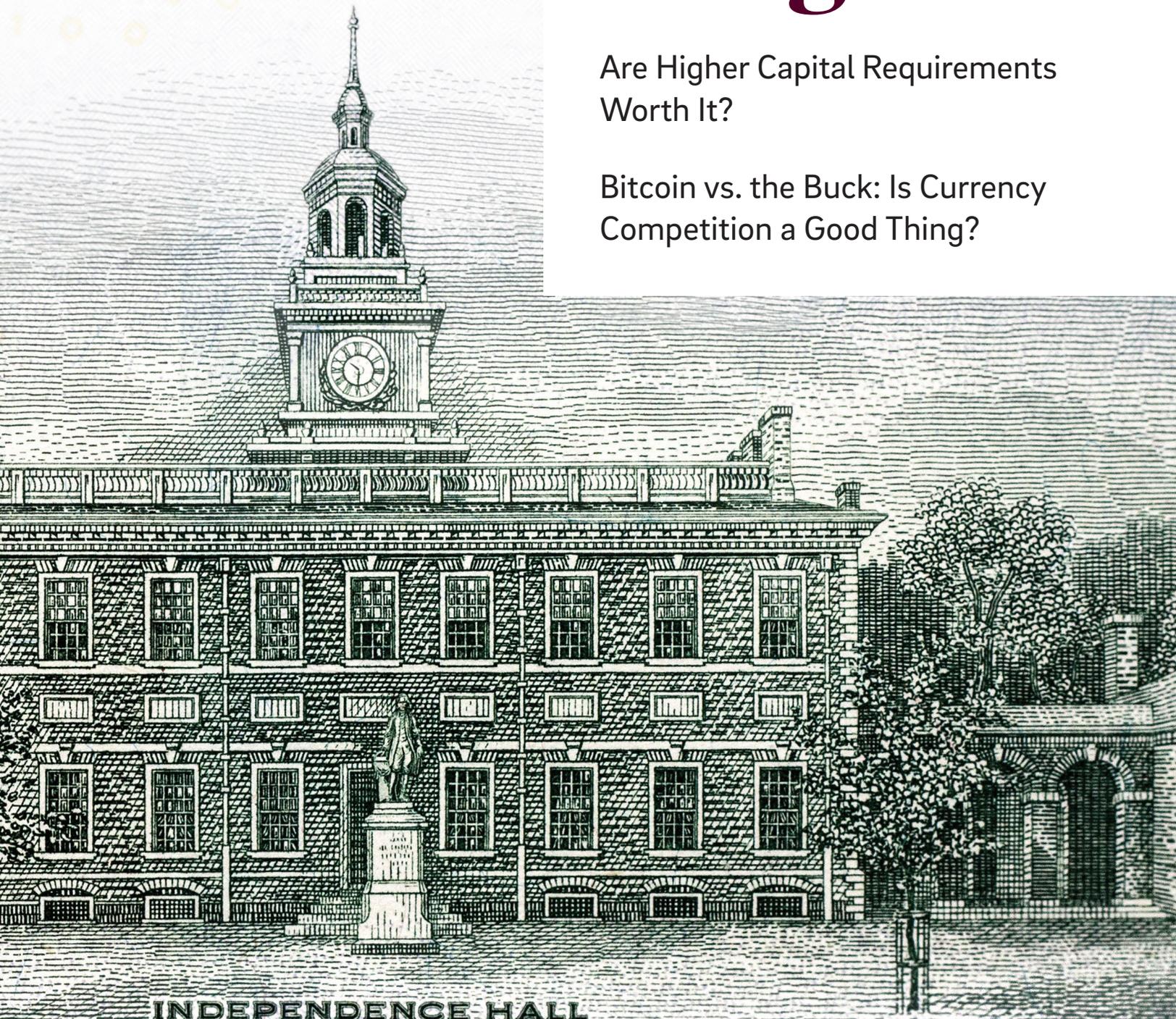


# Economic Insights

Are Higher Capital Requirements Worth It?

Bitcoin vs. the Buck: Is Currency Competition a Good Thing?



INDEPENDENCE HALL

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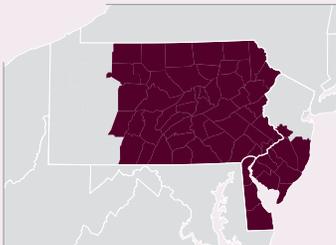
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## Economic Insights

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The \$100 bill is all about Philadelphia—and the founding of our nation. On its face is Benjamin Franklin, whose arrival in Philadelphia from Boston at age 17 helped change the course of history. On the reverse is the engraving adapted for our cover image of Independence Hall, where the Declaration of Independence and Constitution were debated and signed. Two blocks north on Sixth Street is the current home of the Federal Reserve Bank of Philadelphia, founded after the Federal Reserve Act of 1913 authorized the issuance of Federal Reserve notes such as the \$100 bill. To see how the look of the \$100 bill has evolved since 1914, go to:

<https://www.uscurrency.gov/denominations/100>.

Photo by Rich Wood.



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# Are Higher Capital Requirements Worth It?

Curbs on bank leverage are intended to prevent bailouts but can slow economic growth. The challenge is to obtain precise estimates of the impact so policymakers can weigh the tradeoff.

**Pablo D'Erasmus** is an economic advisor and economist in the Research Department of the Federal Reserve Bank of Philadelphia. The views expressed in this article are not necessarily those of the Federal Reserve.

BY PABLO D'ERASMO

When trillions of dollars in loans and other assets went bad in the financial crisis, banks across the globe were unprepared to absorb the losses. The bank failures and government assistance that followed led policymakers in the U.S. and worldwide to tighten regulations for financial institutions. At the center of these new regulations are higher capital requirements. The idea is that a well-capitalized bank will be able to handle major write-downs of its assets without defaulting on its creditors and depositors.<sup>1</sup> By inducing banks to internalize their losses in this way, regulators seek to prevent banks from straining federal deposit insurance funds and especially to prevent government bailouts.

Their overarching objective, however, is to foster a more stable financial system. The nature of commercial banking is inherently unstable, as banks fund their long-term lending mostly with short-term debt in the form of insured deposits or by borrowing from other banks or from investors by issuing bank bonds. This high degree of leverage in the financial industry means that, if confidence in the financial system is shaken, as happened in 2008, even banks that are not exposed to catastrophic losses are vulnerable to panic-selling of assets to meet worried depositors' and creditors' sudden demand for liquidity. Requiring banks to hold a larger portion of their liabilities in the form of equity is intended to reduce the risk that they will be forced to sell off their assets at fire-sale prices and trigger the sort of contagion that threatened the global financial system in 2008.<sup>2</sup>

Not only the financial sector but also the whole economy benefits from confidence in the banking system, since financial turmoil often precedes deep recessions. Such crises are very costly. During the Great Recession, U.S. GDP dropped more than 5 percent from

its previous peak, 8.8 million jobs were lost, and the federal government spent \$250 billion to stabilize banks and \$82 billion to stabilize the U.S. auto industry.

Are the new capital requirements sufficient to prevent another crisis? At what cost? The relative benefits and costs of

See *"Raising the Floor Under Capital."*

higher capital requirements are the subject of ongoing debate. It is still not clear how changes in

capital regulation affect the likelihood of a new crisis, the dynamics of the banking industry, or business cycle fluctuations in credit—the grease for the engine of commerce. Banks' role in credit intermediation between investors and depositors helps the economy expand over the long term. And to the extent that larger banks are better able to increase their capital, higher minimums will reduce competition in the banking industry, which can result in less efficient intermediation in the form of higher borrowing costs. Moreover, precisely measuring the cost of a crisis is not so simple, because the size of a contraction will generally depend on the size of the very expansion that led to the crisis in the first place. Therefore, measuring whether imposing higher capital requirements would have avoided a crisis requires understanding how the economy would have behaved with and without the higher minimums throughout the entire boom and bust cycle and not just during the decline.<sup>3</sup>

FIGURE 1  
Great Recession's Impact



Jobs Lost  
8.8 mn

U.S. Government Spending to Stabilize Select Industries  
Banking: \$250 bn  
Automotive: \$82 bn

Sources: U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics.

Regardless, as I will show, higher capital requirements have the potential to reduce bank risk-taking and competition in the financial sector while increasing borrowing costs, which might also translate into higher risk-taking by borrowers. The challenge for policymakers, therefore, is to balance financial stability with efficiency. And the challenge for economists is to more precisely estimate the degree to which the effects of regulation will dampen lending and economic growth so that policymakers can weigh that tradeoff. Since the Great Recession, economists have been seeking better ways to measure the economic effects of higher capital requirements to gain a firmer understanding of what amount of bank capital is optimal.

## Optimal for Whom?

To maximize its profits, a bank would not typically choose the level of capital preferred by regulators, who take into account more than just the individual bank's profits. So it is helpful to ask what level of capital a bank would choose absent capital regulation. At the most basic level, the bank will balance the costs of funding its loans and other investments with debt (deposits, CDs, or bonds) versus the cost of funding its activities by raising equity. In this sense, the tradeoffs are similar to those of any type of firm that faces limited liability, and traditional theories of optimal capital structure provide some guidance. On the one hand, a better-capitalized bank faces lower costs of financial distress and might be able to maintain a positive charter value.<sup>4</sup> On the other hand, debt financing has two advantages over equity financing: One, it offers banks tax benefits, as interest payments can be deducted and, two, it may cost the bank more to raise equity by selling shares than by borrowing funds.<sup>5</sup>

Other factors unique to banks help explain why they tend to use debt funding more than nonfinancial firms do. Unlike the debt of nonfinancial firms, bank debt is used as money and, thus, is important in facilitating exchange. Think about writing checks on your deposit account. Producing liabilities to support exchange is as much a part of the business of banking as making loans. Importantly, deposit insurance reduces banks' cost of funding their activities with deposits and tends to make those costs relatively insensitive to bank risk.<sup>6</sup> That is, as long as customers know that their accounts are federally insured, they will not monitor their bank as closely as they otherwise might for signs of higher bank risk-taking, allowing riskier banks to avoid having to attract depositors by paying higher interest rates.

What level of capital do regulators prefer? The failure of an individual bank is not necessarily a problem for its depositors or investors, since depositors' losses can be covered by deposit insurance, and its bondholders are compensated via market prices that reflect default risk. However, the failure of a bank can have important negative implications for other banks and other sectors of the economy—a contagion effect.<sup>7</sup>

See **"Raising the Floor Under Capital."**

Unlike banks, regulators take into account these negative effects, or externalities, that a bank's actions may have on other banks, firms, and individuals in the economy.

While a bank thinks only about its own potential cost of financial distress, a regulator takes into account the cost of financial

distress to all banks. According to this logic, the regulator would like banks to choose loan portfolios that are less risky and to hold more capital than banks would prefer. So, regulators set minimum capital ratios above the level of capital that an unregulated bank would choose on its own.

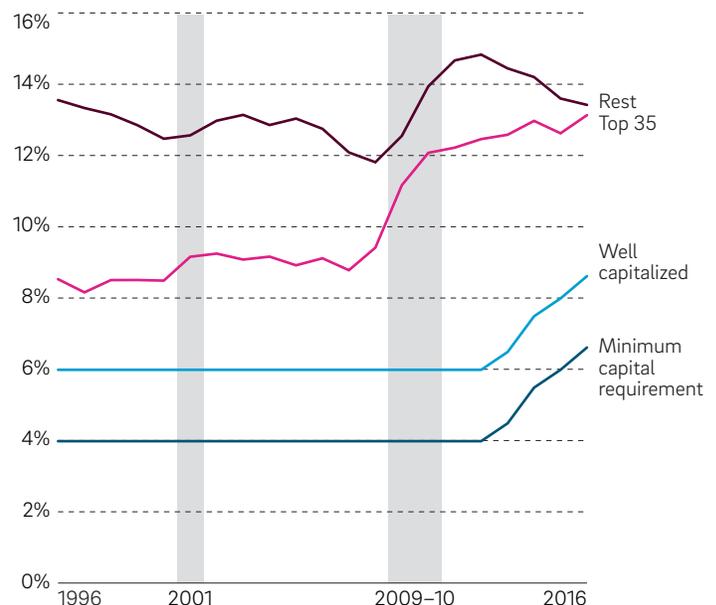
Given these conflicting interests of banks and regulators, what levels of capital do banks currently hold? The average tier 1 capital ratio (mostly common equity) at the end of 2016 was 13.20 percent of risk-weighted assets; in the 1996–2016 period, the average risk-weighted tier 1 capital ratio was 10.09 percent—well above the minimum required.<sup>8</sup> It is important to note that actual capital ratios far exceed what the regulations define as *well capitalized* (2 percentage points higher than the minimum), suggesting that banks have a precautionary motive.<sup>9</sup> A bank that was adequately capitalized but not well capitalized would not be subject to regulatory scrutiny but would be unable to engage in certain activities, for example, taking brokered deposits or partaking in international activities. Although from the bank's perspective it would rather not incur the cost of maintaining large amounts of capital, in practice, banks tend to hold a buffer above the minimum required.<sup>10</sup> That way they avoid inadvertently letting their capital slip to a level that would trigger closer regulatory scrutiny and restrictions on their activities.

Within these averages, the capital levels that large and small banks choose are quite different. The level of capital ratios for commercial banks is inversely related to bank size, as measured by assets. Average asset-weighted ratios vary substantially among banks, and there is a lot of cross-sectional dispersion. For the top 35 banks in terms of assets, the average for 1996–2016 was 8.81 percent, versus 12.90 percent for all other banks (Figure 2).<sup>11</sup> This inverse relationship between capital levels and bank size can be seen both before and after the crisis (Figure 3).

FIGURE 2

### Actual Ratios Exceed Requirements

Average risk-weighted capital ratios, by bank size, 1996–2016.



Source: Federal Reserve Call Reports.

## Economy Affected via Three Main Channels

Determining optimal capital settings is relevant not just to the profitability of banks or the stability of the financial industry but to the whole economy’s ability to grow. In my research with Dean Corbae, we show that tighter capital regulations force banks to change their balance sheet composition, which alters the quantity and quality of credit directed to the overall economy through three main channels:

One, reduced lending: A bank can increase its capital ratio either by raising new equity or by slowing the growth of its assets by making fewer loans. If banks in general take the latter route, it can result in less lending economywide and higher prevailing loan interest rates, since banks would seek to offset the reduction in profitability from having smaller loan portfolios by increasing their net interest margin—the difference they pocket between how much interest they pay out to their depositors and other funders and how much they charge their borrowers. The higher loan rates would discourage borrowing, thereby curbing spending and investment and ultimately economic growth.

Two, risk-taking: The standard argument is that by increasing capital ratios, bank risk-taking is reduced.<sup>12</sup> The intuition is simple. Since higher capital ratios imply greater losses for equity holders in the event of default, they reduce shareholders’ incentive to take on risk. However, imposing higher capital ratios might also increase bank risk-taking. Increasing capital requirements could reduce the continuation value of a bank, that is, its stream of future profits.<sup>13</sup> The bank is forced to allocate more funds toward less risky assets that generally carry lower expected returns. In addition, since there is limited liability, the bank’s individual owners share in the high profits when risky portfolio choices pay off but lose only their own investments when the

bank suffers large asset losses. The reduction in its charter value induces the bank to take on more risk.<sup>14</sup> These offsetting effects imply that the overall effect can be ambiguous.<sup>15</sup>

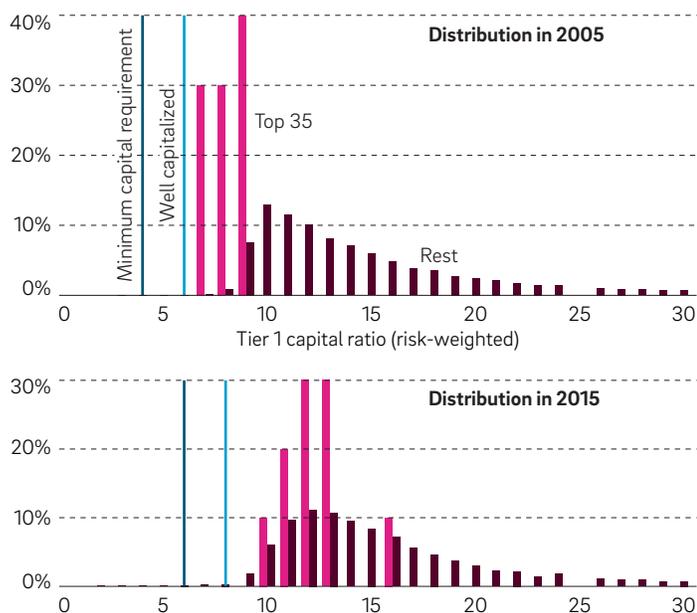
If we look more broadly, increasing commercial banks’ need for capital introduces a competitive advantage for bank-like institutions such as those in the shadow banking sector, which operates outside the purview of regulators and therefore is not subject to capital requirements, shifting financial activities from regulated banks to unregulated firms.<sup>16</sup> This shift might increase risk-taking in the economy as a whole even while reducing risk-taking by banks.

Three, competitive effects: Regulation can increase or decrease the industry’s level of competition, which can be measured, for example, as the share of loans extended by the biggest banks or the industry’s asset concentration. Higher capital requirements can affect regulated banks differently depending on their size. In the short run, higher capital requirements might result in a less concentrated banking industry by reducing the largest banks’ share of the loan market, thereby benefiting smaller banks. As I described previously, large banks typically hold smaller cushions above the required capital level, so a higher capital requirement will force them to reduce their loan portfolios—especially given that, following the collapse of the asset-backed securities market in the financial crisis, banks now have considerably fewer opportunities to make loans with the intention of selling them to securitizers. In the long run, however, higher capital requirements may reduce competition by acting as an entry barrier for new banks. Higher capital requirements may also make banking less profitable by shifting the composition of banks’ balance sheets toward safer assets, thereby reducing the value of creating a bank. If more potential competitors are prevented from forming, higher capital requirements might protect existing banks by giving them more market power to raise loan rates, account fees, and other costs for their customers, thereby curbing overall economic growth.

FIGURE 3

### Actual Ratios Vary Substantially by Bank Size

Average risk-weighted tier 1 capital distribution, top 35 vs. rest.



Source: Federal Reserve Call Reports.

## Estimated Costs and Benefits

How can we quantify all these effects? Concerns about what implications higher capital requirements may have for the financial industry and for households and firms in general have motivated economists to seek more precise ways to measure the impact. As with any shift in regulatory policy, when policymakers are armed with realistic estimates, they are in a better position to weigh the cost of a change against the benefit. Unfortunately, not all the estimates that researchers have generated so far can be easily compared. For example, some of the studies I discuss next estimate the rise in banks’ loan rates, while others estimate the effect on the level or growth rate of the gross domestic product. Taken together, though, these disparate estimates offer a general sense of how sizeable the impact is likely to be. I will also describe a new approach I helped develop that seeks to quantify the effect of higher capital levels using a more realistic model of the banking landscape.

## Raising the Floor Under Capital

As banks' reliance on capital has fluctuated, regulators in developed countries have responded by repeatedly raising minimums. These efforts have been coordinated by the Basel Committee on Banking Supervision at the Bank for International Settlements in Basel, Switzerland, with the understanding that national central banks and other regulatory authorities would write the specific rules and time-tables for implementation in their countries. In the United States, Basel III has been largely implemented through the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010. The Bank for International Settlements discusses the evolution of global banking regulations at <http://www.bis.org/about/chronology.htm>.

### Required Ratios



**Tier 1 capital** = common equity + preferred noncumulative stock + minority interests in consolidated subsidiaries.

**Tier 2 capital** = tier 1 capital + allowances for loan losses + perpetual preferred stock + subordinated debt + various hybrid capital instruments.

## Banks' Funding Costs

One way to gauge the impact of raising capital requirements is to measure the change in what it costs banks to fund their lending and other activities using traditional finance models of capital structure. According to Franco Modigliani and Merton Miller's celebrated theorem, a firm's debt-equity mix does not affect its cost of capital as long as the mix does not affect its risk-taking and debt and equity are taxed identically.<sup>17</sup> Ignoring taxes for a moment, Modigliani and Miller show that a rise in required capital—that is, a shift toward equity funding and away from debt funding—will have no effect on banks' cost of capital. Even though equity investors require a higher return than debtholders do to compensate them for the higher risk of stock returns, the decrease in banks' leverage reduces the return that their stockholders require as risk compensation, leaving banks' weighted average cost of capital unaffected. If one then takes into account that banks can deduct the interest and principal payments they make to their debtholders but not the dividends to their stockholders, the rise in banks' weighted average cost of funds is due solely to debt's more favorable tax treatment.

Using this approach, Anil Kashyap, Jeremy Stein, and Samuel Hanson found that a 10 percentage point increase in required capital ratios had a modest long-run impact on loan rates, in the range of 25 to 45 basis points.<sup>18</sup> To get a sense of the modest nature of this impact, banks' average loan interest margin—the difference between the interest rates they charge on loans and the interest they pay on deposits—since 1990 has been 4.42 percent.<sup>19</sup>

One limitation of these estimates is that they are based on linear equations, so they might accurately capture the change in the average ratio of banks' capital to their total assets (7 percent in their sample) from relatively small changes in capital requirements but are unsuited for evaluating the effect of large increases in regulatory capital ratios.<sup>20</sup>

Standard economic theory and all asset pricing models predict a positive relationship between the risk of an investment and its expected return: Low-risk assets should earn less, on average over the long run, than high-risk assets. So, if a bank reduces its reliance on leverage, its shareholders should require smaller dividends to invest in the bank. However, Malcolm Baker and Jeffrey Wurgler note that in real-world asset markets, a bank that reduces its risk profile by reducing its leverage does not reduce its cost of raising equity as much as the simplest asset pricing models—including the model used by Kashyap and his coauthors—would predict (indeed, their estimates suggest it ends up costing the bank more to raise capital). They estimate that, in a competitive lending market, increasing capital by 10 percentage points would add 60 to 90 basis points to the lending spread.<sup>21</sup>

## Empirical Estimates from Past Crises

Several studies attempt to estimate the costs and benefits of changes in capital regulation by analyzing historical data on interest rates and economic output across countries and then projecting values for those variables based on changes to the current level of capital.<sup>22</sup> The basic idea of this approach is to estimate the net effect of higher bank capital, with the costs

stemming mostly from the reduction in GDP that results from wider lending spreads and with the benefits arising from a reduced probability of a financial crisis and its associated costs. To quantify how much the likelihood of a crisis changes with the level of bank capital, these studies estimate how much equity banks would have needed on their books during past crises to absorb enough of the observed losses so that no government recapitalization of the banks would have been necessary.

One such study, by Jihad Dagher and his coauthors, suggests there is a limit to the amount of crisis prevention to be had from raising the floor on capital. They found a strong initial benefit if capital ratios were relatively low to start with. Raising the ratio from 15 to 23 percent rapidly decreased the probability of a crisis. But once capital ratios reached around 23 percent, the marginal benefit of raising them further started to shrink; nearly the same percentage of crises were avoided as when capital minimums were at 30 or even 40 percent.

It is important to note that the estimated size of the marginal benefit that these studies found depended heavily on their assumed loss given default (LGD). When a borrower defaults, the bank typically recovers less than the full value of the loan; this shortfall is its LGD. Different assumptions about LGD have led other studies to estimate greater marginal benefits at higher capital ratios.<sup>23</sup>

Cost estimates also vary significantly across studies, but they all indicate that boosting capital might lead banks to charge substantially higher interest rates on loans. For example, a 2016 study by the Federal Reserve Bank of Minneapolis estimated that if capital ratios were increased to 23.5 percent, the level of GDP could drop 1.52 percent annually and loan rates could increase by 60 basis points.

The studies' estimates of the optimal ratio of capital—the amount that would generate the most benefit for the least cost—range from 13 percent to 25 percent, depending largely on their underlying assumptions of LGD and of how much of the change in their financing costs banks pass on to their customers.

## Changes in Credit and Output: Model Estimates

Every model of the economy has its limitations, and uncertainty comes with any estimate a model produces. One way that economists seek to reduce the uncertainty about the correct way to model the economy is to use a wide variety of models to produce a range of estimates. Using 13 different models, a report by the Bank for International Settlements Macroeconomic Assessment Group found that a 1 percentage point increase in required capital—the target ratio of tangible common equity to risk-weighted assets—would lead to a maximum decline in the level of GDP of about 0.19 percent relative to no change in required capital. To put this estimate in context, a decline in the level of economic output of this size would be equivalent to a 0.04 percentage point reduction in the annual GDP growth rate, which in recent years has been trending around 2 percent. Using a similar approach to generate a range of estimates, the Bank for International Settlements Basel Committee on Banking Supervision found that a 1 percentage point increase in the capital ratio regardless of the cause—higher regulatory minimums,

higher required buffers, or changes in what qualifies as capital—would reduce the level of GDP by at most 0.6 percent and would widen loan spreads by 13 basis points.

Importantly, these estimates were derived using general equilibrium models, which seek to approximate the economy's dynamic nature by accounting for interconnections across all sectors of the economy and for how regulatory changes affect all prices and quantities. For instance, many of the models used in this study incorporate the effects of international spillovers. Estimates from such dynamic models are not directly comparable with those derived from a more empirical approach that cannot capture the general equilibrium effects of changes in capital ratios. This difference highlights the importance of using general equilibrium models as opposed to linear predictions when estimating the impact of capital requirements, as general equilibrium effects tend to mitigate the costs of changes in capital regulation, for a relatively modest net effect on output.<sup>24</sup>

A serious limitation of all the foregoing approaches is that they do not tell us anything about how higher capital requirements might change risk-taking, competition, or the efficiency of intermediation in the banking industry. What effects do we estimate if we take into account these real-world channels?

## The Three Channels at Work

The literature on the interaction between the banking sector and the overall economy has advanced considerably in the last 10 years. However, most of the analysis is based on models that assume a perfectly competitive financial sector, which allows for a very limited role for changes in the degree of competition and bank risk-taking. In reality, though, the data show that the banking sector is highly concentrated—the top 10 banks' asset market share has more than doubled in the past 20 years—and that bank risk-taking was a significant driver of the financial crisis. In order to study whether incorporating these features is quantitatively relevant, Corbae and I developed a model that features a realistic competitive structure that incorporates all three channels through which higher capital requirements might affect the economy: higher borrowing costs, risk-taking, and competitive effects.<sup>25</sup> In our framework, as in real life, many banks compete in an environment in which a few large banks dominate the industry and have market power, while many small banks act as price takers. In addition, new banks form when they expect to make a profit, and unprofitable banks go out of business under limited liability (in economics terms, bank entry and exit are endogenous). As in the real world, banks in the model allocate their funds across different asset classes such as loans, securities, and cash, and finance their investments with deposits and other short-term borrowing.

The model generates several predictions that are in line with the data: Small banks operate with higher capital ratios than large banks do, and default frequency, loan returns, and markups are countercyclical; that is, they increase in bad times and decline in good times. One of the drivers of the observed differences in capital ratios is that small banks' source of short-term funding is more volatile. We estimate that deposits at small banks fluctuate considerably more than at large banks, prompting small banks to maintain larger buffers.

Our framework shows that higher capital requirements alter the mix of bank sizes present in the industry, resulting in a much more concentrated loan market. This new mix in turn amplifies the effect of the change in policy. While banks of all sizes hold more capital, large banks grow larger, putting pressure on small banks to merge or close. As large banks' market power increases, they extract higher profits by raising loan rates, which tightens credit and depresses the economy's output. In addition, far fewer fail even as they take more risks, since their charter value is higher under the tighter requirements. With this effect on industry concentration, an increase in required capital from 4 percent to 8.5 percent widens the lending spread by 18 basis points and reduces the value of loans outstanding about 0.65 percent. These effects result in a decline in GDP of 0.46 percent in the long run. Short-run effects are likely smaller, since the amplification occurs gradually.

## Conclusion

The studies I have reviewed suggest that for every 1 percent increase in capital minimums, lending rates will rise by 5 to 15 basis points and economic output will fall 0.15 percent to 0.6 percent. Despite this variation, it is reasonable to expect that increases in borrowing costs of this magnitude may curtail lending enough to create a lasting drag on overall economic activity. Less clear is what harm would ensue from another financial crisis without more well-capitalized banks. Indeed, if the risk-weighted capital ratio had been 6 percent—in line with the new minimum—the International Monetary Fund estimates that large U.S. banks would have had enough capital to cover their losses at the peak of the 2008–2009 crisis. That would have avoided a financial sector meltdown and the severely depressed economic activity and large-scale government intervention that followed. <sup>14</sup>

FIGURE 4

### For Every 1% Increase...

The long run will be impacted.

Lending Rates  
Basis Points

▲ 5–15

Economic Output

▼ 0.15–0.6%

## Notes

- 1 With enough capital, a bank may be able to handle major losses by cutting dividends, liquidating a fraction of its safe assets, and injecting new capital.
- 2 In economic jargon, capital regulation is intended to reduce the moral hazard of risk-taking by financial institutions that operate under limited liability and deposit insurance. Moreover, bank capital acts like a buffer that may offset losses and save banks' charter value.
- 3 Another reason that it is not always straightforward to measure the cost of a crisis (or the benefit of higher capital requirements) is that crises occur very infrequently in developed economies. Therefore, many studies use information on financial crises in developing economies, which are generally accompanied by currency crises or sovereign debt crises, which complicates comparisons. For historical databases on credit booms and crises, see, among many others, the studies by Moritz Schularick and Alan Taylor; Enrique Mendoza and Marcos Terrones; or Helios Herrera, Guillermo Ordoñez, and Christoph Trebesch.
- 4 A bank's charter value, also called its continuation value, is its ongoing worth to its shareholders as long as it remains a going concern. It can also be understood as the value that would be forgone if the bank were to close its doors.
- 5 Yaron Leitner's 2012 *Business Review* article on contingent bank capital provides an excellent explanation.
- 6 John Kareken and Neil Wallace wrote the seminal paper on the link between deposit insurance, moral hazard, and bank regulation.
- 7 Contagion in this context refers to the potential consequences of a bank's failure for its trading partners and for the trading partners of its trading partners. Problems at one bank can transmit to others fairly quickly when there are numerous linkages among financial institutions. See Leitner's 2002 *Business Review* article on financial contagion and network design.
- 8 All data presented in this article come from the Consolidated Report of Condition and Income (known as Call Reports) that depository institutions submit to the Federal Reserve each quarter. The data can be found under Balance Sheet and Income Statements at <https://cdr.ffiec.gov/public/>.
- 9 In a typical year, about 0.5 percent of the banks maintain the minimum capital required. On average, 75 percent of the banks that operate at the minimum fail or are taken over via a merger within two years.

- 10** Note that a bank's book equity capital (the difference between the reported values of its assets and liabilities) can lag its economic capital (its market value or market capitalization) because a loss of equity market value need not be reflected in book equity. Mark Flannery discusses the differences between book and economic capital and examines the concept of "adequate" capital as it refers to the level of economic capital a bank would need to absorb losses during a crisis.
- 11** The Federal Reserve performed its stress tests in 2016 on the top 35 banks.
- 12** Frederick Furlong and Michael Keeley provide evidence that capital requirements reduce banks' incentive to take risks.
- 13** Michael Koehn and Anthony Santomero, Daesik Kim and Santomero, and Jean Rochet show that improperly chosen risk weights may increase the riskiness of banks.
- 14** Charter value, continuation value, and franchise value are being used synonymously. Lawyers would say that bank stockholders are protected by limited liability.
- 15** See the works by Thomas Hellmann, Kevin Murdock, and Joseph Stiglitz and by Rafael Repullo for discussions of this argument.
- 16** While a possible shift of activities to the shadow banking sector is an important concern, I don't address this issue in this article. Daniel Sanchez's *Business Review* article discusses the role of the shadow banking sector in the last financial crisis.
- 17** The best way to think about this theorem is that it makes precise the conditions in which the debt-equity mix actually does affect the firm's cost of capital. Indeed, much of modern finance is an exploration of the conditions under which the theorem is violated, which include that the firm's mix of debt and equity doesn't affect bankruptcy costs and that its owners and managers do not know more about the firm's prospects than other investors do.
- 18** Kashyap and his coauthors assume that the deductibility of debt payments is the only difference between debt and equity. Their lower estimate assumes that the bank replaces long-term debt with equity, while the higher estimate assumes that they replace short-term debt (deposits) with equity. It is more costly to shift away from deposits because depositors value the liquidity.
- 19** They also warn that higher capital ratios cause lending to migrate to the shadow banking sector, but they do not attempt to quantify this effect.
- 20** These estimates can be understood as *local approximations*, which refers to the approximation of a general function that exploits information on the function and its derivatives around a benchmark point to obtain the value of that function on a neighborhood point.
- 21** The lending spread is defined as the difference between lending rates and the cost of funds. The wider spread that Baker and Wurgler found resulted from an increase in tier 1 capital. For definitions of capital tiers, see "[Raising the Floor Under Capital.](#)"
- 22** See the works by Martin Brooke and his coauthors; Jihad Dagher and his coauthors; and Simon Firestone, Amy Lorenc, and Benjamin Ranish.
- 23** The Federal Reserve Bank of Minneapolis estimates that marginal benefits are still high even beyond 23 percent capital ratios with a loss given default of 62.5 percent.
- 24** Michael Dotsey's *Business Review* article discusses how dynamic stochastic general equilibrium (DSGE) models are used for the analysis of monetary policy.
- 25** In 2008, Skander Van den Heuvel initiated the literature of general equilibrium models looking at optimal capital requirements in a perfectly competitive environment. Other structural models include the models of Repullo and Javier Suarez and of Gianni De Nicolò, Andrea Gamba, and Marcella Lucchetta, as well as the general equilibrium models of Juliane Begenau and Thiên Nguyen. See my research with Dean Corbae for a comprehensive review of the literature.
- 26** The difference between requiring a larger minimum versus requiring a minimum plus a conservation buffer is that banks might continue to operate "as normal" when their capital levels fall into the conservation buffer range. Regulators might impose restrictions on dividend payments as long as capital stays in the buffer range. If a bank fails to meet the minimum capital ratio, it would be subject to capital directives or other formal enforcement action by the FDIC to increase capital. Failure to comply could lead to the bank's liquidation.

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# Bitcoin vs. the Buck: Is Currency Competition a Good Thing?

Ever since the U.S. established a single currency in the 19th century, the idea of private money has evoked panics and bank failures. In the cryptocurrency era, can the dollar stay sound?

BY DANIEL SANCHES

A central proposition in economics is that competition is good. Free markets are typically the most efficient way to provide people with the goods and services they want and to allocate resources and organize economic activity throughout the economy. Despite the logic of the argument, there is one element of this economic activity that even ardent proponents of laissez-faire economics have been afraid to leave to the vicissitudes of the free interchange of supply and demand: money. Historically, the issuance and oversight of currency have been considered strictly the province of government, and the idea of currency competition has been associated with financial instability. Indeed, for 150 years, U.S. financial firms such as commercial banks had been prohibited from issuing currency. And even though financial deregulation in the past two decades has provided U.S. banks with the opportunity to issue electronic currency to compete with official money, banks have not ventured into the business of private currency issuance.

However, in the past few years, innovations in computer science have permitted entrepreneurs to create digital currencies, most notably Bitcoin. Proponents cite the ease of payments in a decentralized transaction system requiring no third-party clearinghouse, while regulators express concern that these transactions fall outside the current regulatory framework.<sup>1</sup>

To economists, this innovation raises intriguing questions. Is a private currency even sustainable as sound money? Does the proliferation of private currencies inevitably lead to unstable prices and hyperinflation? Or is the profit motive sufficient to cause a private issuer to limit how much virtual money it pumps into circulation? To answer these questions we need a basic understanding of how currencies—including cryptocurrencies—work. This discussion focuses on those aspects of cryptocurrencies that are key to understanding their role in monetary exchange, and so, glides over many technical details.

0  
Jan 10, 2009  
1,000  
Nov 29, 2013  
May 1, 2018

Source: Bitcoin.com

## What Exactly Are Cryptocurrencies?

Cryptocurrencies are the private sector counterpart of government-issued currency.<sup>2</sup> They are issued in divisible units that can be easily transferred in a transaction between two parties. Like government-issued currency, digital currencies are not a claim on goods or any other assets, nor do they legally entitle the bearer to have them converted into government-issued currencies. In other words, digital currencies are intrinsically useless electronic tokens that travel through a network of computers.<sup>3</sup>

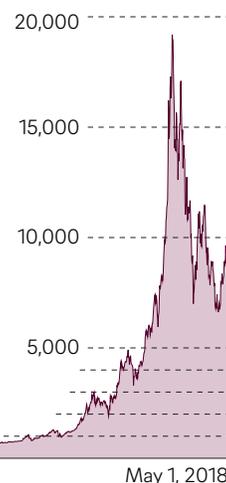
Advances in computer science have allowed for the creation of a decentralized system for transferring these electronic tokens from one person or firm to another. The most prominent digital currency in circulation is Bitcoin. Launched in 2009, it quickly gained the attention of economists and the financial community. The key innovation of the Bitcoin system is the creation of a payments system across a network of computers that does not require a trusted third party to update balances and keep track of the ownership of the virtual units.

To understand why a decentralized system that functions without a trusted third party is an innovation, consider how ordinary transactions in dollars and cents are cleared through the existing U.S. payments system that has been in place for decades.<sup>4</sup> When a buyer pays for something by check, the seller's bank sends the check for payment to a clearinghouse, which credits the seller's bank and debits the buyer's bank for the amount of the check.

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FIGURE 1  
Rise of Bitcoin  
Price in U.S.\$.



In this way, even though the buyer's and seller's accounts are obviously hidden from each other, there is third-party verification that the precise amount of money was subtracted from the buyer's bank and added to the seller's so that the buyer cannot spend it again. Thus, existing payments systems require that participants trust a bank or another financial institution to keep track of their account balances.

## Bitcoin, Briefly Explained

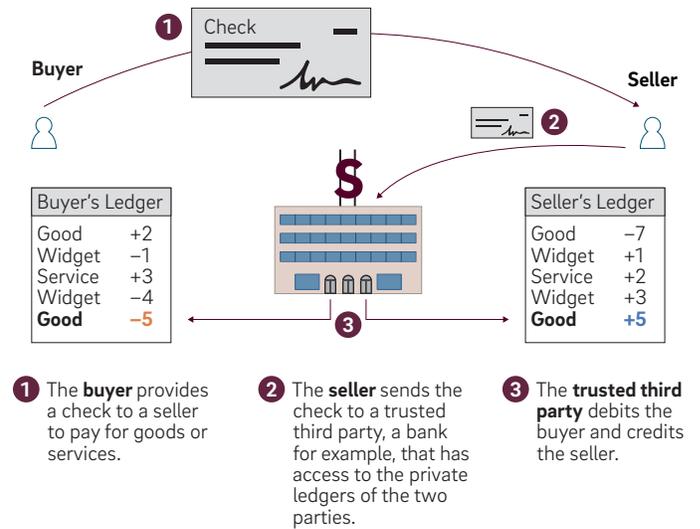
The Bitcoin system works in a different way. Instead of using a third party, it relies on an innovative *consensus mechanism*. Whenever someone in the network wants to carry out a transaction, the Bitcoins are transferred from the buyer's account to the seller's according to a set of rules that make the transfer's legitimacy transparent to everyone else in the network, even though parties to the transaction remain anonymous. Other cryptocurrencies, such as Ether, Ripple, and Litecoin, have gained considerable market capitalization in recent years. These virtual currencies also rely on a consensus mechanism similar to that used in the Bitcoin system.

To understand how the Bitcoin consensus mechanism works, suppose that Person A wants to transfer all of her bitcoins to Person B. Without a third party to verify the exchange, what would prevent the two from fraudulently recording the transfer in their account but never carrying out the exchange? And if other network participants then go to conduct business with Person B, how can they be sure his account really has all the bitcoins he says it does? Likewise, what would prevent Person B from falsely claiming that Person A never transferred all of her bitcoins to him?

To be assured that all bitcoins that belonged to Person A now belong to Person B, everyone in the network must be able to see how many bitcoins are in the participant's account at any given moment. To achieve this transparency while still preserving members' anonymity, Bitcoin developed a process for permanently adding each new transaction to the public ledger. Known as the Bitcoin blockchain, this ledger is a database of files linked into what are called blocks and contains a record in chronological order of every Bitcoin transaction and the creation of every Bitcoin unit to date.

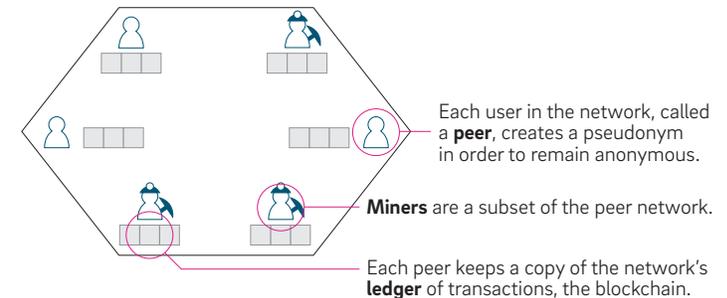
To join the Bitcoin system, a person creates a pseudonym to access its network of computers, allowing the participant to send encrypted messages through the network containing his or her payment instructions. These instructions are captured by a subset of Bitcoin participants who earn bitcoins by updating the blockchain. Known as miners, they collect pending transactions, verify that each person who wants to transfer bitcoins to someone else actually owns those units, and assemble the transactions into what is known as a block candidate.<sup>5</sup> These miners compete to be the first to demonstrate that the transactions in their block candidate are legitimate and to solve a computationally intensive cryptographic problem in order to link the new block to the chain, a trial and error process typically using multiple computers to speed up the calculations. As you can imagine, this procedure requires substantial computer power, which necessarily consumes a large amount of energy. The difficulty of the computation and the resulting cost hurdle are intended to

**FIGURE 2**  
A Simplified Version of the Trusted Third-Party Model

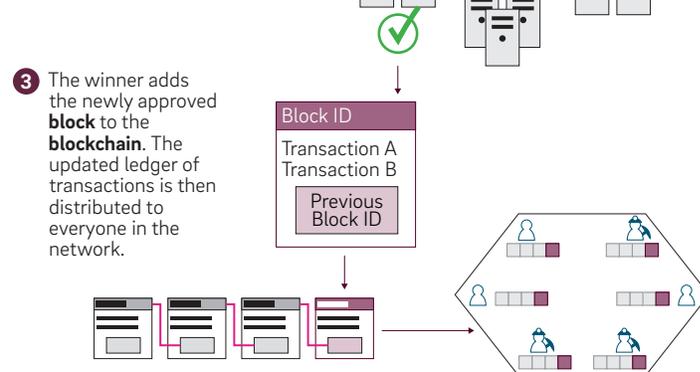
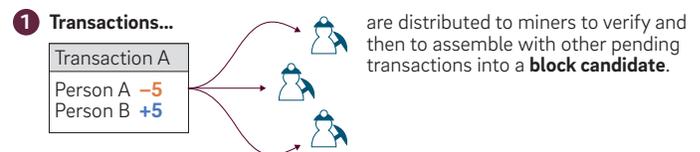


**FIGURE 3**  
A Simplified Model of Bitcoin and the Blockchain

### Bitcoin Network of Users/Peers



### How Transactions Work



prevent someone from altering the record of a prior transaction or inserting an illegitimate one, which would require amassing an unrealistic amount of computing power.<sup>6</sup>

Once others in the network see how the first miner solved the problem, it is easy for them to verify that the solution is correct. After it is verified by a few others, the pending Bitcoin transaction is cleared and the virtual units appear in the seller's account and become available to him to spend. In the process of carrying out this transaction, a block is added to every network participant's copy of the blockchain, building on and linking immutably to preceding blocks through cryptographic mathematical techniques.

It is important to keep in mind that, even though virtual currency holders remain anonymous behind their pseudonyms, the consensus mechanism rules allow everybody to know the history of every transaction associated with each pseudonym since Bitcoin started.

To ensure involvement in the mining competition among network participants, a miner who succeeds in creating a valid block candidate is compensated with newly issued bitcoins, which are recorded in the newly added block. Thus, each time a payment is made in bitcoins, the number of bitcoins in circulation increases. Currently, a successful miner receives 12.5 units per block added. As of June 1, 2018, winning a mining contest generated an income of \$93,627. Recall, though, that mining requires highly specialized computer hardware and access to cheap electricity. The estimated annual electricity consumption associated with Bitcoin was 69.4 TWh, which could power approximately 6.4 million U.S. households for one year. The estimated annual global mining cost was approximately \$3.5 billion.<sup>7</sup>

For every 210,000 blocks added to the blockchain, the compensation is halved. By the time the compensation reaches zero, 21 million bitcoins will have been created. Once Bitcoin reaches this fixed supply, there will be no new bitcoins to provide the incentive to mine them. Instead, miners will be compensated by parties to each transaction with fees paid in bitcoin. Interestingly, the Bitcoin algorithm allows for fees even today.<sup>8</sup>

## Is Currency Competition a Good Thing?

The rise of cryptocurrencies as alternatives to government-issued money has inevitably reopened the debate on currency competition. Although competition is the best way to provide households with goods and services, economists have argued that perfect competition can deliver socially desirable outcomes only if three assumptions hold: There can be no market power on either side of the market, parties to a transaction must be equally informed about the

economic environment, and they must not renege on their promises if circumstances change.<sup>9</sup>

If one of these premises is violated, unfettered competition will not necessarily deliver an efficient outcome. For instance, a market with several buyers and just a single seller of a certain good will result in excessive concentration of market power in the hands of the seller. As a consequence, it is very likely that the seller will charge an inefficiently high price for the good. If markets fail to deliver socially desirable outcomes, then government intervention may be desirable.

Given these assumptions, should the provision of money be left to the market, subject to the rules applying to all other economic activities? Or should the government have a monopoly on money creation? To answer these questions, it is helpful to start by considering the role that money plays in the economy.

## What Is Money?

Why do we need money? The textbook definition says that the main purposes of money are to serve as a medium of exchange, a store of value, and a unit of account. Many economists believe this definition is not helpful for developing theories of monetary exchange.

In an influential article, Narayana Kocherlakota provides a more satisfactory definition of money by arguing that money works as a rudimentary record-keeping device.<sup>10</sup> In his words, money is memory. To understand this idea, consider a hypothetical economy with perfect recordkeeping so that a publicly available balance sheet is kept for each person. Each individual specializes in the production of a single good or service but wants to consume a large variety of goods and services. The only way a person can buy all the goods he or she wants is by trading with other people.

In this economy, no money is needed. Buyers and sellers are willing to make all transactions via a credit-debit system. When an individual is the seller in a transaction, his balance rises by the value of the goods he sells, which means that his capacity for buying goods in the future goes up. When he is the buyer, his balance falls, and so does his capacity for buying goods in the future. Each person is willing to supply goods to someone else because he wishes to have a sufficiently high balance to buy the goods he wants.

If someone reneges on his promises, everybody in the economy will know it, given that all transactions are a matter of public record. Sellers will likely refuse to give goods on credit to those who have reneged on their promises. Thus, people have an incentive to make good on their promises to continue to be able to buy goods on credit.

In reality, it would be extremely costly to keep such a balance sheet for each person. In recent years,

FIGURE 4

## The Rewards and Costs of Bitcoin Mining

AS OF JUNE 1, 2018

A Winning Miner's Reward  
**\$93,627**

The Estimated Global Cost of Mining  
**\$3.5 billion**

Electricity Consumed for Mining  
**69.4**  
Terawatt hours or

**6.4 mn**  
powered U.S. households

Source: Bitcoin.com, Digionomist.net.

advances in information technology have substantially reduced the costs that would be associated with implementing such an ideal system. But even today, the costs are not negligible, and for a long time in history the costs were prohibitively great for large societies.

Now consider a hypothetical economy without public financial recordkeeping. The absence of recordkeeping means that if a seller agrees to give goods to a buyer in exchange for a future payment, the buyer would have an incentive to renege on his promise, given that he knows that no one else will find out about his default and that there are many other sellers with whom he can trade in the future.

Anticipating the buyer's behavior, the seller will not agree to give goods in exchange for a future payment. Thus, no trade takes place. The only way to settle the trade is if the buyer has something tangible to give as a means of payment, such as other goods or assets. A seller is willing to accept a specific good or asset as a means of payment if she believes she can easily exchange it later for other goods she wants to consume. In other words, certain goods and assets can circulate as *money*.

It turns out that money is usually a cheaper way of providing recordkeeping for the members of an economy. If someone has money balances, it means that he has supplied goods or services in the past. By accumulating money, this person expects that he will be able to buy goods in the future because he believes that other people will accept his money as a means of payment. For this reason, Kochevlakota says that money is a system of financial recordkeeping.

Given this definition of money, we can see that many types of assets can serve as money as long as they possess three critical attributes.

### The Three Properties of Money

To make for an effective recordkeeping device, an object being used as money must be easily storable, readily recognizable as money, and hard to counterfeit. For instance, because they possess all three of those properties, gold coins have been used as money in many societies for millennia. However, gold coins are extremely costly to mint.

Moreover, a growing economy needs to keep creating new money for recordkeeping purposes because the number of transactions increases over time. Yet, a growing supply of gold coins depends on the discovery of new gold deposits, so there is a limit to the amount of gold coins that can be minted each year.

Paper money also satisfies the previously mentioned properties so that it can be an alternative to gold coins. However, there is no natural limit to the creation of new monetary units, given that the cost of printing paper money is negligible. In fact, the debate over the type of money that should be used as the most efficient and reliable recordkeeping device boils down to the kinds of limit that can be imposed on the growth of the money supply. With gold coins, there is a truly exogenous limit on money creation. In the case of paper money, government can potentially limit the growth of the money supply.

### Do We Need Government for Sound Money?

Nobel laureate economist Milton Friedman argued that the use of gold coins as money is consistent with a free economy. However, the cost of a full-fledged currency operation based on gold would be too high. Friedman estimated that the annual resource cost of such a system for the U.S. economy would be 2.5 percent

of gross national product, which is a considerable amount of resources devoted to the operation of the monetary system.

He argued that paper money is the best choice provided two conditions are met. There should be no competition in paper money creation. In other words, the provision of paper money should not be left to the market; rather, the government should have a monopoly on its creation. This is because competition among private producers would lead to an oversupply. If paper money has a market value greater than its cost of production, then any individual producer—including the government—has an incentive to issue additional amounts, leading to unstable prices and hyperinflation. Therefore, the second condition is that there should be an external limit on the amount of paper money the government can issue each year.<sup>11</sup>

Friedrich Hayek, another Nobel laureate economist, made precisely the opposite argument. He said that private agents through markets can deliver sound money with no need for government intervention. Hayek argued that reputational effects will limit the negative effects of competition. If a producer oversupplies his brand of physical currency, the value of each unit will decrease and people will no longer be willing to use it, so he will end up going out of business.

So a producer who wants to stay in business needs to keep the purchasing power of his currency roughly constant, which requires him to limit how many units he puts into circulation. Hayek pointed out that governments also tend to print too much money and that external limits on the money supply are hard to enforce. For instance, many Latin American countries experienced extremely high and volatile inflation rates in the 1980s as a result of a lack of rules designed to control the growth of the money supply.

## Do We Need Government for Sound Money?

### Milton Friedman

Paper money is the best choice provided two conditions are met:

- 1 No competition in paper money creation
- 2 A limit on the amount of paper money issued

### Friedrich Hayek

Private agents can deliver sound money with no need for government intervention. Should a producer oversupply his brand of money, the value of each unit will decrease, and people will no longer use it, putting him out of business.

## Do Cryptocurrencies Change the Debate on Currency Competition?

Even though they are virtual, cryptocurrencies are costly to operate, just as precious metals are costly to mint into coins. Under the protocol used for most cryptocurrencies, the only way to obtain new units is by validating transactions through a proof-of-work procedure, which can be very costly.<sup>12</sup>

As we have seen, miners use real inputs, such as computational resources, programming effort, and electricity, to validate transactions. Additionally, there is fierce competition among miners because only the miner who is first to generate a valid solution gets the “prize.” The energy cost incurred by all the other miners who did not succeed in generating a valid solution can mount quickly as more and more people enter the mining business. In economic terms, mining is thus a costly activity that is undertaken by agents who seek to maximize profits subject to the cost structure in the network. Therefore, because the Bitcoin system and other virtual currencies are designed to operate in a decentralized, costly, and competitive environment, it is very unlikely that any individual miner will be able to control the total supply of virtual monetary units.

This lack of control over the total supply of money in circulation has critical implications for the stability of prices across the economy. Jesús Fernández-Villaverde and I have shown that, in an environment with multiple digital currencies in circulation and no centralized way to limit the supply of units, the value of these virtual units will inevitably diminish to zero in the long run. In other words, the economy will end up in a state of hyperinflation.

Additionally, we have shown that in such an environment the price level in the economy can fluctuate considerably in the near term. We have demonstrated that equilibrium can occur in which, in the short and medium terms, the value of digital currencies goes up and down unpredictably as a result of self-fulfilling prophecies in which a decline in value leads to pessimistic expectations, which lead to less demand, further lowering values and eventually converging to zero. Thus, our study concludes that, under standard technological assumptions, private currency competition will not provide households and firms with sound money.<sup>13</sup>

To understand the implications of this result, it is perhaps helpful to compare it with a standard analysis of monetary policy in the textbook model, in which it is usually assumed that there is a single currency issued by a government-owned central bank. Thus, the central bank controls the size of the money supply in the economy. In this standard model, the value of money can

also fluctuate considerably if the central bank does not maintain a credible policy to control the value of money. After all, government-issued currency is also an intrinsically useless token that is equally subject to self-fulfilling prophecies. However, an active central bank whose stated goal is to stabilize the value of its own currency will likely succeed in establishing an equilibrium situation in which the value of money remains roughly constant over time. Although it is possible to observe short-run deviations from price stability, households and firms are fully convinced that the central bank is committed to maintaining a constant value for its currency, which becomes a self-fulfilling prophecy. As a result, short-run fluctuations in the price level will not persist, and long-run stability will prevail.<sup>14</sup>

It is important to emphasize that my coauthor’s and my conclusions that competition among digital currencies will lead to hyperinflation assumed that there was no fixed upper bound on the total supply of each digital currency. As we have seen, some cryptocurrencies, including Bitcoin, have been designed in such a way that a fixed upper bound is imposed on the total supply. Fernández-Villaverde and I have argued that this property of cryptocurrencies—built-in limits on the number of units in circulation—could promote monetary stability as long as the government was able to somehow limit the number of cryptocurrency brands.

This stabilizing feature of cryptocurrencies could make them an attractive alternative to government-issued money in countries whose governments have abused their monopoly on money creation. Venezuela, for example, has suffered ruinous hyperinflation by printing money to fund unsustainable fiscal budgets.

In the absence of substantial barriers to entry, as is now the case, the number of cryptocurrency brands is not fixed. So even though the supply of each cryptocurrency brand is bounded, there is no limit on the total number of cryptocurrency units that can be put into circulation. Therefore, there is no effective upper bound on the *total* money supply, which if there were a profusion of cryptocurrencies could lead to runaway inflation. In the absence of an effective upper bound, Friedman’s arguments regarding the instability of prices are likely to hold.

## Conclusions

The sudden appearance of private sector alternatives to government-issued currencies has reopened the theoretical debate on currency competition. But despite cryptocurrencies’ innovative computer algorithms, the economic arguments regarding the benefits of currency competition have not changed. As long as entrepreneurs are free to enter into the virtual currency-issuing business, a monetary system with a proliferation of privately issued currencies would likely result in unstable prices and hyperinflation. ■

## Notes

- 1** Regulators around the world are particularly concerned with certain criminal activities that can be facilitated by the introduction of digital currencies on a global scale. There is also a concern that cryptocurrencies can promote tax evasion.
- 2** Cryptocurrencies are a subset of digital currencies, which include reserves issued by the Federal Reserve.
- 3** The simplified explanation of Bitcoin that follows borrows from Aleksander Berentsen and Fabian Schär's comprehensive but accessible discussion in the *St. Louis Fed Review*. Also see the *St. Louis Fed Regional Economist* article.
- 4** In its "What Is the Fed?" series, the Federal Reserve Bank of San Francisco details the Fed's role in the payments system, <https://www.frbsf.org/education/teacher-resources/what-is-the-fed/payment-services/>.
- 5** Each participant has a public key for sharing transaction information anonymously and a mathematically connected private key. To shield the identities of the parties to a Bitcoin transaction, miners can derive a participant's public key from the paired private key but not the private key from the public key. A useful reference is <https://www.blockchain-council.org/blockchain/how-does-blockchain-use-public-key-cryptography/>.
- 6** See the article in the *St. Louis Fed Regional Economist*.
- 7** Source: Digiconomist.net.
- 8** Fees may be voluntarily added by the seller or buyer in a Bitcoin transaction, with the miner adding this transaction to the block candidate. In this arrangement, the buyer ends up paying the transaction fee. It is also possible to construct other arrangements in which the buyer and the seller share the transaction cost. Adding fees to a candidate transaction increases the probability that it will be promptly validated and added to the blockchain.
- 9** The absence of externalities is another general condition for market efficiency.
- 10** Narayana Kocherlakota is a leading scholar of monetary and financial economics and the former president of the Federal Reserve Bank of Minneapolis.
- 11** This is one of the underlying reasons for adopting a money supply rule, which is one of Friedman's main conclusions in his analysis of optimal monetary policy.
- 12** For instance, the estimated amount of energy required to clear a single Bitcoin transaction is sufficient to power 26.5 U.S. households for one day. Source: Digiconomist.net.
- 13** The basic assumptions are an absence of a sunk cost and a strictly convex technology for the creation of new monetary units.
- 14** Hayek argued that market forces should be used to provide households and firms with stable money because he believed that central banks were invariably subject to political interference. Modern monetary theory highlights the benefits of central bank independence as a viable alternative to market forces. It has been shown that a credible independent central bank can provide a stable monetary framework in the absence of private competition.

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# Research Update

These papers by Philadelphia Fed economists, analysts, and visiting scholars represent preliminary research that is being circulated for discussion purposes.

The views expressed in these papers are solely those of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Philadelphia or Federal Reserve System.

## Declining Labor Turnover and Turbulence

The rate of job loss has been on a secular decline for the last four decades or longer. Changes in demographics or industry composition do not account for the trend. This paper seeks to identify possible sources of this decline using a simple labor matching model with two types of workers, experienced and inexperienced, in which the former type faces a risk of skill loss during unemployment. When the skill loss occurs, the worker is required to restart his career and thus suffers a drop in his wage. I show that a higher risk of skill loss results in a lower job separation rate, because workers are willing to accept lower wages in exchange for keeping their jobs. Various other potential hypotheses are also examined in the model.

Supersedes Working Paper 15–29. Working Paper 18–06. Shigeru Fujita, Federal Reserve Bank of Philadelphia Research Department.

## On the Economics of Digital Currencies

Can a monetary system in which privately issued cryptocurrencies circulate as media of exchange work? Is such a system stable? How should governments react to digital currencies? Can these currencies and government-issued money coexist? Are cryptocurrencies consistent with an efficient allocation? These are some of the important questions that the sudden rise of cryptocurrencies has brought to contemporary policy discussions. To answer these questions, we construct a model of competition among privately issued fiat currencies. We find that a purely private arrangement fails to implement an efficient allocation, even though it can deliver price stability under certain technological conditions. Currency competition creates problems for monetary policy implementation under conventional methods. However, it is possible to design a policy rule that uniquely implements an efficient allocation by driving private currencies out of the market. We also show that unique implementation of an efficient allocation can be achieved without government intervention if productive capital is introduced.

Working Paper 18–07. Jesús Fernández-Villaverde, University of Pennsylvania, NBER, CEPR, and Federal Reserve Bank of Philadelphia Visiting Scholar; Daniel Sanches, Federal Reserve Bank of Philadelphia Research Department.

## Accounting for the Sources of Macroeconomic Tail Risks

Using a multi-industry real business cycle model, we empirically examine the microeconomic origins of aggregate tail risks. Our model, estimated using industry-level data from 1972 to 2016, indicates that industry-specific shocks account for most of the third and fourth moments of GDP growth.

Working Paper 18–08. Enghin Atalay, University of Wisconsin-Madison; Thorsten Drautzburg, Federal Reserve Bank of Philadelphia Research Department; Zhenting Wang, Tianhong Asset Management.

## The Interplay Among Financial Regulations, Resilience, and Growth

Interconnectedness has been an important source of market failures, leading to the recent financial crisis. Large financial institutions tend to have similar exposures and thus exert externalities on each other through various mechanisms. Regulators have responded by putting more regulations in place with many layers of regulatory complexity, leading to ambiguity and market manipulation. Mispricing risk in complex models and arbitrage opportunities through regulatory loopholes have provided incentives for certain activities to become more concentrated in regulated entities and for other activities to move into new areas in the shadow banking system. How can we design an effective regulatory framework that would perfectly rule out bank runs and TBTF (too big to fail) and to do so without introducing incentives for financial firms to take excessive risk? It is important for financial regulations to be coordinated across regulatory entities and jurisdictions and for financial regulations to be forward looking, rather than aiming to address problems of the past.

Working Paper 18–09. Franklin Allen, Imperial College London; Itay Goldstein, Wharton School, University of Pennsylvania; Julapa Jagtiani, Federal Reserve Bank of Philadelphia Supervision, Regulation, and Credit.

## A Model of the Federal Funds Market: Yesterday, Today, and Tomorrow

The landscape of the federal funds market changed drastically in the wake of the Great Recession as large-scale asset purchase programs left depository institutions awash with reserves, and new regulations made it more costly for these institutions to lend. As traditional levers for implementing monetary policy became less effective, the Federal Reserve introduced new tools to implement the target range for the federal funds rate, changing this landscape even more. In this paper, we develop a model that is capable of reproducing the main features of the federal funds market, as observed before and after 2008, in a single, unified framework. We use this model to quantitatively evaluate the evolution of interest rates and trading volume in the federal funds market as the supply of aggregate reserves shrinks. We find that these outcomes are highly sensitive to the dynamics of the distribution of reserves across banks.

Working Paper 18–10. Gara Afonso, Federal Reserve Bank of New York; Roc Armenter, Federal Reserve Bank of Philadelphia Research Department; and Benjamin Lester, Federal Reserve Bank of Philadelphia Research Department.

## Does Scale Matter in Community Bank Performance? Evidence Obtained by Applying Several New Measures of Performance

We consider how size matters for banks in three size groups: banks with assets of less than \$1 billion (small community banks), banks with assets between \$1 billion and \$10 billion (large community banks), and banks with assets between \$10 billion and \$50 billion (midsize banks). Community banks have potential advantages in relationship lending compared with large banks. However, increases in regulatory compliance and technological burdens may have disproportionately increased community banks' costs, raising concerns about small businesses' access to credit. Our evidence suggests that (1) the average costs related to regulatory compliance and technology decrease with size; (2) while small community banks exhibit relatively more valuable investment opportunities, larger community banks and midsize banks exploit theirs more efficiently and achieve better financial performance; (3) unlike small community banks, large community banks have financial incentives to increase lending to small businesses; and (4) for business lending and commercial real estate lending, large community banks and midsize banks assume higher inherent credit risk and exhibit more efficient lending. Thus, concern that small business lending would be adversely affected if small community banks find it beneficial to increase their scale is not supported by our results.

Supersedes Working Paper 16–15.

Working Paper 18–11. Joseph P. Hughes, Rutgers University; Julapa Jagtiani, Federal Reserve Bank of Philadelphia Supervision, Regulation, and Credit; Loretta J. Mester, Federal Reserve Bank of Cleveland and Wharton School, University of Pennsylvania; Choon-Geol Moon, Hanyang University.

## Shrinking Networks: A Spatial Analysis of Bank Branch Closures

As more consumers take advantage of online banking services, branch networks are declining across the country. Limited attention has been given to identifying any possible spatial patterns of branch closures and, more importantly, the community demographics where branches close their doors. This analysis uses an innovative spatial statistics concept to study financial services: Using data from 2010 to 2016, a random labelling test is conducted to understand branch closure clustering in the Philadelphia, Chicago, and Baltimore metropolitan statistical areas (MSAs). Additionally, spatial autocorrelation is tested, and an MSA-level spatial regression analysis is done to see if there is a pattern to branch closures in metropolitan areas. I find evidence of branch closure clusters in the Chicago and Philadelphia MSAs; however, this spatial pattern is only observable within the suburbs, not the primary city itself. Using a random labelling test is a methodological innovation in regional economic studies and propels our understanding of banking deserts and underserved neighborhoods.

Working Paper 18–12. Anna Tranfaglia, Federal Reserve Bank of Philadelphia Payment Cards Center.

## Forthcoming

# Investing in Elm Street: What Happens When Firms Buy Up Houses?

# Banking Trends: Measuring Cov-Lite Right



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