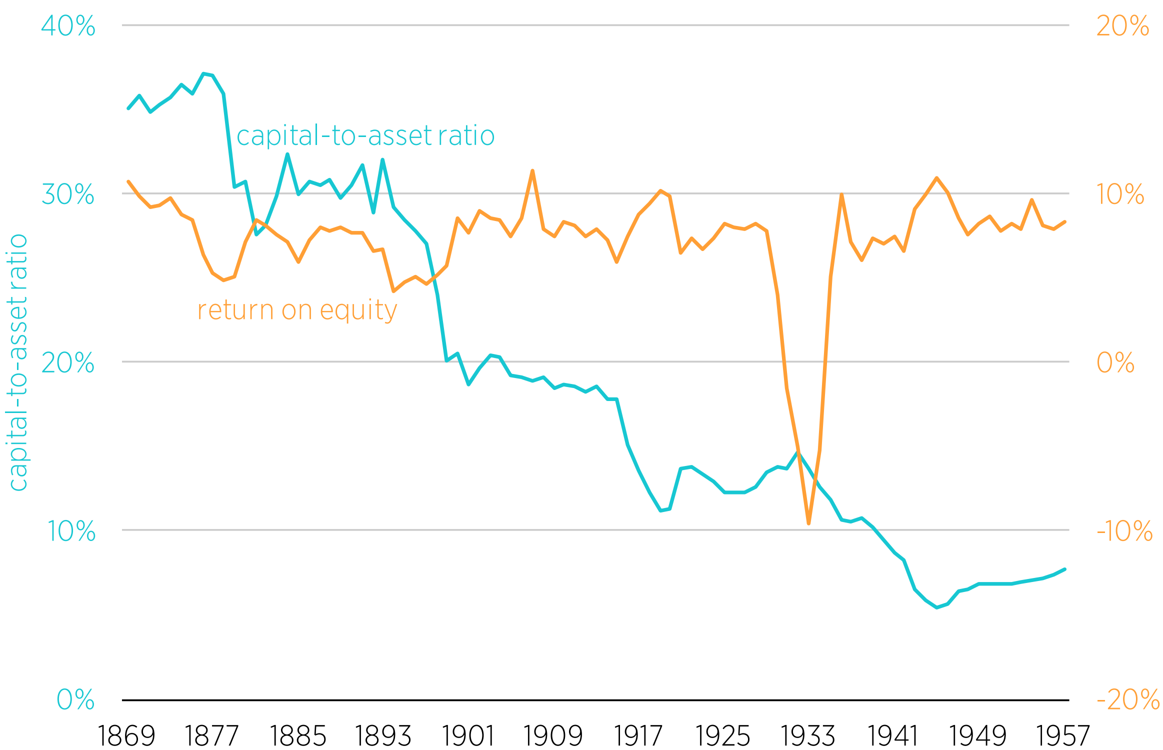
Figure 2. Capital-to-Asset Ratio: All Banks, National Banks, and Nonnational Banks



Sources: US Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1957* (Washington, DC: US Department of Commerce, 1961); and Federal Deposit Insurance Corporation.

Perhaps more importantly, as figure 3 shows, by gradually lowering their capital ratios, national banks were able to maintain a relatively stable return on equity over time, except during the Great Depression.

Figure 3. National Banks: Capital-to-Asset Ratio and Return on Equity



Sources: US Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1957* (Washington, DC: US Department of Commerce, 1961).

B. US Small Bank Experience versus Canadian Large Bank Experience

In contrast to the relatively more crisis-prone US banking system, Calomiris and Haber (2014) and Bordo, Redish, and Rockoff (2015) discuss how Canada has experienced no system-wide banking crises since confederation in 1867. This remarkable situation occurred even though the Bank of Canada was not created until 1935 and Canada did not have government deposit insurance until 1967. Unlike the US banking system, the Canadian system has traditionally been dominated by a few large national banks that operate throughout the country. Consequently, Canadian banks tended to have access to a steady supply of deposits and substantial geographical diversification, which better enabled them to avoid and absorb losses. Also, Canada limits competition by limiting the number of bank charters. Keeley (1990) argues that the decline in the value of US bank charters as a result of increased competition in the 1980s may explain the subsequent increase in bank risk-taking.[10]

C. Larger Bank Era

The Depository Institutions Deregulation and Monetary Control Act of 1980 and the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994[11] removed the restrictions on interstate banking acquisitions and mergers, as well as some of the restrictions on branching. This development marked a significant change in the dominance of the political collusion that existed between populist political interests and small banking interests. The number of banks began to fall starting in 1980, while banks got larger in asset size mainly through mergers and acquisitions (Janicki and Prescott 2006). In addition, the Gramm-Leach-Bliley Act of 1999[12] repealed existing restrictions so that a financial services holding company could have banks, securities firms, and insurance companies as subsidiaries.

The US banking crisis that began in the spring of 2007 resulted in the Great Recession. Although bank size is frequently blamed for the 2007–2009 crisis (see FCIC 2011), Erel, Nadauld, and Stulz (2013) and Miller (2017) show that securitizing banks tended to have greater holdings of highly rated, private-label structured products and tended to perform poorly during

[10] At the same time, capital requirements may themselves serve as barriers to entry, as Mengle (1990) and Walter (2006) observe for the pre-FDIC era, when reductions in minimum capital requirements resulted in new banks entering the market. In that case, higher capital could restore franchise value for banks.
[11] Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994, Pub. L. No. 103-328, 108 Stat. 2338 (1994).
[12] Gramm-Leach-Bliley Act of 1999, Pub. L. No. 106-102, 113 Stat. 1338 (1999).

the crisis. Following the crisis, sections 606 and 607 of Dodd-Frank called for financial holding companies to be "well capitalized and well managed."

Whenever serious banking problems have arisen, the response has been to enact a new law with the governmental promise that "never again" would such problems disrupt the financial markets and other economic activity.[13] Yet crises have continued to happen, despite the many new laws and regulatory agencies shown in figure 1. Although the frequency of crises has declined, the severity of crises has not similarly declined. This phenomenon reflects at least in part a failure to conduct a benefit-cost analysis of any proposed major banking legislation before that proposed legislation becomes law.

3. Benefits and Costs of a Higher Capital Ratio

As the previous section shows, the United States still experiences crises, even as the regulatory environment becomes more complex. As a way to assess the merits of moving toward a simpler regulatory regime, we draw on the approach of Miles, Yang, and Marcheggiano (2013) to examine the benefits and costs of a simpler, higher capital requirement. Specifically, we examine the benefits and costs of raising the flat equity leverage ratio from 4 percent to 15 percent for banks with greater than $1 billion in assets.[14] Although we report some statistics concerning optimal capital ratios that equate marginal benefits and costs as in Miles, Yang, and Marcheggiano (2013) and Cline (2016), our aim is to assess whether the benefits of a rule that increases the leverage ratio would exceed the costs. We therefore examine under what conditions

[13] For example, the phrase was used after the 2007–2009 crisis in a White House blog post describing President Barack Obama's stance on banks that had been deemed "too big to fail." See Jesse Lee, "President Obama: Never Again Will the American Taxpayer Be Held Hostage by a Bank That Is 'Too Big to Fail,'" White House blog, January 21, 2010.

[14] An issue that we do not address here is whether capital requirements should be implemented at the bank holding company level, the bank subsidiary level, or both. See Black, Miller, and Posner (1978) and Kupiec (2015), who suggest that capital adequacy is better addressed at the subsidiary level, rather than at the holding company level.

the marginal benefit equals or exceeds the marginal cost of increasing the equity leverage ratio from 4 percent to 15 percent.

A. Estimating the Benefits of a Higher Equity Leverage Ratio

Our assessment of the benefits of a higher equity leverage ratio focuses on the relationship between the aggregate bank capital-to-asset ratio and major banking crises between 1892 (when observations for all other variables included in our regression framework are first available) and 2014. However, because data from before 1892 are available, we offer a preliminary sense of the relationship between banking crises, real per capita GDP growth, and the aggregate bank capital-to-asset ratio in table 1. The construction of the variables reported, as well as the data sources, are reported in table A1 in the appendix. Jalil (2014) finds that between 1837 and 1929, major crises occurred in 1837, 1839, 1857, 1873, 1893, and 1907.[15] After 1929, the United States also experienced a banking crisis during the Great Depression (1930–1933), the S&L crisis (1987–1992), and the 2007–2009 financial crisis.[16]

The figures in table 1 suggest that GDP has declined by small amounts during most banking crisis years, and in some cases growth was still positive; exceptions include the crisis in 1907 and the Great Depression, when the growth rate was negative and less than –10 percent. This observation suggests that the distribution of GDP shocks in the United States may be smaller than what has been reported in Miles, Yang, and Marcheggiano (2013) and Cline (2016).

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[15] Jalil (2014) covers the period from 1825 to 1929, which also includes the banking crisis of 1833. However, that episode lies just outside our sample.

[16] For the Great Depression, we choose 1930–1933 because the percentage declines in the number of banks equaled –5 percent, –8 percent, –13 percent, and –24 percent, respectively. For the S&L crisis, which took nearly a decade to resolve (between 1986 and 1995), we use Federal Deposit Insurance Corporation data on bank failures to identify the S&L crisis years as 1987–1992. In the 1986–1995 period, the six years with the highest number of bank failures were 1987–1992, which comprised 1,807 out of the 2,181 total bank failures during the S&L crisis. For the Great Recession, we use 2007–2009 because large financial institutions, such as Citigroup and MetLife, began to experience distress in 2007, and their stock prices rose after March 2009.

The previous section highlights how restrictions on interstate banking factored into earlier US banking crises, for which we find some supporting empirical evidence, even when capital ratios were high. The data in table 1 also suggest that when the capital ratio was above 25 percent, banking crises were never associated with a large crisis cost, defined as a negative real per capita GDP growth rate.

Table 1. Real Per Capita GDP Growth and Capital Ratios during Major Crisis Years, 1834–2014

Banking crisis year	Real per capita GDP growth (%)	Subsequent years with negative growth	Capital ratio (%)
1837	−2		41
1839	0	1840 (−2%), 1841 (−1%)	47
1857	−2		39
1873	5	1874 (−1%), 1875 (−3%)	28
1893	−8	1894 (−1%)	25
1907	1	1908 (−13%)	17
1930	−10		14
1931	−7		14
1932	−14		15
1933	−2		15
1987	3		6
1988	3		6
1989	3		6
1990	1		6
1991	−1		7
1992	2		8
2007	1		10
2008	−1		10
2009	−4		11

Source: See table A1 in the appendix for details about variable construction and data sources.

With this brief historical synopsis in mind, to estimate the benefits as in Miles, Yang, and Marcheggiano (2013), we compute the marginal benefit of a higher equity leverage ratio by computing the product of a term measuring the loss per crisis and a term capturing how a higher capital ratio lowers the probability of a crisis:

$$\frac{\Delta Benefit}{\Delta Capital} = \underbrace{\left[w_T \cdot \frac{1-\delta^T}{1-\delta} + (1-w_T)\cdot\frac{1}{1-\delta}\right]\cdot Cost\ of\ Crisis}_{Loss\ Per\ Crisis} \cdot \frac{\Delta \Pr(Banking\ Crisis)}{\Delta Capital}, \tag{1}$$

where w_T is the weight for the temporary component of the effects of a crisis on GDP, δ is the discount factor, and $1-\delta$ is the discount rate. $Cost\ of\ Crisis$ is measured as the one-year decline in real GDP per capita growth during a banking crisis, and $\frac{\Delta \Pr(Banking\ Crisis)}{\Delta Capital}$ measures how increasing capital lowers the probability of a banking crisis. For the case in which a crisis may have partly permanent effects, we assume w_T equals 0.75, meaning the permanent component equals 0.25; in the case when there are no permanent effects, we assume w_T equals 1. We assume that a crisis might last five years, as in Miles, Yang, and Marcheggiano (2013), but to generate more conservative estimates of the benefits that may be appropriate for the United States, we also examine what happens when we assume temporary effects that last only two years.[17] The result of this latter assumption is that the expected benefit of higher capital requirements per percentage point reduction in the probability of crises equals only 46 percent of one year's GDP, which is more conservative than the baseline estimates of 55 percent and 64 percent used by Miles, Yang, and Marcheggiano (2013) and Cline (2016), respectively. We assume that the cost of a crisis equals 10 percent of GDP as in Miles, Yang, and Marcheggiano (2013) and Cline (2016), but in section A2 of the appendix, we provide estimates from an instrumental variable treatment regression framework that includes our probit specification as the first stage, which indicates that the cost of a crisis during our sample may have averaged only –4.5 percent.

[17] We use two years because we estimate a vector autoregression of real per capita GDP growth and the banking crisis dummy variable in a way similar to Jalil (2014), whose results are based on an industrial production index rather than on GDP. Thus, we find that a banking crisis has a contemporaneous effect as well as a one-year lagged effect on growth before dying out.

Although we follow Miles, Yang, and Marcheggiano (2013) for the most part in calculating the loss per crisis, we deviate from their approach to estimate the association between changes in capital and changes in the probability of a banking crisis for two reasons. First, Miles, Yang, and Marcheggiano (2013) and Cline (2016) use data from a panel of countries to estimate the benefits of reducing the likelihood of a crisis and the associated decline in GDP growth. The frequency of banking crises in the United States suggests that the US case merits study in isolation. Second, Miles, Yang, and Marcheggiano (2013) rely not on data but on well-reasoned assumptions about the link between GDP shocks and bank balance sheets to reach conclusions about the relationships among bank capital ratios, banking crises, and real per capita GDP growth between 1821 and 2008. For the United States, a long history of data on real GDP per capita exists. Broad aggregate banking statistics also exist, including the overall level of capitalization in the industry over a long horizon. We therefore use such data to empirically examine the direct link between the bank capital ratio and the probability of a banking crisis, which we can then link to GDP growth.

The last term in equation (1) measures the likelihood of a crisis in a given year. One way to estimate how changes in capital are associated with a change in the probability of a banking crisis is to use a limited dependent variable method, from which we can then compute the marginal effects at representative values of the capital ratio.

To illustrate this limited dependent variable method, assume that the crisis dummy variable, I_t^{crisis}, depends on an unobservable latent variable, L_t^*, which relates to other variables as follows:

$$I_t^{crisis} = \begin{cases} 1 \; if \; L_t^* > 0 \\ 0 \; otherwise \end{cases}$$
$$L_t^* = X_t'\gamma_X + \gamma_{Capital} Capital_{t-1} + e_t \quad (2)$$

where $Capital_{t-1}$ is the ratio of aggregate, non-risk-weighted bank capital to aggregate bank assets or liabilities at the end of the previous year between 1891 and 2013, X_t includes other continuous and dummy variables, and e_t is an independently distributed error. The construction of each variable, as well as the data sources, are reported in table A1 in the appendix.

Among the other variables, we include the one-year lag of the natural log of the cyclical component of the number of US banks extracted from the filter that Christiano and Fitzgerald (2003) propose from 1891 to 2013, because bank entry following regulatory changes may have factored into past banking crises. For instance, Mengle (1990) and Walter (2006) discuss how states historically used minimum dollar capital requirements as a barrier to entry, and those barriers to entry were based on the size of the population where the banks were located. Thus, a correlation exists between the aggregate capital ratio, the population, and the number of banks. However, Spearman correlation tests of independence indicate that the cyclical component of the number of banks is statistically independent of the capital ratio and could be useful in examining the extent to which a sudden rise in bank entry might factor into banking crises.

We also include one-year lagged inflation, one-year lagged real per capita GDP growth, and changes in the natural log of one-year lagged government size as a fraction of GDP. We include this last variable because we also estimate instrumental variable treatment regressions to generate alternative estimates of the cost of a crisis in the United States, and the variable appears frequently in growth regressions. Finally, we include Shiller's (2015) estimates of one-year lagged real returns on the S&P 500 and one-year lagged real changes in the housing price index to capture the potential effects of asset returns on banking crises.

Although our regressions do not include some of the variables found in other studies of banking crises (see Kauko 2014), given the unique institutional features of the US banking system, we do include dummy variables to reflect some legislative and regulatory regimes in the United States. Among these, we include variables for the pre–Federal Reserve (Fed) period from 1892 to 1912, the pre-FDIC period from 1892 to 1933, the pre-Basel period from 1892 to 1987, and the pre-Riegle-Neal-Act period from 1892 to 1994. Since we control for the pre-Fed and pre-FDIC periods, the pre-Basel period could reflect what Gorton (2012) has called the “Quiet Period” when no banking crises occurred, and the pre-Riegle-Neal-Act period could reflect some of the effects of interstate banking restrictions.

In section A3 of the appendix, we report tests of nonstationarity and stationarity for each of the right-hand-side variables in equation (2). With the exception of the raw lagged capital ratio, we find that the continuous variables are probably stationary. The apparent nonstationarity of the capital ratio, which is bounded, may be because of structural breaks. However, these tests of nonstationarity and stationarity also indicate that the residuals of a regression of the lagged capital ratio on the four dummy variables previously described may be stationary. This finding suggests that changes in the regulatory environment may explain the apparent nonstationarity.

Assuming that a crisis is a normally distributed random variable, then the probability of a crisis and noncrisis, respectively, equals

$$I_t^{crisis} = \begin{cases} 1 \; with \; prob.: \Pr(L_t^* > 0) = \Phi\left(X_t'\gamma_X + \gamma_{Capital} Capital_{t-1} \right) \\ 0 \; with \; prob.: \Pr(L_t^* \leq 0) = 1 - \Phi\left(X_t'\gamma_X + \gamma_{Capital} Capital_{t-1} \right) \end{cases}, \tag{3}$$

which we estimate using a probit model.[18] Probit regressions assume normality, so we also repeat the exercise for logit and complementary log-log regressions, the latter being better suited for modeling rare events. In table 2, the first three columns report the results with lagged capital as the only continuous variable, and the last three columns report results using all continuous variables.

Table 2. Probit, Logit, and Complementary Log-Log Estimates of the Banking Crises, 1892–2014

1. Variable	2. Probit	3. Logit	4. Cloglog	5. Probit	6. Logit	7. Cloglog
Lagged capital ratio	2.55 (8.74)	5.85 (16.65)	2.28 (15.32)	−59.41** (26.99)	−107.63** (49.31)	−93.83** (42.84)
Lagged inflation	—	—	—	−16.06** (7.51)	−27.36** (13.51)	−21.92* (11.65)
Lagged cyclical component of banks				23.02*** (8.26)	42.52*** (15.71)	38.12*** (14.11)
Lagged real per capital GDP growth	—	—	—	−4.45 (5.67)	−8.47 (10.92)	−6.34 (10.49)
Lagged changes in size of government	—	—	—	2.92* (1.54)	5.29* (2.81)	4.41* (2.54)
Lagged returns on S&P 500	—	—	—	−3.70** (1.56)	−6.66** (2.89)	−5.19** (2.54)
Lagged changes in real house prices	—	—	—	4.46 (3.53)	7.06 (6.24)	5.59 (5.02)
Pre–Federal Reserve	−0.59 (0.73)	−1.17 (1.41)	−0.89 (1.28)	3.64* (1.98)	6.53* (3.69)	5.77* (3.33)
Pre-FDIC	1.05 (0.74)	2.18 (1.51)	2.29 (1.44)	3.32** (1.61)	6.26** (2.95)	5.55** (2.51)
Pre-Basel	−2.67*** (0.65)	−4.94*** (1.32)	−4.22*** (1.11)	−4.15*** (1.16)	−7.62*** (2.23)	−6.58*** (1.87)
Pre–Riegle-Neal	1.67** (0.65)	2.81** (1.15)	2.10** (0.83)	1.50* (0.84)	2.52* (1.46)	1.94* (1.16)
Constant	−1.28 (0.91)	−2.29 (1.71)	−2.03 (1.57)	4.44* (2.47)	8.10* (4.48)	6.69* (3.88)
N	123	123	123	123	123	123

Note: Levels of statistical significance are represented as follows: 99% (***), 95% (**) and 90% (*).

[18] This approach implicitly assumes each crisis year is statistically independent. Jalil's (2014) findings for the 1825–1929 period may well be consistent with this assumption. However, since the Great Depression, crisis years may no longer be independent because crises tend to last longer than one year. In table A4 in the appendix, we show that the results are qualitatively similar when we add a lagged dependent variable to the model in equation (2). Some reviewers have also suggested that an alternative approach might be to estimate the parameter using a survival analysis framework. This approach has merits in the sense that you can treat each crisis as a unique event, arising from idiosyncratic features. The downside to such an approach is that it would not address the duration of a crisis.

The regression results suggest that even though we use an aggregate banking statistic, because it reflects the level of capitalization across the industry—holding other factors constant—the lagged level of capital is negatively associated with banking crises.[19] We will return to this issue shortly.

In addition, we find that the cyclical component of the number of banks is positively associated with the likelihood of banking crises, while lagged real returns on the S&P 500 are negatively associated with the likelihood of banking crises. Lagged changes in the size of government are positively associated with the likelihood of banking crises. Lagged real per capita GDP growth is negatively associated with the likelihood of banking crises. Lagged real house price changes are positively associated with banking crises, but the results are not statistically significant at the 90 percent level or higher.

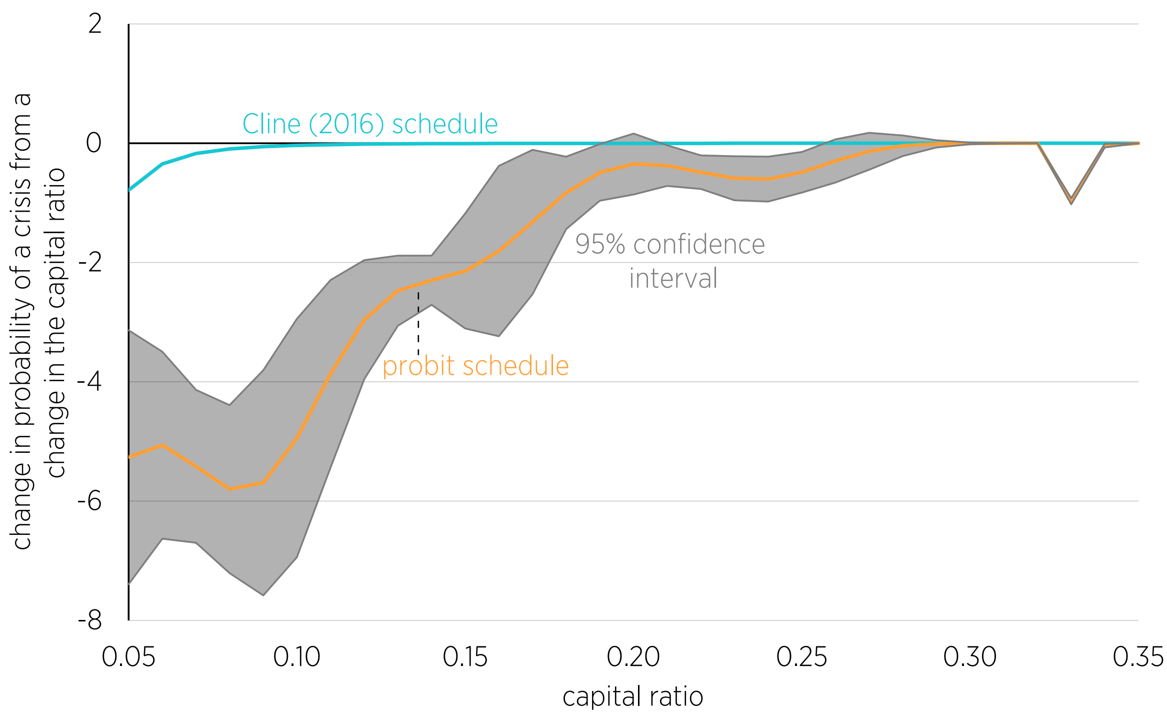
For the dummy variables, the negative and statistically significant coefficients for the pre-Basel FDIC period could be consistent with a lower likelihood of a banking crisis during the "Quiet Period" after 1934. The positive and statistically significant coefficients for the pre–Riegle-Neal Act period could be consistent with claims by Calomiris and Haber (2014) and Bordo, Redish, and Rockoff (2015) that banking crises occurred more frequently before interstate banking.

From the probit regression estimates, summarized in the fifth column of table 2, we compute the key input in calculating the benefits of higher capital, which we depict in figure 4. The figure illustrates the marginal effects at representative values of the one-year lagged capital ratio on the probability of a banking crisis, as well as the analogous first derivative of Cline's

[19] One concern about using lagged capital as a right-hand-side variable is that it could be endogenous with respect to crises if crises last more than one year, which has been the case since the Great Depression. This endogeneity bias may not factor into the results, given that estimates of equation (2) after including a lagged endogenous variable, which we report in table A4 of the appendix, are qualitatively similar. However, this issue merits further study.

(2016) Cobb-Douglas function relating a change in the capital ratio to the change in the probability of a banking crisis.[20] In section A5 of the appendix, we show that the probit estimate schedules are similar to those for logit and complementary log-log regression estimates.

Figure 4. Marginal Effects at Representative Values of the One-Year Lagged Capital Ratio on Probability of a Banking Crisis



[20] Cline uses estimates reported in BCBS (2010) to estimate a log linearized Cobb-Douglas relationship between the probability of a banking crisis and the capital ratio. The Cobb-Douglas relationship for Cline's (2016) baseline optimal capital ratio case, reported in table 3, is $Pr = 0.000000314*k^{-3.5}$. The first derivative of this relationship equals $Pr = -3.5*0.000000314*k^{-4.5}$, which we depict in figure 4.

Figure 4 shows that there are large effects at low capital ratios, but the schedule tends to zero at higher values of the leverage ratio. We later use these marginal effects at representative values of the lagged capital ratio and Cline's (2016) schedule, depicted in figure 4, to calculate the benefits and costs of a higher capital ratio. This calculation in turn helps to determine whether an increase in the simple equity leverage ratio has benefits that equal or exceed the costs.

B. Estimating the Costs of a Higher Capital Ratio

To estimate costs, Miles, Yang, and Marcheggiano examine the extent to which decreasing bank leverage raises the cost of capital for banks. This cost is then passed on to borrowers in the form of higher interest rates, thereby reducing capital formation and GDP. While Miles, Yang, and Marcheggiano (2013) focus only on large banks, by using a $1 billion bank asset cutoff we can assess the impact of a rule change for almost all US banking activity.

To measure the marginal costs, Miles, Yang, and Marcheggiano (2013) translate changes in the weighted average cost of capital (WACC) into a higher cost of capital to estimate the elasticity of output with respect to a higher cost of capital. They specify a production function, with capital and labor as inputs, to calculate the elasticity of output with respect to capital as follows:

$$\begin{aligned} \frac{dY}{dP_K}\frac{P_K}{Y} &= \frac{dY}{dK}\frac{K}{Y}\cdot\frac{dK}{dP}\frac{P}{K}\cdot\frac{dP}{dP_K}\frac{P_K}{P} \\ &= \alpha\cdot\sigma\cdot\frac{1}{\alpha-1} \end{aligned} \tag{4}$$

where capital's share of income, α, is assumed to be 0.4, and the elasticity of substitution between capital and labor, σ, as measured by Lawrence (2015), equals about 0.5. Cline (2016) applies the same parameter values for the United States to calculate the elasticity in equation (4) in his baseline case. Using these parameter values yields an elasticity of output equal to –0.33, which is comparable to Miles, Yang, and Marcheggiano's (2013) value of –0.25.

With this elasticity, as in Miles, Yang, and Marcheggiano (2013), we assume that banks pass on the costs of higher capital to firms borrowing from the bank. As the capital asset pricing model (CAPM) implies, a firm's market risk is measured by the sensitivity of a firm's equity returns to returns for the stock market as a whole, a concept known as beta risk. We assume that firms have a market sensitivity of equity returns relative to the market that equals 1, which implies that the cost of capital equals the sum of the risk-free rate plus the market risk premium (multiplied by 1). Therefore, we can translate the cost of funding into a marginal cost using equation (5), where all symbols are as defined above for equation (4):

$$\frac{\Delta Cost}{\Delta Capital} = \frac{1}{1-\delta} \left[\frac{\alpha \cdot \sigma \cdot \frac{1}{\alpha - 1} \cdot \frac{Bank\ Loan\ Corporate\ Funding}{All\ Corporate\ Funding}}{Cost\ of\ Capital\ for\ Firm} \right] \frac{\Delta WACC_{Bank}}{\Delta Capital} \tag{5}$$

Miles, Yang, and Marcheggiano (2013), and Cline (2016) use a value of one-third in their base case to measure the fraction of corporate funding coming from bank loans. Because the United States has been much less reliant on the banking system than other countries, Miles, Yang, and Marcheggiano (2013) suggest that this ratio would be lower for the United States. We accordingly measure the fraction from the ratio of depository institution loans to nonfinancial corporate business total liabilities.[21]

In our baseline case, we use the 1996–2014 average fraction of financing of nonfinancial corporations that arises from bank loans, which equals 7 percent. We consider what might happen if that fraction rose to 21 percent, which lies just above the historical maximum that

[21] We obtain data on depository institution loans from https://research.stlouisfed.org/fred2/series/BLNECLBSNNCB (see FRED 2017a) and on total nonfinancial corporate liabilities from https://research.stlouisfed.org/fred2/series/TLBSNNCB (FRED 2017b), which are available back to 1945.

occurred in the fourth quarter of 1974. We also consider fractions of 33 percent, as in Miles, Yang, and Marcheggiano's and Cline's baseline cases, and 66 percent to compare our results with Cline's (2016) assumption that bank loans make up 33 percent of corporate funding and nonbank loans make up an additional 33 percent. As in Miles, Yang, and Marcheggiano (2013), we also assume the market risk premium equals 5 percent in the baseline case or 7.5 percent otherwise. Finally, we analyze the effects of a 25 percent tax rate to reflect the tax advantage of debt.[22] Because we assume a constant elasticity of output with respect to capital, the marginal costs are horizontal and shift vertically as we vary the assumed parameter values.

To estimate how changing the capital ratio changes costs for borrowers, we follow Miles, Yang, and Marcheggiano (2013), who combine the CAPM and Modigliani and Miller's (1958) theorem insights (for a discussion of this relationship, see Rubinstein 1973). A key insight from the CAPM is that market risk is priced, whereas firm-specific risk is not priced because it can be diversified away. A key insight from Modigliani and Miller (1958) is that, under certain conditions, altering a firm's capital structure between debt and equity will have no effect on the value of the firm. If the Modigliani-Miller theorem holds, tilting a bank's capital structure toward more equity might not result in a higher cost of capital, even if the return on equity exceeds that for debt, because the return on equity would fall, as a less leveraged (more equity-financed) bank is safer. However, given our empirical findings discussed in the context of table 3, we assume that the theorem's prediction does not take place. By combining the CAPM and Modigliani-Miller insights, it is possible to link changes in leverage (the inverse of the leverage ratio) to the cost of capital.

[22] This figure is approximately equal to the values reported by Damodaran for "regional banks" and "money center" banks, available from http://people.stern.nyu.edu/adamodar/New_Home_Page/datafile/wacc.htm, as of the writing of this section.

Table 3. Levels Estimates of Bank Asset Betas with Respect to Leverage across Methods Using Total Assets to Equity as an Estimate of Leverage, Q3 1996–Q4 2014

	Banks with total assets > $1 billion			Banks with total assets > $50 billion		
	Pooled OLS	**Fixed effects**	**Random effects**	**Pooled OLS**	**Fixed effects**	**Random effects**
Assets to equity capital ratio	–0.002 (0.007)	–0.001 (0.008)	–0.002 (0.007)	0.004 (0.011)	–0.008 (0.029)	–0.000 (0.014)
Intercept	0.513*** (0.091)	0.366*** (0.102)	0.513*** (0.091)	0.680*** (0.161)	0.789** (0.374)	0.745*** (0.178)
N	16,154	16,154	16,154	3,929	3,929	3,929
R-squared overall	0.008	0.008	0.008	0.086	0.083	0.085
R-squared within		0.009	0.009		0.092	0.091
R-squared between		0.007	0.009		0.026	0.044
Hausman test (*p*-value chi-squared)		0.485			0.000***	
Test for serial correlation (*p*-value *F*-test)		0.468			0.929	

Note: Standard errors clustered on the holding company are in parentheses. Levels of statistical significance are represented as follows: 99% (***), 95% (**), and 90% (*). OLS = ordinary least squares.

The intuition here is that the CAPM suggests that debt has firm-specific default risk but no systematic market risk, whereas equity has systematic market risk. As Miles, Yang, and Marcheggiano (2013) show, a bank's measure of systematic equity risk should be proportional to the bank's asset risk multiplied by a bank's leverage.

To see why, in general, consider that the dollar value of a bank's assets multiplied by the beta for its assets equals the dollar value of its equity multiplied by the equity's beta, plus the dollar value of its debt multiplied by the debt's beta:

$$\beta_{Asset} Assets = \beta_{Equity} Equity + \beta_{Debt} Debt \tag{6}$$

Because the dollar value of the assets must equal the sum of debt plus equity, after dividing both sides by assets and substituting the sum of debt plus equity for assets, one obtains the following:

$$\beta_{Asset} = \beta_{Equity} \frac{Equity}{Assets} + \beta_{Debt} \frac{Debt}{Assets} = \beta_{Equity} \frac{Equity}{Equity + Debt} \tag{7}$$

The last equality arises because while debt as an obligation has only default risk (which is specific to the firm) and interest rate risk, the covariance between bond returns and the market portfolio equals zero, such that $\beta_{Debt} = 0$. Under these conditions, solving for the equity beta suggests that if a relationship exists between the asset beta and equity beta, the equity beta should be proportional to leverage (the inverse of the leverage ratio):

$$\beta_{Equity} = \beta_{Asset} \frac{Equity + Debt}{Equity} \tag{8}$$

This relationship is useful because while estimating the equity beta and measuring leverage is fairly straightforward, estimating the asset beta can prove challenging because assets may not trade frequently, thereby making it difficult to quantify the market sensitivity. Given the difficulty in estimating asset betas, we accordingly estimate them as in Miles, Yang, and Marcheggiano (2013), from the coefficient of a regression of each bank's equity beta against the bank's book-value equity leverage ratio.

Because they have only semiannual data on bank leverage, Miles, Yang, and Marcheggiano (2013) apply the market model to daily closing stock prices for the six largest UK banks to estimate semiannual equity betas from 1996 to 2010. They then estimate the banks' asset betas using pooled ordinary least squares (OLS), fixed effects, and random effects regression estimates of the relationship between the banks' semiannual equity beta and measures of semiannual leverage. Larger US bank holding companies report leverage and other capital ratios at quarterly frequencies. Because our goal is to explore the implications of reducing bank leverage through the equity-to-asset ratio, we estimate the relationship between bank equity betas and bank leverage, measured as total assets to book equity capital at quarterly frequencies.[23]

To estimate bank equity betas, we use a variant of Lewellen and Nagel's (2006) method of estimating quarterly betas from intra-quarterly, daily data. This method applies Dimson's (1979) correction for nonsynchronous trading arising from the use of daily data.[24] We compute 2,512,186 daily returns across all bank holding companies with at least $1 billion in assets that had between 59 and 64 observations per quarter computed from daily closing prices from January 2, 1996, to December 31, 2014.[25] As a benchmark portfolio, we use Datastream's non-financial index to eliminate any possible spurious correlations arising from the fact that we regress a bank's stock against an index that might otherwise include the stock.

As in Miles, Yang, and Marcheggiano (2013), we apply Fisher-type panel unit root tests to both the full sample and the large bank sample, with a drift term but no trend to both the equity betas and leverage. We reject the null hypothesis that all series are nonstationary, but we do not reject the null hypothesis of no serial correlation of the idiosyncratic errors based on Wooldridge's (2002) Wald test. In table 3, we report the estimated asset betas as suggested by equation (8) by regressing the equity betas against one-quarter lagged bank leverage for banks with at least seven observations.[26]

The estimated asset betas lie even closer to zero than those reported by Miles, Yang, and Marcheggiano (2013), whether we look at banks with total assets above $1 billion or $50 billion. This finding makes sense given that bank assets tend to be debt-like claims, which would have

[23] We find similar results if we estimate the regressions replacing book leverage with total assets to Tier 1 capital or risk-weighted assets to Tier 1 capital.
[24] Dimson's (1979) method calls for correcting nonsynchronous trading bias by adding one-day leading and lagging returns to the standard bivariate market model and summing the three coefficients. The Q3 1996–Q4 2014 average Dimson beta equals 0.85, while the average ordinary market model beta equals 0.92.
[25] We lose 30,672 observations using this cutoff point.
[26] We get similar results when we do not include this restriction.

no systematic risk. Alternatively, the link might be weak because betas are estimated using market-determined prices, while the leverage measures are calculated from book values.

The Hausman test statistics in table 3 suggest that we cannot reject the hypothesis of no systematic differences between fixed- and random-effects specification for all banks. While Miles, Yang, and Marcheggiano (2013) use their fixed-effect estimates, we use the random-effects estimates of equation (8) for the constant, $\hat{\beta}_0$, and estimated asset beta from the coefficient on the asset-to-equity-capital ratio, $\hat{\beta}_{Asset}$, to compute the return on equity as follows:

$$R_{Equity} = R_F + \left(\hat{\beta}_0 + \hat{\beta}_{Asset} \cdot \frac{Equity + Debt}{Equity} \right) R_M \tag{9}$$

As in Miles, Yang, and Marcheggiano (2013), we assume that both the risk-free rate and the market risk premium equal 5 percent, but we also try a higher market risk premium of 7.5 percent.

Miles, Yang, and Marcheggiano (2013) examine the effects of reducing leverage from 30 to 15. For the United States, total assets to book equity averaged 11.64 during our sample. Because in 2014 the leverage ratio under Basel III was 4 percent, we examine the effects of raising the equity-to-asset leverage ratio from 4 percent to 15 percent, which by computing the inverse implies a reduction in leverage from 25 to 6.67.

Given that the asset betas reported in table 3 are small and not statistically different from zero, we assume that no Modigliani-Miller offset exists. This assumption provides a more stringent benchmark that would raise the costs of capital above that which might occur if the Modigliani-Miller offset exists. Using equation (9), at a market risk premium of 5 percent, the return on equity equals 7.56 percent. When we assume a market risk premium of 7.5 percent, the return on equity equals 8.85 percent. These figures are lower than those reported in Miles, Yang, and Marcheggiano (2013) but may be reasonable for the United States.[27]

Using these inputs, we estimate the WACC using bank-specific leverage as follows:

$$WACC = R_{Equity}\,\frac{Equity}{Equity + Debt} + R_F\left(1 - \frac{Equity}{Equity + Debt}\right) \tag{10}$$

For the baseline case in which the risk-free rate and market risk premium equal 5 percent, equation (10) yields an average WACC of 5.1 percent at a bank leverage of 25. The WACC rises to 5.4 percent when bank leverage falls to 6.67, when we assume that both the risk-free rate and equity premium equal 5 percent. These average values lie close to the 5.33 percent that Miles, Yang, and Marcheggiano (2013) estimate for the six UK banks in their sample.

4. Comparing the Benefits and Costs of a Higher Equity Leverage Ratio

Miles, Yang, and Marcheggiano (2013) focus their analysis on finding the "optimal capital ratio" from reducing bank leverage such that marginal benefits equal marginal costs. The marginal benefits arise from the reduction in the expected costs of a banking crisis, expressed in terms of the reduction in forgone GDP. The marginal costs arise from a comparison of the costs (expressed in terms of lost GDP) associated with higher bank capital, which might drive up the WACC for firms. This higher cost of capital would result in a lower level of real capital formation and hence reduced GDP. In what follows, we assess the benefits and costs of a rule increasing the minimum capital ratio, which we specifically define as an equity leverage ratio, from the 2014 value of 4 percent, shown in tables 1 and 2 of Barth and Miller (2017), to 15 percent. While we report some optimal

[27] These figures lie in the range of values reported by Damodaran for "regional banks" and "money center" banks, available from http://people.stern.nyu.edu/adamodar/New_Home_Page/datafile/wacc.htm as of the writing of this section. The values we use are also comparable to those observed in figure 3 above for national banks. Cline (2016) uses values of 7 percent, 10 percent, and 13 percent for the high, baseline, and low optimal capital ratio cases, and our values therefore fall on the lower end of his range of assumed values.

capital ratio summary statistics to compare our results with those reported in Miles, Yang, and Marcheggiano (2013) and Cline (2016), we focus primarily on analyzing the conditions in which the marginal benefits from increasing the leverage ratio from 4 percent to 15 percent exceed the marginal costs.

We begin by generating 256 optimal capital ratios, which arise from varying assumptions, to generate benefits and costs. We make eight different assumptions about benefits, including (1) whether crises have temporary and permanent effects versus only temporary effects, (2) whether shocks last two years versus five years, and (3) whether the loss per crisis is –4.5 percent or –10 percent. Our 16 different cost assumptions arise from assuming (1) a tax advantage of debt versus no tax advantage of debt, (2) a market risk premium of 5 percent versus 7.5 percent, and (3) bank loans making up 7 percent versus 21 percent, 33 percent, or 66 percent of all corporate funding. From the 8 benefit and 16 cost assumptions, we get 128 cases at a discount rate of 2.5 percent and 128 cases at a discount rate of 5 percent, for a total of 256 cases.

In table 4, we report summary statistics of the optimal capital ratio across all cases, as well as for subsets of the sample based on our assumptions. The results below the top line are sorted by the mean optimal capital ratio. In addition to the average, we report the median and 25th and 75th percentiles to provide a sense of the distribution of values.

Across all cases, the median optimal capital ratio equals 26 percent, while the average equals 23 percent. Those figures suggest that on average, the benefits of increasing the leverage ratio from 4 percent to 15 percent at least cover, if not exceed, costs. From the subset of assumptions we make, the presence of permanent effects of GDP shocks, a higher loss per crisis, the absence of a tax advantage of debt, and a relatively low fraction of corporate funding coming from bank loans (7, 21, and 33 percent) tend to increase marginal benefits relative to marginal costs.

Table 4. Summary Statistics of Optimal Capital Ratios

	25th percentile	Median	Mean	75th percentile	Standard deviation	*N*
All cases	0.18	0.26	0.23	0.27	0.05	256
Bank loan funding fraction 7 percent	0.27	0.27	0.27	0.28	0.02	64
Some permanent effects of shocks	0.26	0.26	0.26	0.27	0.03	128
Growth –10 percent	0.25	0.26	0.25	0.27	0.04	128
Bank loan funding fraction 21 percent	0.22	0.26	0.24	0.27	0.04	64
No tax advantage of debt	0.19	0.26	0.24	0.27	0.04	128
Tax advantage of debt	0.18	0.26	0.23	0.27	0.05	128
Market risk premium 5 percent	0.19	0.26	0.23	0.27	0.05	128
Market risk premium 7.5 percent	0.18	0.26	0.23	0.27	0.05	128
Bank loan funding fraction 33 percent	0.18	0.25	0.23	0.26	0.04	64
Growth –4.5 percent	0.18	0.25	0.22	0.26	0.05	128
No permanent effects of shocks	0.17	0.19	0.21	0.26	0.05	128
Bank loan funding fraction 66 percent	0.17	0.18	0.19	0.25	0.05	64

In table 5, we report coefficient estimates of an OLS regression of the optimal capital ratio against dummy variables that reflect the assumptions used to generate each optimal capital ratio. We include as right-hand-side variables (1) a dummy variable equal to 1 if shocks have temporary and permanent effects and 0 if shocks have only temporary effects, (2) a dummy variable equal to 1 if the duration of shocks equals five years and 0 if it equals two years, (3) a dummy variable equal to 1 if the cost of a crisis equals –10 percent and 0 if it equals –4.5 percent, (4) dummy variables equal to 1 if the fraction of corporate funding coming from bank loans equals 7 percent, 21 percent, or 33 percent and 0 if it equals 66 percent, (5) a dummy variable equal to 1 if we assume a no-tax advantage of debt and 0 if a tax advantage of debt exists, (6) a dummy variable equal to 1 if the market risk premium equals 7.5 percent and 0 if it equals 5 percent, and (7) a dummy variable equal to 1 if the discount rate equals 5 percent and 0 if it equals 2.5 percent.

Table 5. Determinants of the Optimal Capital Ratio

	OLS regression of OCR
Only temporary shocks (vs. temporary and permanent shocks)	–0.05***
Duration of shock, 5 years (vs. 2 years)	0.02***
Larger cost of a crisis, –10 percent (vs. –4.5 percent)	0.03***
Market risk premium, 7.5 percent (vs. 5 percent)	–0.00
Fraction of corporate funding from bank loans, 7 percent (vs. 66 percent)	0.07***
Fraction of corporate funding from bank loans, 21 percent (vs. 66 percent)	0.05***
Fraction of corporate funding from bank loans, 33 percent (vs. 66 percent)	0.03***
No tax advantage of debt (vs. tax advantage of debt)	0.01***
Discount rate, 5 percent (vs. 2.5 percent)	0.02***
Constant	0.18***
R-squared	0.79
N	256

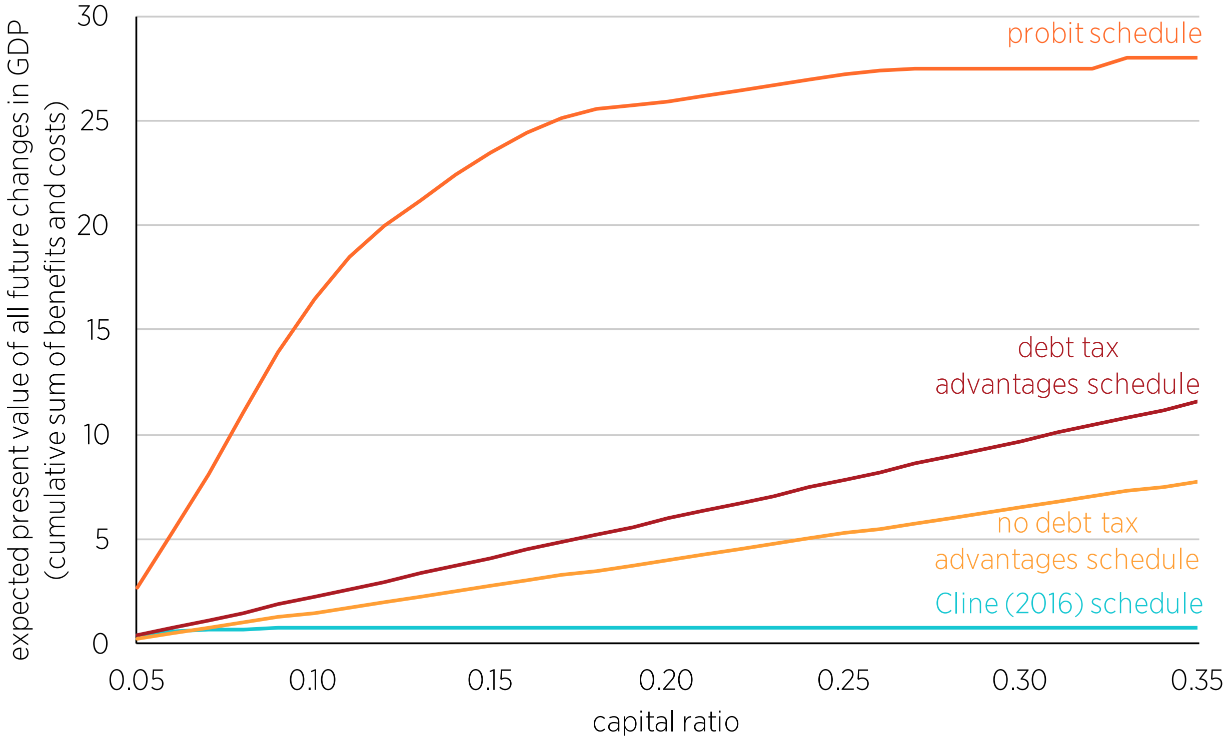
Note: Robust standard errors used to determine statistical significance. Levels of statistical significance are represented as follows: 99% (***), 95% (**) and 90% (*). OCR = optimal capital ratio.

The constant equals 18 percent, and it reflects the baseline case with permanent shocks and temporary shocks that last two years, a crisis cost of –4.5 percent, a tax advantage of debt, a fraction of corporate funding coming from bank loans of 66 percent, a market risk premium of 5 percent, and a discount rate of 2.5 percent. The results suggest that on the benefits side, the optimal capital ratio falls by 5 percent when the permanent effects of crises are eliminated, rises by 2 percent when shocks have a longer duration, and rises by 3 percent when the cost of a crisis rises from –4.5 percent to –10 percent. On the cost side, raising the market risk premium from 5 percent to 7.5 percent has only a small negative effect that roughly equals 0 out to two decimal places, and it is statistically insignificant. However, the optimal capital ratio rises by 3 percent, 5 percent, and 7 percent, respectively, when the fraction of corporate funding coming from bank loans falls from 66 percent to 33 percent, 21 percent, and 7 percent, respectively. The optimal capital ratio rises by 1 percent when we eliminate the tax advantage of debt. Finally, the optimal capital ratio rises by 2 percent when the discount rate is increased from 2.5 percent to 5 percent.

Having examined the effects of the assumptions on the marginal benefits and costs of a higher leverage ratio, we now examine the merits of a rule change that raises the leverage ratio to 15 percent using the total benefit and cost schedules under our preferred assumptions. The analysis is similar to the baseline case of the regression coefficient estimates reported in table 5. Specifically, we analyze the effects with and without a tax advantage of debt, assuming shocks have partly permanent effects and partly temporary effects that die out after two years, and assuming that the cost of a crisis equals only –4.5 percent. We also assume that bank lending makes up 66 percent of all corporate funding, which is much higher than the current value and tends to raise the costs of higher capital.[28] Finally, we assume the market risk premium equals 7.5 percent. Thus, we compare benefits under conservative assumptions about the benefits of a higher leverage ratio, with costs arising from high cost assumptions. We depict our total benefit schedule along with that implied by Cline's (2016) estimated schedule and two total cost schedules reflecting whether a tax advantage of debt exists in figure 5, assuming a 2.5 percent discount rate.

[28] This larger figure may also capture any other adverse effects on the growth of real GDP per capita owing to less bank lending of all types, which we may not be allowing for because we are closely following the approach of Miles, Yang, and Marcheggiano (2013).

Figure 5. Total Benefits and Total Costs across Preferred Assumptions, Discount Rate Equal to 0.025.



In line with our regression estimates in table 5, we find that the optimal leverage ratio equals about 18 percent whether or not we assume a tax advantage for debt, which means that the marginal benefits at least equal the marginal costs of increasing the leverage ratio from 4 percent to 15 percent. If we apply Cline's (2016) functional form and parameters for his baseline optimal capital ratio to estimate benefits, we find that the optimal capital ratio falls to 5 percent, whether or not we assume a tax advantage of debt. While we do not depict the results, if we use Miles, Yang, and Marcheggiano's (2013) assumptions that shocks take five years to die out and that the cost of a crisis equals –10 percent, then the optimal leverage ratios increase to 26 percent with or without a tax advantage of debt. This result means that the benefits of increasing the leverage ratio from 4 percent to 15 percent exceed the costs.

One implication of our findings is that it may be important to include periods when capital was higher when measuring the association between changes in capital and changes in the probability of a banking crisis. For instance, Cline's (2016) estimates of how changes in capital relate to changes in the probability of a crisis come from estimates found in BIS (2010). While Cline (2016) finds that a Cobb-Douglas relationship explains the BIS data well, the capital requirements observed in BIS (2010) reflect only recent history, when—as we showed in figures 1 and 2 and table 1—capital requirements were historically low by US standards. It is also not clear how that range of values can be used to assess the merits of values that lie above that range.

Moreover, 166 of the 256 optimal capital ratios we compute lie within the 20–30 percent range that Admati and Hellwig (2013) advocate, and in only 7 of the 256 cases, the optimal capital ratio lies below 15 percent. Our average values also exceed those of Miles, Yang, and Marcheggiano (2013) and Cline (2016). To understand why, consider that Miles, Yang, and Marcheggiano (2013, figure 5) show that as the capital ratio approaches 20 percent of risk-weighted assets, the marginal benefits approach zero. However, those benefits do become positive again when the capital ratio rises above 30 percent, reflecting the effects of extreme negative GDP shocks. As a result, the optimal capital ratio lies just under 20 percent of risk-weighted assets for most cases, but it can reach 47 percent relative to risk-weighted assets in the case when those assets include the full distribution of possible outcomes. In this latter case, the optimal capital-to-risk-weighted assets ratio converts to a 20 percent capital-to-asset ratio. Cline (2016) finds that the distribution of optimal capital-to-asset ratios ranges from about 5 percent to 12 percent, although the mean equals 7 percent.

One way to summarize the differences is that Miles, Yang, and Marcheggiano (2013) assume both that fairly large benefits exist and that the costs would be higher for UK banks than for US banks. They make this second assumption because the return on equity is higher and because banks provide a higher fraction of corporate funding in the United Kingdom than in the United States. In contrast, Cline (2016) assumes limited benefits. While the return on equity is comparable to what we assume, Cline also assumes that bank loans make up a high fraction of corporate funding, which would drive up the costs considerably. As such, Cline's (2016) net benefit is much smaller than what we find.[29]

5. Conclusions

The United States has experienced financial crises frequently, but the US legislative and regulatory framework has often evolved to fix the last crisis while potentially creating problems that feature in subsequent crises. Therefore, we examine the feasibility, in terms of costs and benefits, of a simpler solution that implements simpler, higher capital requirements. We examine the equity leverage ratio in particular.

While higher bank equity capital requirements may come at a cost, the key benefit is reducing the likelihood of a banking crisis. Existing conditions are costly for the United States because of the higher probability of experiencing a crisis when capital ratios are low, rather than because the actual decline in GDP is high during a banking crisis. In considering the effect of raising the leverage ratio from 4 percent to 15 percent, we find that the marginal benefits generally exceed the marginal costs under a wide range of assumptions.

[29] Dagher et al. (2016) report that capital ratios of 15–23 percent of risk-weighted assets would have been sufficient to stop banking crises in most advanced economies. In BIS (2010), the purpose was to examine minimum capital ratios rather than capital ratios that would equate marginal costs and benefits.

If we assume that crises have permanent effects, that they have a longer duration, or that costs of crises are larger, we find that benefits tend to increase relative to costs. On the cost side, the tax advantage of debt, a higher market risk premium, and especially a larger fraction of corporate funding coming from bank loans tend to drive up marginal costs relative to marginal benefits. But a higher discount rate tends to reduce the marginal costs relative to the benefits.

The results presented here are consistent with calls to implement a simple leverage ratio that could apply to all banks, rather than just banks of a certain size. Clearly, given the importance of higher capital requirements in bank regulation, more research is warranted on measuring the benefits and costs.

Appendix: Data Sources and Alternative Analyses

A1. Data

Table A1. Data

Type of data	Table or figure	Variable contruction and data source
Capital ratio, all banks	Figure 1, figure 2, table 1, table 2	For 1834–1933, divide series N-24, "Capital, surplus, and net undivided profits," by series N-20, "Total assets or liabilities (or total resources)," in Bureau of the Census, US Department of Commerce, *Historical Abstract of the United States: 1789–1945* (Washington, DC: US Government Printing Office, 1949), 262–63, http://www2.census.gov/prod2/statcomp/documents/HistoricalStatisticsoftheUnitedStates1789-1945.pdf. After 1933, divide "Total Equity Capital" by "Total Liabilities and Equity Capital," from Federal Deposit Insurance Corporation, "Liabilities and Equity Capital, FDIC-Insured Commercial Banks, US and Other Areas: Balances at Year End, 1934–2015," table CB14, accessed January 31, 2017, https://www5.fdic.gov/hsob/SelectRpt.asp?EntryTyp=10&Header=1.
Capital ratio, national banks	Figure 2, figure 3	Divide series X-62, "Capital accounts," by series X-43, "Total assets or liabilities," in Bureau of the Census, US Department of Commerce, *Historical Abstract of the United States: Colonial Times to 1957* (Washington, DC: US Government Printing Office, 1960), 626–27, https://fraser.stlouisfed.org/files/docs/publications/histstatus/hstat_1957_cen_1957.pdf.
Capital ratio, state banks	Figure 2	Divide series X-84, "Capital accounts," by series X-65, "Total assets or liabilities," in Bureau of the Census, US Department of Commerce, *Historical Abstract of the United States: Colonial Times to 1957* (Washington, DC: US Government Printing Office, 1960), 628–29, https://fraser.stlouisfed.org/files/docs/publications/histstatus/hstat_1957_cen_1957.pdf.
Return on equity, national banks	Figure 3	Bureau of the Census, US Department of Commerce, "Net profits as percent of total capital accounts," *Historical Abstract of the United States: Colonial Times to 1957* (Washington, DC: US Government Printing Office, 1960), series X-199, 638, https://fraser.stlouisfed.org/files/docs/publications/histstatus/hstat_1957_cen_1957.pdf.
Real per capita GDP growth	Table 1	Calculated as the annual change in the natural log transformation of real GDP per capita, available from Louis Johnston and Samuel H. Williamson, "What Was the U.S. GDP Then?," MeasuringWorth, accessed January 31, 2017, https://www.measuringworth.com/usgdp/.
Inflation (GDP deflator)	Table 2	Calculated as the annual change in the natural log transformation of the GDP deflator, available from Louis Johnston and Samuel H. Williamson, "What Was the U.S. GDP Then?," MeasuringWorth, accessed January 31, 2017, https://www.measuringworth.com/usgdp.
One-year lagged cyclical component of the number of banks	Table 2	Lagged value of the cyclical component of the Christiano Fitzgerald filter applied to the number of banks. Data for the number of banks from 1891 to 1933 are from the Bureau of the Census, US Department of Commerce, "Number of Banks," *Historical Abstract of the United States: 1789–1945*, series N-19 (Washington, DC: US Government Printing Office, 1949). Data after 1933 are from Federal Deposit Insurance Corporation, "Number of Institutions, Branches and Total Offices, FDIC-Insured Commercial Banks, US and Other Areas: Balances at Year End, 1934–2015," table CB01, accessed January 31, 2017, https://www5.fdic.gov/hsob/SelectRpt.asp?EntryTyp=10&Header=1.

One-year lagged growth in government size	Table 2	Calculated as the annual change in the natural log transformation of the ratio of government outlays to nominal GDP. The nominal GDP data series comes from Louis Johnston and Samuel H. Williamson, "What Was the U.S. GDP Then?," MeasuringWorth, accessed January 31, 2017, https://www.measuringworth.com/usgdp/. The government outlays series from 1891 to 1901 comes from Office of Management and Budget, "Total Expenditures, Excluding Debt Retirements," *Fiscal Year 2017 Historical Tables: Budget of the U.S. Government* (Washington, DC: US Government Printing Office, 2016), series P-99. From 1902 to 2014, the series comes from Office of Management and Budget, "Total Outlays," *Fiscal Year 2017 Historical Tables: Budget of the U.S. Government* (Washington, DC: US Government Printing Office, 2016), table 1.1.
One-year lagged returns on the S&P 500	Table 2	Shiller's estimate of the natural log of the quantity one plus the real return on the S&P 500 index from 1891 to 2013 is available from the "long term stock, bond, interest rate and consumption data" hyperlink found at http://www.econ.yale.edu/~shiller/data.htm.
One-year lagged real house price index	Table 2	Calculated as the annual change in the natural log transformation of the real housing price index from 1891 to 2013, available from the "US Home Prices 1890-Present" hyperlink found at http://www.econ.yale.edu/~shiller/data.htm.
Dimson beta	Table 3	Estimate from intra-quarterly regressions of daily bank stock returns is computed from closing stock price data, available from https://wrds-web.wharton.upenn.edu, against Datastream's daily nonfinancial index returns for the United States, available from Datastream.
Asset-to-equity leverage	Table 3	Bank leverage is calculated from Call Report data series bhck2170 divided by bhck3210.

A2. Alternative Estimates of the Cost of a Crisis

In addition to using the probit method to estimate the marginal effects at representative values of the capital ratio, we also estimate alternative values of the cost of a crisis using 2SLS-probit and OLS-probit results, where the probit regression is as described previously in equations (2) and (3).[30] The 2SLS-probit results are more robust to specification errors in the probit equation.

In the final 2SLS and OLS regression stage, we assume that the growth equation takes the following form:

$$d \ln GDP_t / Pop_t = X_t' \beta + \delta I_t^{crisis} + \varepsilon_t, \qquad \text{(A1)}$$

[30] See Cerulli (2014) for a description.

where $d \ln GDP_t / Pop_t$ measures growth of real GDP per capita, and I_t^{crisis} is an indicator variable that takes a value of 1 in 1893 and 1907 (as noted by Jalil (2014)), as well as in 1930–1933, 1987–1992, and 2007–2009, and equals 0 otherwise. The other variables in X_t include (1) one-year lagged changes in the natural log of government size as a fraction of GDP, (2) one-year lagged returns on the S&P 500, and (3) one-year lagged inflation. Finally, ε_t is an independently distributed error term.

Table A2 indicates that the cost of a crisis may be no more than –4.5 percent. We accordingly analyze the results using this assumption, which would tend to lower estimates of the benefits of higher capital.

Table A2. Alternative Estimates of the Cost of a Crisis

	OLS	Probit-OLS	Probit-2SLS
Banking crisis	–0.034*** (0.011)	–0.045** (0.020)	–0.045** (0.019)
Lagged changes in size of government	0.030 (0.020)	0.031 (0.019)	0.031 (0.020)
Lagged returns on S&P 500	0.115*** (0.030)	0.109*** (0.031)	0.109*** (0.031)
Lagged Inflation	0.094 (0.105)	0.068 (0.115)	0.072 (0.107)
Constant	0.012* (0.006)	0.015** (0.007)	0.014** (0.007)
R-Squared	0.26	0.25	0.26
N	123	123	123

Note: Robust standard errors are in parentheses. Levels of statistical significance are represented as follows: 99% (***), 95% (**) and 90% (*).

A3. Tests of Nonstationarity and Stationarity

Table A3 reports feasible generalized least-squares augmented Dickey-Fuller (ADF) nonstationarity tests proposed by Elliott, Rothenberg, and Stock (1996) and KPSS stationarity tests proposed by Kwiatkowski, Phillips, Schmidt, and Shin (see Kwiatkowski et al. 1992) for each of the continuous variables used to estimate equation (3). Unless otherwise specified, the tests assume that a trend exists. We use the Akaike information criterion to determine the number of lags to include in computing the ADF test statistics, which is reported in parentheses next to the test statistic. We use the Newey-West automatic bandwidth selection procedure to determine the number of lags to include in computing the KPSS test statistics, which is reported in parentheses next to the test statistic. For the ADF tests, if the test statistic is larger in magnitude than the 1 percent critical value, we can reject the null hypothesis that the series is nonstationary. For the KPSS test, if the test statistic lies below the 10 percent critical value, we cannot reject the null hypothesis that the series is stationary.

Table A3. Tests of Nonstationarity and Stationarity

	ADF test null (alternative) hypothesis I(0) (I(1))	**KPSS test null (alternative) I(1) (I(0))**
Lagged capital ratio		
Test stat	-2.46 (2)	0.36 (7)
Critical value	-4.03	0.12
Residuals of regression of capital against dummy variables (no trend)		
Test stat	–4.31 (2)	0.13 (7)
Critical value	-2.60	0.35
Lagged inflation		
Test stat	–5.39(1)	0.07 (6)
Critical value	–4.03	0.12
Lagged cyclical component of banks (no trend)		
Test stat	–8.23 (7)	0.04 (7)
Critical value	–2.60	0.35
Lagged real per capital GDP Growth		
Test stat	–6.67 (1)	0.07 (6)
Critical value	–3.50	0.12
Lagged changes in size of government		
Test stat	–5.85 (5)	0.03 (5)
Critical value	–3.50	0.12

Lagged returns on S&P 500		
Test stat	−6.18 (2)	0.04 (2)
Critical value	−3.50	0.12
Lagged changes in real house prices		
Test stat	−6.14 (3)	0.05 (7)
Critical value	−3.50	0.12

The results suggest that with the exception of the one-year lagged capital ratio, the series are likely stationary. The capital ratio is in principle bounded between 0 and 1. However, in principle, a bounded series can still be found nonstationary in a finite sample. We find that we cannot reject the ADF test, and we do reject the KPSS test for the lagged capital ratio. However, this could be owing to structural breaks that may reflect changes in regulations. The ADF and KPSS tests, when applied to the residuals of a regression of the lagged capital ratio against the pre-Fed, pre-FDIC, pre-Basel, and pre-Riegle-Neal-Act dummy variables, suggest the residuals may be stationary.

A4. Including Lagged Endogenous Variables

Table A4 compares estimates of the probit, logit, and complementary log-log model estimates reported in table 2 with estimates of the same equations that include a lagged dependent variable. The lagged dependent variable is not statistically significant at the 10 percent level, and the standard errors tend to be slightly larger when the lagged dependent variable is included in the specifications; however, the results are qualitatively similar.

Table A4. Probit, Logit and Complementary Log-Log Estimates of the Banking Crises, 1892–2014

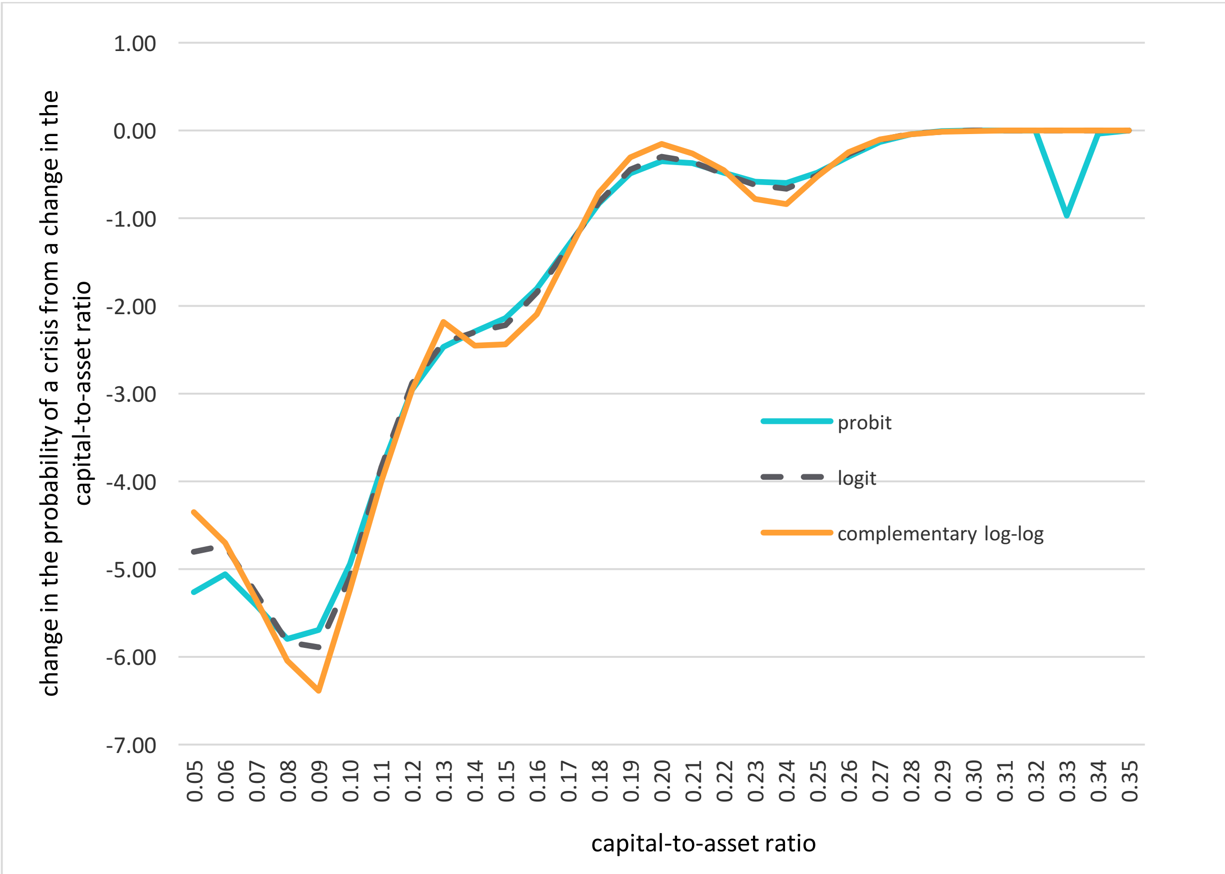
	Probit	Probit	Logit	Logit	Cloglog	Cloglog
Lagged crisis year	–	1.30 (0.84)	–	2.13 (1.52)	–	1.70 (1.33)
Lagged capital ratio	−59.41** (26.99)	−55.16* (29.41)	−107.63** (49.31)	−97.86* (52.91)	−93.83** (42.84)	−84.80* (45.14)
Lagged inflation	−16.06** (7.51)	−14.93* (8.54)	−27.36** (13.51)	−26.95* (15.12)	−21.92* (11.65)	−22.68* (12.68)
Lagged cyclical component of banks	23.02*** (8.26)	21.20** (8.91)	42.52*** (15.71)	38.51** (16.24)	38.12*** (14.11)	34.41** (14.60)
Lagged real per capita GDP growth	−4.45 (5.67)	0.00 (7.05)	-8.47 (10.92)	0.02 (13.91)	−6.34 (10.49)	−0.21 (12.84)
Lagged changes in size of government	2.92* (1.54)	2.49 (1.74)	5.29* (2.81)	4.72 (3.16)	4.41* (2.54)	4.16 (2.75)
Lagged returns on S&P 500	−3.70** (1.56)	−2.78 (1.72)	−6.66** (2.89)	−5.18* (3.09)	−5.19** (2.54)	−4.30 (2.68)
Lagged changes in real house prices	4.46 (3.53)	6.49 (4.26)	7.06 (6.24)	11.02 (7.60)	5.59 (5.02)	8.98 (6.28)
Pre-Federal Reserve	3.64* (1.98)	3.17 (2.17)	6.53* (3.69)	5.45 (4.07)	5.77* (3.33)	4.60 (3.62)
Pre-FDIC	3.32** (1.61)	3.18* (1.74)	6.26** (2.95)	5.84* (3.11)	5.55** (2.51)	5.19** (2.58)
Pre-Basel	−4.15*** (1.16)	−3.08** (1.39)	−7.62*** (2.23)	−5.73** (2.56)	−6.58*** (1.87)	−4.95** (2.20)
Pre–Riegle-Neal	1.50* (0.84)	0.69 (1.04)	2.52* (1.46)	1.31 (1.81)	1.94* (1.16)	0.95 (1.33)
Constant	4.44* (2.47)	3.66 (2.72)	8.10* (4.48)	6.54 (4.89)	6.69* (3.88)	5.34 (4.18)
N	123	123	123	123	123	123

Note: Levels of statistical significance are represented as follows: 99% (***), 95% (**), and 90% (*).

A5. Comparing Estimates of the Marginal Effects at Representative Values of the Capital Ratio across Methods

Figure A1 depicts the marginal effects at representative values of the capital ratio for the probit, logit, and complementary log-log regressions. The result suggests that the methods generate broadly similar marginal effects at representative values schedules, which implies that the assumed distribution of dependent variables has little effect on the results.

Figure A1. Comparing Estimates of the Marginal Effects at Representative Values of the Capital Ratio across Methods



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